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Research Article

Investigating the Potential to Improve the Efficiency of IRAN's Road Bridge Management System From The Point of View of Bridge Maintenance Experts

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Abstract

Bridges, the most important road infrastructure in construction and operation conditions, are constantly exposed to the crisis of depreciation and destruction. With the reduction of government budgets and the consequent reduction of their maintenance credits, the approach of this crisis to a disaster is implausible. In such a situation, a dynamic and comprehensive system that can appropriately prioritize limited budget allocation is undoubtedly desirable for the trustees. This system is called Bridge Management System (BMS). This research seeks to investigate the capacities of improving the management system of road bridges in Iran. For this purpose, a library study method has been used to examine the findings of other researchers in the field of BMS improvement potentials. The result of this study is the selection of three techniques of project risk management, comprehensive quality management and data mining, whose functions and characteristics to be able to match and improve BMS functions. A field study tested the improved performance of BMS in front of bridge maintenance operators in the country. The final result of the research showed that the proposed improved performance. It has raised the expectations of the operators of the maintenance of Iranian bridges in a general and step-by-step manner.

Keywords: Bridge management system; concrete road bridges; optimization; IRAN

1. Introduction

Transportation network plays is indispensable role in creating spatial links between locations and supporting the movement of people, goods, and freights. Since any disruption to a transportation network would have detrimental effects on the continuous flow of people, essential goods and vehicles, and in turn, economic security, the network is generally expected to maintain the prescribed minimum levels of service under normal and even disturbed conditions.[Ghasemi; Lee ,2021]

the cost optimization of the transportation system is essentially important in terms of the economic point of view and the safe withstand-ability of the bridges subjected to the natural hazard. Some of the benefits of an optimal design include reducing the hazard consequences and associated costs, providing travel comfort, easy access, and reducing adverse social and environmental impacts. The path of an optimal design is to identify the most appropriate alternative and find the best solution, which leads to stipulating the quality of the design. [Safari; et al. ,2021]

The economic savings in bridge maintenance are one of the most important issues, and the long-term maintenance and maintenance of structural load capacity is one of the goals and plans. The shallow replacement rate of bridges in most countries indicates that long-term bridge maintenance is generally considered a law. However, in many cases, bridges are functionally disabled before they are structurally inactive. Otherwise, more than the maintenance cost will be required to prevent excessive rates in some countries.

Since the current Iranian government is struggling with a lack of construction credits, the problems and failures of the existing bridge management system have reduced the efficiency of executive systems in maintaining and increasing the cost of maintaining the bridges, thereby depleting national funds due to the collapse of bridges over the years to come. On the other hand, choosing or setting up a proper system without considering the country's prevailing conditions and the region's climate will not improve the management of the bridge. Using the scientific findings of domestic and foreign researchers and the achievements of other countries without considering the principles of Bench Marking can lead to the failure of various optimization schemes, resulting in the waste of resources and a reduction in the desire of senior managers. Therefore, in this article, we investigate the improvement capabilities in an efficient bridge management system from the perspective of Iranian road bridge maintenance executives. They are initially investigating the studies identified how different techniques have been used to improve the performance of the bridge management system. In the next step, more effective techniques were selected and, by developing a hypothetical improved model of bridge management, its performance was evaluated through a field study.

2. Literature Review

2.1 Bridge management system (BMS)

The first line of defense against disruption is the absorptive capacity (or robustness) of a bridge, which is the capability to absorb the shock of the disruption and is considered an inherent feature of a bridge. The adaptive capacity (or redundancy) of a bridge is the capability to continue carrying loads after the occurrence of damage or failure of one or more of the bridge components. It acts as

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the second line of defense when absorptive capacity is in sufficient. [Ghasemi;Lee,2021]

Bridge management system (BMS) is defined as ‘‘a tool for assisting highway and bridge agencies in their choice of optimum improvements to the bridge network that are consistent with the agency's policies, Long-term objectives, and budgetary constraints'' [Organization for Economic, 1992]. A typical BMS consists of four basic modules database module, performance prediction module (sometimes called deterioration module), cost module and optimization module. These modules are organized as shown in Figure 1 according to their dependencies. [Czepiel, 1995].

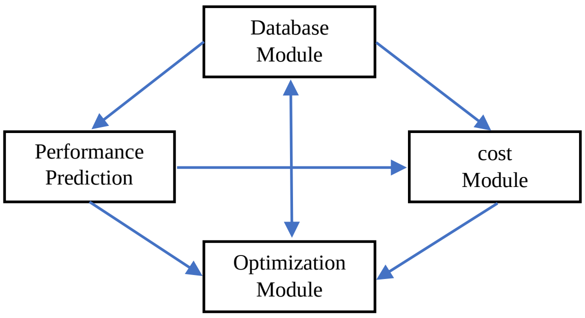

Fig. 1. Typical BMS Components [Czepiel, 1995]

Several essential components comprise a BMS to make it a fully integrated system able to analyze the database and then interact with other details and 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 condition rating) followed by a prediction of the costs of various maintenance strategies. Figure 2 illustrates the stages in the whole life of the bridges [Ryall, 2001].

2.1.1 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.

2.1.2 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.

2.1.3 Maintenance component

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

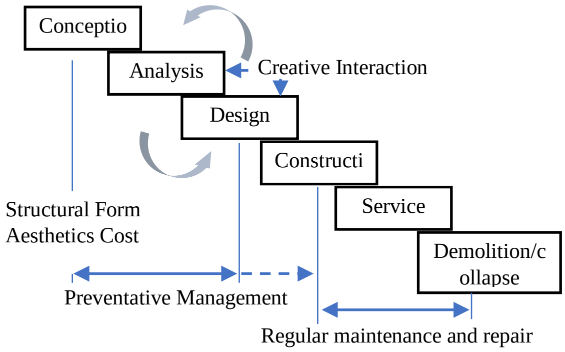

Fig. 2. The stages in the life of the bridges [Ryall, 2001]

2.1.4 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.

2.1.5 Management component

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

2.1.6 Database

The database is a store containing the entire store containing all 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.

2.2. BMS in IRAN

The native version of the country's concrete road bridge management, which has been on the agenda of the National Roads and Transport Organization since 1977, is completed in two stages: completing the bridge information form and downloading the web-based software that has been implemented, and in the second step, recording the damage information, the status of the bridge failure and uploading of information and images into the mentioned system (that are not yet operational). Finally, to prioritize bridges based on the grading method (weighted), the score of the structural damage index of the whole bridge, the index of damage of the exploitation of the whole bridge, and the overall condition status of the bridge are being defined. Training on how to use this system was conducted in short 24-hour courses. The models used in this release are as follows: (Figure 3)

A. ID Model

1- Administrative data: Organization (3 titles)

2- Technical data: Geometric data, global coordinates, openings, design (14 titles)

B. Module of Public Inspection

Public Hits, Report of Damages (1 Title)

C. Main Inspection Module

Conducting major and general inspections, recording failures, responsible checklists, evaluating members, and reporting (Total Bridge Structural Damage Index score, Total Bridge Serviceability Damage Index, and Overall Bridge Condition Rating)

<table>
<tr><td>Day</td><td colspan="2" rowspan="3">Completion data</td><td colspan="7" rowspan="3">Inspection form and technical identification of Bridge</td></tr>
<tr><td>Month</td></tr>
<tr><td>Year</td></tr>
<tr><td colspan="4">Photo</td><td colspan="6">Bridge profile information</td></tr>
<tr><td rowspan="7">Aerial Photo (Satellite)</td><td colspan="3" rowspan="7">Long View of the armpit</td><td></td><td>Route code</td><td></td><td colspan="3">Province</td></tr>
<tr><td></td><td>Bridge code</td><td></td><td colspan="3">Country Area</td></tr>
<tr><td></td><td>Year of construction</td><td></td><td colspan="3">(source-destination) Axis</td></tr>
<tr><td></td><td>GPS-X</td><td></td><td colspan="3">Beginning</td></tr>
<tr><td></td><td>GPS-Y</td><td></td><td colspan="3">Kilometers</td></tr>
<tr><td></td><td>Structural Bridge system</td><td></td><td colspan="3">Name of bridge</td></tr>
<tr><td></td><td>Type of cross-over complication</td><td></td><td colspan="3">Route direction</td></tr>
<tr><td rowspan="6">Crossover View (Base View and Deck View)</td><td colspan="3" rowspan="6">View of the cavern from above</td><td colspan="6">Geometric Bridge information</td></tr>
<tr><td></td><td>Type of bridge material</td><td></td><td colspan="3">Number of opening</td></tr>
<tr><td></td><td>Free height (m)</td><td></td><td colspan="3">Length of largest Span (m)</td></tr>
<tr><td></td><td>Axle type</td><td></td><td colspan="3">Total width of bridge (m)</td></tr>
<tr><td></td><td>Alternate route (bypass)</td><td></td><td colspan="3">Total bridge length (m)</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Number of traffic lanes</td></tr>
<tr><td colspan="10">Corrupted member information</td></tr>
<tr><td>explanations</td><td>Photo number</td><td>Failure index</td><td>The severity of the injury</td><td>Type of injury</td><td>Type of materials</td><td>Member name</td><td>Damage code</td><td>Member code</td><td>Row</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Ranking Overall Bridge Status</td><td></td><td colspan="4">Structural Damage Index the</td></tr>
<tr><td></td><td colspan="4">Damage index of operation of the whole bridge</td></tr>
<tr><td colspan="10">The overall status of the bridge is determined by the following: :
1- Good condition: There is no need for restoration now and in the short term.
2-Good general condition: There is the potential for minor maintenance of standard maintenance measures for minor components.
3. Precautions: Consideration is needed in the short term and action in the short or medium term. There is the potential to apply operating restrictions and undertake general improvement measures to recover the initial or desired status (rapid recovery).
4. Critical Situation: The member, subsystem or bridge complex has lost its optimal performance and there is an urgent need for urgent remedial action, improvement and immunization. In this case, the necessary measures clearly have the technical and economic justification; however, the road blocking and the bridge will most likely need to be removed.
5. Critical Situation: It is necessary to block the road and remove the bridge from operational feasibility studies with respect to technical and economic aspects.
6. Deterioration: Technically and economically, remedial action is clearly unjustifiable, and destruction, reconstruction, or use of other alternatives to the pathway is justified. (In this case it is necessary to remove the blockage and the bridge an operation).</td></tr>
</table>

Fig. 3. Information entry form

Based on inquiries from the Road and Transportation Authority of the country and its provincial general offices as overseers of road infrastructure maintenance in the country, the system for identifying, evaluating, prioritizing and determining bridges as a bridge management system which we have introduced, focused on eye-catching, and the web-based software provided by the National Road and Transport Organization. In addition to the issues mentioned in the BMS model review, other problems and failures added such as the following:

• Due to the lack of continuous and effective training of the Provincial Roads and Transport Organization experts, new experts have been introduced to software and forms based on experience and oral training. Hence, most experts who complete information forms often lack the skills and understanding of bridge and structural issues. The successive shift of experts in government systems has aggravated the issue.

• Bridging departments are traditional systems, with manpower management, efficiency, and process improvement issues only to be circulated. Most organizations lack the capacity to perform important and complex processes at the BMS level.

• Because the budget allocation is based on the number of critical bridges in each province, it is likely that the figures will be manipulated to lower the bridges status index. For this reason and for the reasons mentioned above, provincial and county senior managers do not trust this system's information.

• Identification of concrete bridges damage and its extent in the model used in Iran, similar to other models, is based on the apparent deformation and visible cracks of the bridge, and the damage prediction model is usually based on a descriptive analysis of the bridge condition index (percentage change) in time-lapse. This means that existing models do not have the power to predict bridge status over the serviceability life based on changes in different conditions (sensitivity analysis).

• Software is not continually optimized and the current software support contract has not been appropriate. This will eliminate software bugs and shortcomings over time.

• Software outputs and reports are not customizable based on the manager level and are based on bridging priorities and budgeting.

2.3 Techniques and methods for improving BMS

Since the subject of this research is to investigate the optimization of the bridges management system, therefore, a review of the research carried out nationwide and worldwide to find out their findings in applying different techniques to improve different dimensions of the bridges management systems and basic repair and maintenance of bridges is essential. For this purpose, 40 papers and theses have been reviewed and information summarized and listed in Table1.

2.3.1 Total quality management

The old concept of quality is reactive which is designed to correct quality problems after they occur, whereas the new concept of quality (i.e., TQM) is proactive which is designed to build quality into the product and process design. TQM requires a culture whereby every member of the organization believes that not one day should go by without the organization in some way improving the quality of its goods and services. [Tesfaye, 2017]

2.3.2 Project risk management

In today’s ever-changing and complex world, projects and processes face immense risks that could cause major disruption in their progress, if not causing the entire project's failure, unless proper precautions and measures are taken into account in order to react to these risks. Risk management is a necessary measure for achieving goals in projects; hence, it is essential to pay special and precise attention to risk management. The presence of any risk in the project would result in additional costs and delay in its progress.

However, a project’s success is not only related to time or cost, factors such as quality, performance, customers’ satisfaction and many others are also important indicators for a project’s success. [Karimi, 2020]

2.3.3 Data mining

Data mining is known as the core stage of knowledge discovery in databases. In recent years, there is an ongoing demand for systems capable of mining massive and continuous streams of real-world data. Such systems can be used in the fields of temperature monitoring, precision agriculture, urban traffic control, stock market analysis, network security, etc. The complex nature of real-world data has increased the difficulties and the challenges of data mining in Terms of data processing, data storage, and model storage requirements. Such a system can handle noise, uncertainty, and asynchrony of the real-world data. Batch classification algorithms like CART, ID3, C4.5, and IFN are not suitable for mining continuous data. [Kazemi, 2011]

Looking at the current bridge management systems used in the world (Table 1), the following strengths, weaknesses and similarities can be seen:

1. Most bridge management models use different criteria and indicators, such as the health degree of the bridge, degree of bridge qualification, status, or degree of bridge performance, to determine the bridge status. In deciding these figures, they used criteria and indicators such as structural, hydrological, climate, safety, strategic importance, facilities, and traffic.
2. Some models also use rankings based on mentioned models and methods based on mathematical or decision models.
3. In all existing models, data collection is assumed to have been done through objective observation or sensors, data entry into an information system and error-free data updating throughout the project life. None of these mentioned comprehensive and reliable methods regarding the quality of data input, quality of breeding programs, model results, and bridge output quality analysis.
4. In most models, how establishing and managing a trusted organization of data collection, data entry and analysis, and implementation of results does not need to address the proper performance of bridge management processes.
5. The errors caused by analyzing the large volume of data collected through the forms are mentioned in none of the models.
6. In most models, although effective conditions and elements in bridges such as those mentioned in paragraph 1 have been used as parameters to determine the status of bridges, however, the sensitivity analysis of the final bridge condition index has not been performed based on these indices.

Table. 1
Summary of research in the field of the bridge management system

Technique	Method	Authors
BHM PRM MCDM	Risk rating of probability and effect	Andric, 2016
BMS MCDM	Highway Safety Maintenance Assessment	Zhao, 2016
BMS PRM	Determine the degree of vulnerability to fire	Naser, 2015
BMS PRM	sensitivity analysis on Risk	Chen, 2014
BHM(3D-CAD)	Image processing	Kim, 2013
BHM	Wireless Network Sensors (WSN)	Bae, 2013
BHM	A predictive model based on eye observations and sensors	Comisu, 2017
BHM MIS BIM[1]	Sensor network analysis	Jeong, 2017
BHM MIS	Peripheral thermal response of bridges with sensor	Kulprapha, 2012
BHM FBG[2]	Long observation of sensors	Rodrigues, 2010
BHM DM	evaluating based on Structural vibration	Mashayekhizadeh, 201
BMS	Planning bridge maintenance workshops from a cost management perspective	Kosh kish, 2000
BMS MIS	BMS optimization using leveled data flow charts	Karbasizadeh, 2002
BHM	Determination of Sensor Optimal Locations by Finite Element Method	Ramezani omali, 201
BHM DM	Determination of damage location by Consolation method	Zamani hosseinabadi, 20
BMS MCDM	Identification of effective indicators on bridge quality	Darban, 2014
BHM DM GA[3]	Damage Detection in Structural Elements	Chenaghloo, 2002
BHM DM CCA[4]	Detect the location and amount of damage	Amini, 2011
BHM	Optimizing the maintenance of bridges by changing and improving the design philosophy	Akbari, 2012
BMS DSS[5] MIS	Visual Inspection Evaluation of Damage to Bridge Components with a Causal Approach	Rahayi, 2010
BMS MP[6]	Prioritize bridges for maintenance	Abdolahzadeh, 2014
BHM DM ANN[7]	Detection of structural failure Method	Fereydoni, 2012
BHM	Prioritize actions in bridge maintenance management	Ghaleh, 2014
BMS VMS[8]	Deployment of virtual management system in bridge construction	Abbaszadeh, 2016
BMS TQM	Quality Management Pattern in Bridge Projects	Saemi, 2013
BMS NA[9]	Prioritize breakdown repair and maintenance	Gholizadeh, 2015
BMS	A way to improve planning and initial estimation	Sameni, 2003
BMS	Evaluation of compliance of bridges with the desired criteria	Kheradmand, 1983
BMS DM MOPSO[10]	Optimizing corrective maintenance actions	Kiya, 2016
BMS DM MP	Setting Priority Indicators by Budget	Noroozi, 2013
BHM SMS[11]	Detect bridge failure	Abedi, 2015
BMS TOPSIS	Prioritize bridges for maintenance	Zeynalpor, 2016
BMS TOPSIS	Bridge risk assessment	Namdar, 2011
BMS PRM SAP	Bridge risk assessment including traffic load, earthquake, flood, bridge fatigue	Abdollahzadeh, 2018
BHM SAP	Damage detection in bridge structures	Khakpoor, 2016
BHM DM	Measurement of temperature and humidity and its associated displacement or deformation with special data processing techniques	Shorabi sani, 2015
BMS	Design a model for a maintenance program	Ahmadi, 1994

1 Building Information Systems
2 Fiber Bragg Grating
3 Genetic Algorithm
4 Colonial Competition Algorithm
5 Decision Support System
6 Mathematical Programming
7 Artificial Neural Networks
8 Virtual Management System
9 Network Analysis
10 Multi-objective Particle Swarm Optimization
11 Structural Modeling Software

Table. 2
Potential of Different Techniques to Improve Bridge Management System

Risk management function	Data Mining Function	Functions of a Bridge Management System	Total quality management function
L: Identify risks B: Performing qualitative risk analysis B: Perform quantitative risk analysis H: Risk response planning G: Risk Control E, Q: Use scoring and prioritization techniques P: Formulation of mission, policy, goals and scope of work B: Use comments from all team members and the project B,P: Using regular, structured and systematic work schedules B,U:sing teamwork and teamwork P: Risk Assignment to Risk Owners L: Determine risk indicators N: Determine risk thresholds	C: Predicting future events based on past trends M, N: Clustering Topics M, N: Classify topics by attributes and attributes M, N: Classify objects, subjects, or events to identify patterns D, C, F: estimates * Determine the relationship of variables C: Big Data Analysis D, L Anomaly detection * Discover the rules together L, M: Discover sequential patterns C: Identify events that may occur simultaneously M,N: Identify events that cause one to occur. * Discover dependency rules D: Detect and detect fraud D, M, N: regression	A: supply list of bridges B: Records historical (past) and future status of bridge members and components and bridge capacity C: Predicting the future status of members, components of Paul's freight duty D: Estimate the failure rate over time E: The most economical option to maintain F: Calculate different costs to determine lifetime cost G: Assess the consequences of failing to perform the required repairs on traffic safety and traffic congestion H: Providing an optimized and prioritized maintenance plan I: assist in budget planning J: Status Evaluation K: Structural evaluation and classification L: Use risk-based approaches. Modeling Damaged Structures N: Structural Degradation Modeling O: Prioritize bridges in terms of need for repair, reconstruction or improvement P:Establishment of bridge management system in the organization	P: Define Quality The process of identifying the P problems of client failures and dissatisfactions P: Formulation of mission, policy, goals and scope of work B: Use comments from all team members and the project P: Using systematic, structured and systematic work schedules P: Customer Satisfaction B: Improving the use of small groups P: Continuous improvement of processes B: Suggestions system H: Using template topics H: Feedback control system and presentation of corrective decisions I: use qualitative models B: Engage project members and staff B: Using teamwork and teamwork Organize Responsibility for ideas and suggestions B: Evaluating Team and Organization Using Organizational Maturity Issues B: Improving team performance B: Using creativity techniques B: Creating a cultural context for enhancing creativity and member participation B: Using multidisciplinary teams M, N: Using Modeling Methods B: Outsourcing P: Using the strategic plan

2.4 New model of BMS

In this paper, we will look for a new model that addresses the components of the bridge management system, removing the problems and failures of the existing systems so that the new model can utilize different techniques to manage the efficiency of bridge management processes while managing costs and considering budget constraints; The outputs for different levels of managers and experts, enables model planning to identify causes of injury and prioritizes future forecasts and analyzes provided for all relevant groups to become acceptable and understandable. Appropriate measures must be taken to ensure the results of the model.

Based on previous discussions and based on the results of library studies, three methods of risk management techniques, data mining, and total quality management were selected as techniques that can best improve and enhance the different management functions of the bridge. Table 2 shows the various functions of the 4 techniques and the common and improved aspects of the bridge management system have been compared with the other three techniques in the Latin Bold alphabet.

The topics that should be considered in developing an improved BMS model are listed in Table 3. These topics are categorized according to the steps of a standard BMS model.

Table. 3
Questionnaires in the Bridge Management Process of the Research Questionnaire

Stage	Subjects
Preparing the bridges ID	1- The administrative information (bridge general information and bridge trustee organization) should be fully collected during the preparation of the ID.
	2. Technical information (structural, geometrical, traffic and hydrological data) to be fully integrated into the system during the preparation of the ID.
	3 - Historical information (variables related to repair history, etc.) to be completed in the system during the preparation of the ID.
	4. Minimize the likelihood of experts' misunderstanding and gathering of information during the process of preparing a birth ID.
	5. Minimize the likelihood of human errors in completing forms of identification.
	6. Consider the design of the menu’s attraction (user-friendly).
	7. Load images of the current state of the bridges into the system separately concerning quality and quantity.
	8. The system will enable property owners to manage the bridge.
Inspection	1. There is sufficient detail to identify failure or damage in periodic bridge inspection forms.
	2. Form inspection designs are designed so that experts have a common understanding of the content of forms and how to identify and complete them.
	3. Images taken and loaded of damage and breakdowns provide a good understanding of the bridge situation.
	4. History of damage and physical changes of bridges and cracks and injuries are recorded correctly in reports and systems.
	5. The inspection process in this system should be systematically continuous.
	6. Feedback from inspection and timely corrective action in this system are correctly implemented.
	7. The quality of inspection data meets the requirements of maintenance departments.
	8. Maintenance and repair of bridges in the system are effectively recorded and loaded.
Analysis (grading and ranking)	1. Indicators calculated in this system (structural and operational index) are a good basis for prioritizing bridge repairs.
	2. Indicators calculated in this system (structural and operational index) are a good basis for bridge budgeting.
	3. Descriptive analysis of data collected from system identification and inspection steps will provide a good understanding of the remaining bridge life.
	4. Descriptive analysis of data collected from the identification and inspection process of the system provides a good understanding of the periodic and emergency maintenance plan.
	5. This system effectively applies bridge priority models based on the risk development model.
	6. This system works well in applying hazard and damage prediction calculation and location models.
	7. This system effectively identifies the risks that are effective in bridges serviceability.
	8. This system is suitable for bridge maintenance plans based on the status of risks.
Reports	1. Reports of this system provide an overview of the status of the bridges individually.
	2. Reports of this system provide an overview of the status of bridges in a grid (axial and regional) manner.
	3. GIS reports of this system are effective in managing bridges.
	4. The reports of this system have reduced the workload of the experts to an acceptable level.
	5. Reports of this system are usable for financial managers.
	6. GIS reports of this system are effective in managing the bridge's network
	7. Reliance on descriptive and graphical reports and the need for modern analytical reports usage have reduced the efficiency of this system.

3. Methods

3.1 Case study

One of the main tools for gathering the opinions of Iranian road bridge maintenance executives about the features considered for the proposed new BMS model is the use of field study methods and the preparation and distribution of standard questionnaires among the statistical population. The structure and questions of this questionnaire are designed based on the topics of the new model.

3.2 Statistical population and sample

The statistical population of this study is a set of experts with a bachelor's degree or higher who have been involved in the project of road bridge maintenance as an employer, consultant, or contractor. The statistical sample was selected by cluster sampling, method, and 35 questionnaires were sent and analyzed after receiving 15 questionnaires. The selection of 35 samples was performed according to the acceptable error rate which will be addressed in the following sections. Questions of the questionnaire are presented five-point LIKERT scale. The characteristic of the statistical sample of the research is as follows:

The mean age of the sample is 38.8 years, their average work experience is 15.33 years and their average work experience is 8.93 years. 22% of the samples had a Ph.D., 44% had a master's degree, and 16.7% had a bachelor's degree. 27.8% of them are heads of maintenance departments, the same number of experts in maintenance departments and the rest are executive consultants. Nine provinces have commented.

Their knowledge of bridge management and design techniques and high concrete technology is medium to good, with project risk management techniques, overall quality management and decision-making techniques being medium and medium to poor in data mining techniques.

3.3 Research hypotheses

- Hypothesis 1:

Proposed new functions for the country's concrete highway bridge management system meet the expectations of the statistical population.

- Hypothesis 2:

New proposed functions of the identification preparation stage meet the expectations of the statistical society.

- Hypothesis 3:

The proposed new functions of the inspection phase meet the expectations of the statistical community.

- Hypothesis 4:

The proposed new functions of the analysis stage (grading and ranking) meet the expectations of the statistical community.

- Hypothesis 5:

Proposed new functions of the reporting stage meet the expectations of the statistical community.

3.4 Hypothesis analysis

3.4.1 Validation and error of questionnaires:

According to sample size (n=15), statistical population (n=35), 95% error acceptance interval (Z = 0.27, 1.67), (P=0.01) using formula (1) is 19.2%.

$$n = \frac{N(Za/2)2p(1-P)}{(N-1)\varepsilon 2 + (Za/2)P(1-P)} \qquad (1)$$

The overall CRONBACH's alpha coefficient is 0.925 (Table 4).

Table. 4
Questionnaire validity status

CRONBACH's Alpha	CRONBACH 's Alpha Based on Standardized Items	N of Items
0.925	0.918	64

3.4.2 Inferential Test of Hypotheses:

Now, we re-codify hypotheses with regard to their questions. With the new coding, the research hypotheses are transformed into the first hypothesis codes e, and the second to fifth hypotheses are transformed in to e5, e4, e3, e6.

After coding, we will examine hypotheses as to whether or not we follow the normal distribution. To do this we use the Kolmogorov-Smirnov test (Table 5).

According to the explanations presented and given the output of the Kolmogorov-Smirnov test in Table 5, it can be seen that only the variables hypotheses 2 and 4 follow the normal distribution and hypothesis H0 is rejected for the other variables (Formula 2).

$$\begin{cases} H_0 & \text{Data distribution is normal.} \\ H_1 & \text{Data distribution is not normal} \end{cases} \qquad (2)$$

Table. 5
Data distribution normality test

		e	*e3*	*e4*	*e5*	*e6*
N		15	15	15	15	15
Normal Parameters [a,b]	Mean	4.526	4.608	4.425	4.585	4.486
	Std. Deviation	0.387	0.323	0.455	0.510	0.542
Most Extreme Differences	Absolute	0.184	0.262	0.203	0.259	0.171
	Positive	0.126	0.138	0.158	0.208	0.171
	Negative	-0.184	-0.26	-.020	-0.25	-0.162
Test Statistic		0.184	0.262	0.203	0.259	0.171
Asymp. Sig. (2-tailed)		0.181	0.007	0.096	0.008[c]	0.200

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Hypotheses 2 and 4:

We have already stated that with respect to the SPSS output of Table 4, since sig for hypothesis above is about variables 1, 3, and 5 being 0.181, 0.096, and 0.200, then we do not accept hypothesis H0 that 1, 3, and 5 are normal. That means the test is insignificant. Since

Hypotheses 2 and 4 have a normal distribution, a one-way t-test should be used to test Hypothesis I. According to the output of the t-test of Table 6, since sig is 0.00, then we reject hypothesis H0 in test I; that is, for the respondents, the questions in the questionnaire were important and did not have a conclusive opinion.

Table. 6
Distribution of T

	One-sample Test			**Test Value = 0**		
					95% confidence interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
e	45.284	14	0.000	4.5261	4.312	4.740
e3	55.182	14	0.000	4.6083	4.429	4.787
e4	37.655	14	0.000	4.4250	4.173	4.677
e5	34.821	14	0.000	4.5852	4.303	4.868
e6	32.047	14	0.000	4.4857	4.186	4.786

Now, where should we see this significance? Influence or neutral? For this purpose, we use descriptive statistics, i.e., skewness determination (Table 7).

Table. 7
Specifications of hypotheses

	N	Mean	Std. Deviation	Skewness	
	Statics	Statics	Statics	Statics	Std.Error
e	15	4.526	0.3871	-0.587	0.580
e3	15	4.608	0.3234	-0.744	0.580
e4	15	4.425	0.4551	-0.279	0.580
e5	15	4.585	0.5100	-0.817	0.580
e6	15	4.488	0.5421	-0.955	0.580
Valid N (list wise)	15				

The skewness of hypothesis 2 is -0.744 and the skewness of hypothesis 3 is -0.279, which means it has a great impact on Hypotheses 2 and 4, so hypotheses 2 and 4 are generally accepted by the statistical population, namely the issues raised as the new BMS model in the analysis and preparing an ID met the expectations of an efficient system.

Hypotheses 1, 3 and 5

Since Hypotheses 1, 3, and 5 do not have a definite distribution, we use nonparametric methods to test the hypothesis. The nonparametric process is most used when the samples are small. This is true in the current questionnaire (Formula 3).

$$\begin{cases} H0: \mu i \neq \mu j \\ H1: \mu i = \mu j \end{cases} \quad (3)$$

The chi-square test is a non-parametric analysis for a one-way variance analysis. Considering the output of this test (Table 8) since the sig test is not 0.000, the hypothesis is accepted that there is a significant difference.

Here's the question: Where is this inequality? We use the same as before the descriptive statistics. According to the Skewness line in Table 7, skewness can be identified.

It can be seen from Table 7 that the skewness of hypotheses 1,3, and 5 is -0.587, -0.279 and -0.955 respectively. So, hypotheses 1, 3 and 5 are accepted. This means that the statistical community has to admit that the issues raised by the new BMS model in general and at the stage of inspection and reporting have met the expectations of the trustees of an efficient system.

Table. 8
Chi-square test results

	e	e4	e6
Chi-Square	0.867a	2.400[b]	8.400[b]
df	13	8	8
Asymp. Sig.	1.000	0.966	0.395

a. 14 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.1.
b. 9 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.7.

4. Results

According to the results of the field study and confirmation of the proposed actions of this research by the statistical community and considering the case results obtained on the current system of road bridge management in the country the following results are obtained:

Improving the performance and efficiency of bridge management system processes and devices with the help of total quality management techniques.

As can be deduced from Table 2, TQM can enhance BMS performance, particularly in continuous improvement and quality of teams, processes and products, but this technique cannot be applied directly because TQM deployment requires a suitable platform at the organization level. For the convenience of integrating TQM and BMS, you can benefit from the experience of optimizing machine maintenance (NET) systems (similar to bridge maintenance systems and a bridge management system), with Total Quality Management (TQM) and Creating a Total Productivity Model of the net (TPM).

The historical trend of changing the approach to the maintenance of construction machinery from approaches such as the maintenance of BM[12] disruption (which is currently unofficial in the country) to the PM[13] preventive system and the PM[14] the productive net system has led to the creation of the Japanese total and productive net system (TPM[15]) due to extensive maintenance work alongside more sophisticated machinery. The new system is a combination of TQM prevention and maintenance system using Total Quality Management techniques (TQM).

12 Breakdown Maintenance
13 Preventive Maintenance
14 Productive Maintenance
15 Total Productive Maintenance

TQM is a culture and a philosophy as well as a set of guiding principles to show the basics of continuous improvement in the organization. In fact, applying quantitative methods and manpower to improve all processes in the organization and to move ahead of customer needs, both present and future. TQM can integrate core management techniques, remedial activities, and technical tools in a unified manner.

In other words, TQM is "a smart, slow and continuous action that has a powerful impact on achieving the goals of the organization and ultimately leads to customer satisfaction, increased efficiency and increased market competitiveness."

With the implementation of TQM, an organization expects to institutionalize the following six issues:

- Commitment and partner management to provide long-term top-down support (leadership improvement).
- Sustainable focus on internal customers such as employees and outsiders such as suppliers and customers (customer-centric improvement).
- Effective and inclusive use of the workforce (staff empowerment).
- Continuous improvement in tasks and processes.
- Treating suppliers as well as treating partners.
- Establishment of activities performance measurement system (quality management).

TPM's Total productive maintenance and repair system has evolved widely as a new strategy at the enterprise level, where machines and equipment play a unique role in service delivery. With a holistic view, this system calls for all the factors contributing to service delivery and ensures the promotion of all qualitative and productive aspects by increasing equipment effectiveness through creating an appropriate cultural infrastructure.

Although the nature of the machines varies with the dimensions, costs, and operators used by the bridges, there are undeniable similarities such as their size and number, similarity to damage identification and maintenance systems, and the success of machinery net systems in adopting new approaches and improving organizations, individuals and processes, and consequently improving the quality of machinery at a cost and on an ongoing basis. It seems that using the TQM, Total Quality Management technique, to improve bridge management models similarly and by adhering to the modeling principles, the TPM total productivity net system can improve their performance.

By integrating with TQM, it is expected that the bridging organization will include more senior managers, staff, suppliers, and its processes and on the other hand, less chance of errors and mistakes. Also, continuously improving performance by continuously evaluating the status and providing feedback.

Improve data analysis and information management to improve damage detection using data mining (DM) techniques.

Another important issue in addition to the topics discussed is the issue of the enormous volume of data generated by the process and the health monitoring of bridge.

Experience in using MIS[16] information systems and DSS[17] decision support systems already exists in the world of health monitoring and bridge management processes, and even in the systems used by the country's Road and Transportation Organization; However, in modern global approaches, the use of these systems is not appropriate for analyzing and investigating large-scale interactions, and the use of big data concepts and techniques is at the forefront of today's risk analysis of large-scale investment in capital markets and stocks and complex computation of large volumes of data is essential.

It has 350,000 bridge management data and big data. Because of the high volume of data, the speed of data generation, the variety, accuracy and value of data, it meets the requirements of big data.

The lifetime of a big data analytical approach includes:

Business case evaluation, data identification, data acquisition and purification, data extraction, data validation, data representation integration, data analysis, data visualization, using data results.

Big data analytics techniques include the following 7 ways:

Quantitative analysis, qualitative analysis, data mining, Statistical analysis, machine learning, semantic analysis, visual analysis.

Therefore, by applying the principles of big data in bridge management, the benefit from the data collection and validation, and evaluation process will be improved. On the other hand, an appropriate analysis method will be suggested based on the data's type and specificity and the common output type.

One of the analytical methods of mass data that is emphasized in this paper is the method of data mining.

Data Mining is the automatic extraction of new and useful knowledge from the bulk data sources available during a non-obvious process. The implementation of DM involves three steps:

1- Preparing the data
2- Learning the model
3- Evaluating and interpreting the model.

According to the experience of other researchers, in this article, while exploring different data mining methods and algorithms, we will focus more on the following:

- Applying evolutionary meta-heuristic algorithms such as genetic algorithm in predicting and locating damage severity, multi-objective particle swarm algorithm for life cycle and proper repairmen time.
- Using fuzzy logic to calculate risk
- Using of artificial neural networks to detect the failure and its scope
- Using the error tree algorithm to identify and prioritize risk.
- Application of regression and variance analysis in sensitivity analysis of bridge data in network.

16 Management Information System
17 Decision Support System

- Using DEA Data Envelopment Analysis as a mathematical programming model to classify bridges based on each service's cost and the cost with respect to the input and output variables of each bridge.

We are improving the plan of identification, analysis and response to hazards and damages with a predictive approach using the Project Risk Management (PRM) technique.

Bridge management also focuses on damage prevention, although it does not interfere with the occurrence after that. So, risk management techniques, along with customized TQM, can facilitate achieving excellent bridge management goals. Risk management involves minimizing the consequences of adverse events as well as maximizing the effects of positive events.

Risk management is a comprehensive and continuous approach such as total quality management. Because the budget is limited to the trustees of road bridge management, using a risk management approach can identify the quantitative and qualitative analysis of the risks that bridges have been involved with during their service life and develop a risk response program to manage the maintenance and review of feedback from corrective actions.

5. Conclusion

Since country bridges are primarily concrete and the influence of different elements in the construction and maintenance of these bridges is much more significant than the other types, to organize the stages of this article, only Concrete bridges will be considered. Therefore, the purpose of this thesis is to develop an indigenous model for concrete highway bridges management in the country to improve its efficiency by using TQM's total quality management techniques as the central thesis technique and improving information management and analysis, improving and prioritizing bridges, identifying and damage ranking, selection of maintenance methods, detection of damages and limitations, optimization of remedial actions and identification of the appropriate time and place for repair of damage using BD Big Data approach and DM data mining method and process improvements. Identify the risks of bridges, analysis, and response plans using risk management techniques Projects will be PRM.

According to the findings of this study, the following is suggested:

1- The existing model of concrete highway bridge management in the country, although simple, has significant disadvantages that lead to its low efficiency and inability to meet the high goals of bridge management. While it may seem time-consuming and complicated at first, creating a comprehensive model can be offset by better results.
2- To manage highway bridges as a valuable asset of the country, it is recommended to design a modern and new model with the capability of identifying risks, predicting the bridge's condition, and determining the remaining lifetime to prioritize the budget and facilities correctly .
3- Before introducing the new model, it is necessary and inevitable to change the attitudes of managers and employees and the processes of trustee organizations with TQM doctrines.

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