RESEARCHERID
THOMSON REUTERS

[More* 4(4): April, 2017] ISSN 2349-4506
Impact Factor: 2.785

Global Journal of Engineering Science and Research Management

A REVIEW ON CONDITIONAL ASSESSMENT OF BRIDGE STRUCTURES

A. G. More*, V. M. Bogar
* Student M.Tech, Structural Engineering, Government College of Engineering, Karad, Maharashtra, India
Assistant Professor Structural Engineering, Government College of Engineering, Karad, Maharashtra, India

DOI: 10.5281/zenodo.496156

KEYWORDS: Damage assessment of bridge, Bridge Maintains, DER method.

ABSTRACT

Recently a bridge on Savitri River Mumbai-Goa Highway near Mahad, about 170 km from Mumbai collapsed due to heavy rain and flood which was built in British era. The age of bridge is approx 100 years. Similar examples have been seen around which result in heavy loss of lives and public property. As a structural Engineer it is a need of the hour to maintain existing structure with rehabilitation and strengthening as per the requirement for safety. This paper reviews the literature of various approaches for condition / damage assessment of structures. Damage assessment initiates to adopt the most efficient approaches to ensure the most effective method. In this paper an attempt for selection of methods for condition assessment of bridge structures.

INTRODUCTION

Highway networks of most of the developed and developing countries are either completing or being completed, however high maintenance and repair costs of these deteriorating networks become a major concern. When highway networks are completed, fewer new bridges would construct and maintaining existing bridges becomes more important. The structural health and performance of a structure depends on its quality of original construction and quality of maintenance. As a structure goes older and older it shows wear and tear due to ageing, overuse, exposure to the weathering / environment and structurally unplanned modifications and additions, which affect the health of the structure significantly. It's basically for ensuring that the structure and its premises are safe and under no risks. It is a preventive proactive step. As saying goes "stitch in time saves nine". The need of structural audit is for maintenance and repairs of existing structures whose life has exceeded the age of 30 years to avoid any mishaps and save valuable human life. The concrete is widely used as construction material being inexpensive, easy for construction, applications and because of it high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability. If, further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. There is demand of appropriate actions and measures for all such building structures to improve its performance and restore the desired functions of structures which may lead to increase its functional life. Study puts efforts in effectiveness in selection of method from which we can find the most effectively condition of index of the bridges. While designing new structure necessary modification shall be made in design and provision to make the structure sound, durable and promising.

LITERATURE REVIEW

Ko, and Ni [1] presented the significance of implementing long-term structural health monitoring systems for large-scale bridges, in order to secure structural and operational safety and issue early warnings on damage or deterioration prior to costly repair or even catastrophic collapse, has been recognized by bridge administrative authorities. Developing a long-term monitoring system for a large-scale bridge-one that is really able to provide information for evaluating structural integrity, durability and reliability throughout the bridge life cycle and ensuring optimal maintenance planning and safe bridge operation—poses technological challenges at different levels, from the selection of proper sensors to the design of a structural health evaluation system. This paper explores recent technology developments in the field of structural health monitoring and their application to large-scale bridge projects. The need for technological fusion from different disciplines, and for a structural health evaluation paradigm that is really able to help prioritize bridge rehabilitation, maintenance and emergency repair, is highlighted.

Li et.al [2] develoed a methodology and strategy for fatigue damage assessment and life prediction of bridge-deck sections of existing bridges with online structural health monitoring data. A fatigue damage model based on the continuum damage mechanics (CDM) is developed for evaluating accumulative fatigue damage of existing bridges. A structural model for the fatigue stress analysis of bridge-deck structures is proposed, in which structures are modeled by elastic members and welded connections with possible accumulative damage. Based on the proposed model, an analytical approach for evaluating the fatigue damage and service life of bridge-deck sections based on strain history data from an online structural health monitoring system and the CDM fatigue model are suggested. The updating of the representative block of cycles of the local stress by online monitoring data in the future is included in the computational approach. In order to compare results of fatigue damage and service life prediction evaluated by the CDM fatigue damage model, a modified Palmgren–Miner rule is developed for the same fatigue problem.

Webb et.al. **[3]** Presented detailed analysis of measurements from a number of different sensors, including acoustic emission monitors, strain, temperature and displacement gauges for bridge. Two structural monitoring systems are described, a wired system installed by a commercial contractor on behalf of the client and a research wireless deployment installed by the University of Cambridge. Careful interpretation of the displacement and temperature gauge data enabled bearings that were not functioning as designed to be identified. The acoustic emission monitoring indicated locations at which rapid deterioration was likely to be occurring; however, it was not possible to verify these results using any of the other sensors installed and hence the only method for confirming these results was by visual inspection. Recommendations for future bridge monitoring projects are made in light of the lessons learned from this monitoring case study.

Mitani and Matsumoto [4] discussed about the new techniques for safer inspection methods calls for new innovations in bridge inspection technologies. They discussed about advancements in technology and computer science. New technologies are becoming more and more cost effective, and some of the technologies are ready to be applied for onsite bridge assessment practices. NEXCO-West one of major toll road operators in Japan has been working to develop efficient nondestructive highway bridge inspection methods using high definition video (HDV) digital image and Infrared (IR) thermography technologies.

Rashidi and Gibson [5] discussed about developing condition rating method. Many bridge rating systems are based on a very subjective procedure and are associated with uncertainty and personal bias. Structural importance and material vulnerability are the two main factors that should be considered in the evaluation of element structural index and the causal factor as the representative of age, environment, road class and inspection is implemented as a coefficient to the OSCI (overall structural condition index). The AHP (analytical hierarchy process) has been applied to evaluate the priority vector of the causal parameters.

Masoumi, Akgül and Mehrabzadeh[6] carried visual inspections of 200 reinforced concrete bridges in Turkey and non-destructive testing applications performed on 10 bridges, which were most deficient. Penetration resistance, ultrasonic pulse velocity, rebar locating and reinforcement corrosion tests are performed on decks, piers and beams of reinforced concrete bridges and the results are compared with the results of visual inspections reports on bridges.

Rajragavan and Karunananda [7] these author performed a case study on 4 bridges in the National Highway of Sri Lanka. Reliability based condition assessment was performed on the bridges under Ultimate Limit State (ULS) and Serviceability Limit State (SLS) condition and then Analytical Hierarchy Process (AHP) based resource prioritization model was developed to find the priority order of bridge. From the results of the case study they concluded that the proposed methodology can be used for efficient resource prioritization in bridge maintenance and also be concluded that the proposed methodology offers a more rational and systematic method for resource prioritization than the current practice in Sri Lanka.

Liang et.al [8] presented the comparison of matrix method, which is generated from both the analytic hierarchy process and the principle of moment equilibrium, to assess the repair order of existing reinforced concrete (RC) bridges. Ten existing RC bridges in Keelung, Taiwan, were given as an illustrative example. In order to verify the

feasibility and reliability of the proposed method, the D (Degree) E (Extend) R (Relevancy) evaluation method, which is now widely used to evaluate the damage grade for existing RC bridges in Taiwan, was also applied to assessing the same ten existing RC bridges.

DER Evaluation Method [8]

The DER evaluation method involves separating bridge deterioration into D (degree), E (extend), R (relevancy) and U (urgency) for assessment. The major work of the DER evaluation method is visual inspection.

Wankhadea and Landage [9] developed systematic investigation for metrology and a condition ranking procedure based on Analytical hierarchy process (AHP) for Elevated service Reservoir. In this work DER rating technique is used to find out the condition ranking of elevated service reservoir in Karad region in Maharashtra. The ranking assessment for elevated service reservoir structure has been carried our using different Non-destructive test methods like surface hardness, ultrasonic pulse velocity test, half cell potential methods and cover depth measure.

Ayop et.al [10] presented the development of a condition assessment system for assessing the status of concrete marine structures in Malaysia. The assessment system is based on the Condition Index (CI) method developed by the U.S Army Corps of Engineers. The assessment took into account the level of deterioration observed during inspection work. The Functional Condition Index (FCI) approach was used to calculate the CI of the structure. Field data through visual inspection on concrete wharf structure was collected. Three types of deterioration were considered in the assessment: (1) corrosion of reinforcement, (2) cracking, and (3) spalling of concrete surface. The results show that the calculated CI values based on the proposed method is relatively close to the expert opinion values. The condition assessment system based on the CI method is found to be reliable and efficient hence can be used to monitor the performance of marine structures in Malaysia.

Verma et.al [11] presented study of various NDT methods based on different principles, with their individual merits and limitations have been discussed. It has been recognized that NDT plays an important role in condition assessment of existing structures, and there has been an urgent need for developing standards for performing NDT methods and for interpretation of NDT results. Major advantage of NDT methods has been recognised as their capability to test in situ. Great deal of expertise is required for interpretation of NDT field observations and test results. NDT provides useful information by revealing hidden or unknown defects, and repair or replacement of RC structures can be planned according to NDT results. Combination of different NDT methods available is a better way to assess the structures.

Lim and Cao[12] discussed about the traditional method of evaluating the quality of concrete in civil structures is to test specimens casted simultaneously for compressive, flexural, and tensile strengths; these methods have several disadvantages such as results are not predicted immediately, concrete in specimens may differ from actual structure, and strength properties of a concrete specimens depend on its size and shape; therefore to overcome above limitations several NDT methods have been developed. NDT methods depend on the fact that certain physical and chemical properties of concrete can be related to strength and durability of structures. These methods have been used for more than three decades for evaluating the condition of a structure; now in the present century NDT has become more sophisticated, as it has developed from a hammer to Impact Echo and Impulse response.

Shaw and Xu,[13].presented study of NDT has been defined as comprising methods used to examine objects, materials, or systems without impairing their future usefulness, that is, inspect or measure without harm. NDT methods are now considered as powerful tools for evaluating existing concrete structures with regard to their strength and durability. NDT methods have been drawing more and more attention, in the sense of reliability and effectiveness. The importance of being able to test in situ has been recognized, and this trend is increasing as compared to traditional random sampling of concrete for material analysis

Breysse et al. [14] five major factors that need to be considered in NDT survey are required depth of penetration, required vertical and lateral resolution, contrast in physical properties between target and its surrounding, signal to noise ratio for the physical properties between the target and its surroundings, and historical information concerning the methods used in the construction of the structure.

Sharkia et al. [15] conducted survey to assess the structural conditions of bridges and culverts on National Highway N7 in Bangladesh. On that basis they prepared an up-to-date inventory. The survey results signify that some of the bridges and culverts are inadequate to carry the increased traffic load. Some of them are at slightly deteriorate condition and need immediate retrofitting or structural capacity enhancement to keep them in operation. They conclude that the need of regular health monitoring and necessary maintenance program to reduce the structural deterioration over the service life of the structure.

CONCLUSIONS

The main aim of the present study is to know the how to find out the condition index of structures. This paper presents the literature review on condition / damage assessment of structures. On the basis of this study it is concluded that the use of sensors or advance techniques like HDV, Infrared techniques are useful for long span bridges. Otherwise DER system is also useful for condition / damage assessment of bridges on the basis of NDT also there is need of regular health monitoring and necessary maintenance program to reduce the structural deterioration over the service life of the structure.

ACKNOWLEDGEMENT

I would like to thanks to the faculty of Department of Structural engineering, Government College of Engineering, Karad to their valuable suggestions in this research work.

REFERENCES

1. J.M. Ko, Y.Q. Ni, "Technology developments in structural health monitoring of large-scale bridges" Engineering Structures 27 (2005) 1715–1725
2. Z.X. Li, T.H.T. Chan, J.M. Ko, "Fatigue analysis and life prediction of bridges with structural health monitoring data – Part I: methodology and strategy" International Journal of Fatigue, 23 (2001) 45–53
3. G. T. Webb, P. J. Vardanega, P. R. A. Fidler, C. R. Middleton "Analysis of Structural Health Monitoring Data from Hammersmith Flyover Case Study" 10.1061/(ASCE)BE. 1943-5592.0000587.
4. Koji Mitani, Masato Matsumoto "Innovative Bridge Assessment Methods Using Image Processing And Infrared Thermography Technology" 37th Conference on Our World in Concrete & Structures 29-31 August 2012, Singapore
5. Rashidi, M. & Gibson, P., "A methodology for bridge condition evaluation", Journal of Civil Engineering and Architecture, 6 (9), 1149-1157. (2012).
6. F. Masoumi, F. Akgül, and A. Mehrabzadeh "Condition Assessment of Reinforced Concrete Bridges by Combined Nondestructive Test Techniques" IACSIT International Journal of Engineering and Technology, Vol. 5, No. 6, December 2013
7. Rajmohan Rajragavan , Dr.Kamal Karunananda, "Bridge Maintenance Strategy For Sri Lanka Through Analytical Hierarchy Process And Structural Reliability Theory", Internantiom confernce on sustainabble enrgegy & built enviorenment, 2017
8. Ming-Te Liang, Chin-Ming Lin, and Chi-Jang Yeh, "Comparison Matrix Method And Its Applications To Damage Evaluation For Existing Reinforced Concrete Bridges", Journal of Marine Science and Technology, Vol. 11, No. 2, pp. 70-82 (2003)
9. Rajan L. Wankhade , Amarsinh B. Landage "Non-destructive Testing of Concrete Structures in Karad Region", R. Nicole, Procedia Engineering 51 (2013) 8 – 18
10. Sanjeev Kumar Verma, Sudhir Singh Bhadauria and Saleem Akhtar "Review of Nondestructive Testing Methods for Condition Monitoring of Concrete Structures" Journal of Construction Engineering Volume 2013 (2013), Article ID 834572, 11 page
11. Sallehuddin Shah Ayop, Rosli Mohamad Zin, Mohammad Ismail"Condition Assessment of Marine Structures Using Functional Condition Index Approach" Malaysian Journal of Civil Engineering 18(2) 129-138 (2006)
12. M. K. Lim and H. Cao, "Combining multiple NDT methods to improve testing effectiveness," Construction and Building Materials, vol. 38, pp. 1310–1315, 2013.
13. P. Shaw and A. Xu, "Assessment of the deterioration of concrete in NPP- causes, effects and investigation methods," NDT.Net, vol. 3, no. 2, 1998.

14. D. Breysse, G. Klysz, X. Derobert, C. Sirieix, and J. F. Lataste, ´ "How to combine several non-destructive techniques for a better assessment of concrete structures," Cement and Concrete Research, vol. 38, no. 6, pp. 783–793, 2008
15. S. Sharkia & M.N. Haque and M.S.K. Bhuiya "Structural condition assessment of bridges and culverts in national highway N7", IABSE-JSCE Joint Conference on Advances in Bridge Engineering-III, August 21-22, 2015, Dhaka, Bangladesh.