WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on Vibration Analysis of Crack Developed on Bridges Using Ansys

Meghdivya Tandon [a]*, Umang Mishra [b]

[a,b] Department of Civil Engineering, Shri Shankaracharya Technical Campus, Bhilai (C.G.), India..

ABSTRACT

The aim of the present study is to sum up all the topics related to conventional and integral bridge vibration and focus the effects of scour on conventional and integral bridge and finally to suggest future directions of research and innovation. Cracks or crevasses in girder steel bridges caused by moist environmental issues such as corrosion have the possibility of causing structural destruction, resulting in the loss of unanticipated events, assets, and human life. This obliteration can be overlooked if cracks are resolved early. The cracks in the bridge girder alter its strength and vibration characteristics. The current study examines various studies in the field of crack detection/damage detection that have been conducted using various numerical techniques. Analysis of finite elements (FEA) can be highly useful in protecting a structure from damage and cracks. The review deals with the investigation of damage commencing from environmental exposure conditions which can be studied via various numerical investigations by means of simulation techniques.

Keywords: Bridge, Vibration, ANSYS, Simulation.

1. Introduction

The FEM technique is a beneficial tool for calculating mathematical equations in a variety of engineering problems. The method was suggested in the aerospace industry as a tool designed for assessing anxiety in challenging jet systems. It is developed from the matrix analysis procedure, which is utilized in aircraft design. Each researcher and practitioner has made significant progress in their respective fields. The finite element methodology's main principle is to break down a body otherwise structure into smaller, finite-size components known as limited elements.' The variables associated with a limited set of connections known as nodes or nodal points are investigated in the initial frame and structure.

India has the 2nd largest network of roads with 4.7 million km. It has up to 0.65 km of road for a sq. Km of land which is more than USA(0.65) and China(0.16). This network of road transport approximately is more than 60% of all goods in the country and 85% of total passenger traffic. [4]. Road activity has massively progressed over the last past years with improvement in connectivity between various major cities, towns and villages. Government of India under the "Ghatishakti yojan" has reserved 20% of the total budget investment for infrastructure to develop roads. Vehicle loads are applied to a bridges. These structures are becoming slender and, as a result, prone to large amplitude vibration as a result of demand and new construction technology. An appropriate vehicle vibration model is made to learn these cases. The vehicle motion of a bridge is self-sustaining and random in nature. The maintaining of a safe and reliable civil infrastructure is important to a national economy and the well-being of all residents. Vibration is an oscillatory motion and the structure can be classify based on Analysis is Static and Dynamic, in bridge the Static load of vehicle impart full load of vehicle on Bridge but no induced of Force to vibrate the system until the application. in the Dynamic analysis the vehicle is on bridge it imparts a partial load on bridge and it also induce some vibration on bridge. By D'Alembertz principle moving mass generates inertia force it indicates the moving object force dependents on Vehicle load, moving acceleration, damping of the system to cause inertia and system stiffness. the object produces dynamic force on surface of the road and in the bridge deck. Bridge should resist these loads and also vehicle also generate lateral force on surface. These dynamic excitations while cause the bridge to vibrate, Vibration will lead to the behavior of the system. if the bridge is in weak nature will give more frequency. These frequency and displacement can be solved by several ways there are 1) Classical Methods of solution 2) Duhamal Integration Solution 3) Transform Methods 4) Numerical method.

Critical damping is required to remove vibration energy in the system Cr = 2m*Wn and Damping ratio is the relative value of the Critical damping of that system. Damping can be evaluated by the experiments, it is part of nonlinear of the material, The role is to removal of Kinetic energy and Forced energy from the vibrating structure and by virtue of which the amplitude of Vibration decrement steadily. The dampers will convert potential energy and kinetic energy into heat, friction and wave properly into structure.

The natural frequency of the system is depending on physical property, Elasticity modulus, and length of the span majorly. The frequency ratio is defined as ratio of forcing frequency to natural frequency. At frequency ratio is one then forcing and natural frequency are equity, then the Transmissibility of amplitude, acceleration and velocity is inseminated. It can be control by dampers in one way and other way is it's maintenance, operation and evaluation

of bridge strength by implementing the regulation of the outcome. On operation of bridge the physical properties get deteriorate with time. For the old operation bridge can be evaluate on regular time after half years of the life span.

2. LITERATURE REVIEW

Zhang et al. (2019e) [12] has worked on development of existing accelerometer using insulator (silicon) technology. The seismic structural seismic response test is conducted by the researcher using capacitive accelerometer. Besides these techniques, the latest methods like ultrasonic method and radiation method are also used for detection of internal defects for concrete structures.

Carreras et al. (2019) [13] has used X-ray photography to detect cracks induced in metals by using x-ray photography. The load displacement curves along with acoustic emission techniques can also be used.

Sun and Zhen (2019) [14] has worked on detection of damages in steel bridge coated structure. These damages are not visible by naked eyes. The damage detection technology involves use of thermal imaging technology and other electronic sensing devices.

Su et al. (2019b) [15] has worked on establishing relationship between damage deection and its effect on magnetic signal along with its gradient value. The research findings have shown that magnetic signal changes with change in the location and magnitude of stress concentration. Besides using magnetic signal technology, the scanning electron microscope (SEM) can also be used.

Ghassemi and Toufigh (2020) [16] has conducted studies on damage detection of epoxy polymer concrete structures using Scanning Electron Microscope (SEM). The findings have shown that any change in microstructure of concrete (after exposing to moisture for 1 year) is easily observable using SEM.

Zhou et al. (2019b) [17] has worked on the usage of metal magnetic memory technology in corrosion detection of galvanized steel strand cable. The technology has benefits than conventional technology which fails to detect internal corrosion in galvanized steel strand cable.

Macho et al. (2019) [18] has conducted investigation on crack propagation in RC bridge decks. The research findings have shown that damage (cracks) developed in bridge decks increased (crack propagation) due to corrosion which also affected the fatigue life of bridge decks.

Gao et al. (2019) [19] has conducted investigation of damages in steel bridge caused due to manufacturing defects and residual stresses caused by welding. These residual stresses are developed during the manufacturing process of bridge structures. The bridge structures get degraded due to coupled effect of vehicle load as well as ocea loads. The researches has emphasized the need to study the effect of sea water corrosion on structural fatigue damage.

Cui et al. (2019a) [20] has also investigated the effect of sea water corrosion on deterioration of steel bridge structures. The microscopic and mesoscopic mechanism of crack initiation as well as crack propagation is elucidated.

Yang and Nagarajaiah (2014) [21] has worked on damage identification of steel structurus by analyzing vibration characteristics using wavelet transform data.In the process, the “structural vibration responses were transformed into a wavelet domain and then fed as mixtures into a blind source separation model, which was examined through independent component analysis. Consequently, the damage information hidden in wavelet-domain signals was clearly revealed by a sharp spike” [21]. Apart from this technique, the HHT technique can also be used which is based on analysis of time-frequency data and processes nonstationary and non linear signals.

Dong et al. (2013) [23] used a “vector auto-regressive (AR) moving average (ARMA) model, unlike conventional HHT, to represent intrinsic mode functions (IMFs) obtained from the empirical mode decomposition (EMD) of vibration signals”[23]. On the basis of ARMA coefficients, the damage index was defined which indidicated the severity of damage.

Bao et al. (2013) [24] has used HHT method for identification of structural damage and presented the results on the basis of levels ranging from 1-3. The level 1 represented low level damage whereas level 3 represented high level damage.

Han et al. (2013) [25] has worked on identification of damage in civil structures using modal analysis method and HHT method. Besides these techniques, the other methods employed in the analysis are are “random decrement (RD), natural excitation and stochastic subspace identification” [25].

Aied et al. (2016) [26] has worked on damage detection of bridge structures by analyzing sudden change in stiffness using EMD technique. The technique had been successful even during high vehicle speeds and presence of rough profiles and noisy signals.

Li et al. [27] (2010) has used acceleration data obtained from FD technique to determine the presence of cracks induced in building structures. The time frequency data was calculated using box counting method and WT is applied subsequently.

Hester and González (2012) [28] has used wavelet transform to determine wavelet energy content. The variation of wavelet energy indicator could enable to identify the location of damage and intensity of damage.

Roveri and Carcaterra (2012) [29] has used HHT technique to identify location of damage in bridge structure using single point response obtained from the device. The 1st peak in HHT monitor represented damage in the bridge structure.

Kunwar et al. (2013) [30] has worked on identification of crack location developed on bridge subjected to transient vibration loads. The Hilbert spectrum is used which displays peak in amplitude at the location of crack.

Hakim and Razak (2013) [31] has worked on damage detection in steel girder bridge using artificial neural network with natural frequencies. The author had compared the results obtained from ANN (artificial neural network) can compared it with the results obtained from adaptive "neuro fuzzy" system. The damage identification method is more robust as compared to exisiting one.

Neves et al. (2017) [32] has developed ANN based technique for damage detection of bridge structures. The ANN methodology involves collection of acceleration data from healthy bridge. The Gaussian process is used to statistically characterize predicted errors. The structural condition of bridge structure is then determined as healthy or damaged on the basis of damage indices.

Kim et al. (2003) [33] has conducted studies to determine the effect of vehicle traffic on vibrations induced in bridge structures. The analysis is conducted using vibration accelerometer instrument and it was observed from the results that movement of vehicles on the bridges causes change in dynamic characterisitics of bridge structures. These dynamic characteristics are also influenced by the damages induced in the bridge by environmental factors and external loads [34].

Dimarogonas [35] has presented a review on dynamic behaviour of bridge deck structures subjected to external excitation due to moving vehicles. Various researches are done on beams with several cracks and in the simulation, these cracks are represented by massless springs which are rotationless [36,37]. These cracks cause release of energy with higher beam deformation and ither methods like transfer matrix method is also proposed [38-40].

Saavedra and Cuitino (2001) [41] has worked on development of analytical method which employs modeling of multibeam systems. These multibeam systems comprised of tranverse cracks. The "strain energy density" function was defined which is based on flexibility matrix of cracked element. The results obtained using analytical method did not matched with the experiemental results. However, the "transfer matrix" method is regarded as efficient method of investigating free vibration characteristics of cracked beams.

Lin et al. (2002) [42] has used transfer matrix method to study the effect of cracks on vibration induced in the beams. This method was based eigenvalues but the investigation did not take in to account of vehicle movement on the bridges.

3. CONCLUSION

Vibration analysis by experiment on a bridge is a complex method due to various factors defining the dynamic response. It can be determined that the results of the experiment data are related to the bridge system. several to conduct experiments like SHM, NDT numerical analysis, and a comparative study between a standard bridge and a test bridge. According to the preceding review, several researchers have provided numerous methods for modeling harm with varying degrees of accuracy. The formation of a crack in a steel structure might result in changes in vibration response such as natural frequency, mode shape, and so on, which can be examined using multiple techniques of simulation and modeling in a simple, easier, and effortless manner. As a result, it is a well-known fact that various fracture diagnosis procedures aim to ascertain the physical integrity of the structure exposed to vibration. The cracks in the bridge girder alter its strength and vibration characteristics. The current study examines various studies in the field of crack detection/damage detection that have been conducted using various numerical techniques. Analysis of finite elements (FEA) can be highly useful in protecting a structure from damage and cracks. The review deals with the investigation of damage commencing from environmental exposure conditions which can be studied via various numerical investigations by means of simulation techniques. To evaluate the present condition of the bridge.

References

[1] American Society of Civil Engineers (A.S.C.E.). Infrastructure Report Card; 2017

[2] Picture of Vidalta Cable Stayed Bridge, Mexico City. Available from: https://www.plataformaarquitectura.cl/ cl/02-304269/puente-vidalta-mexpresa

[3] Barker RM, Puckett JA. Design of Highway Brides. 3rd ed. Wiley; 2013

[4] Picture of Mexico City Road System. Available from: https://periodicocorreo. com.mx/abren-manana-el-distribuid or-vial-en-la-glorieta-santa-fe/ [5] Picture of Forth Bridge, located on Edinburgh, Scotland. Available from: https://www.railway-technology.com/ projects/forth-rail-bridge-firthscotland/

[6] Picture of Golden Gate Bridge, San Francisco. Available from: https://www. diariodelviajero.com/america/Puente golden-gate-datos-y-curiosidades

[7] Picture of El Zacatal Bridge, Mexico. Available from: http://www.sintemar. com/es/rehabilitacion-de-pilotes-enpuente-el-zacatal

[8] Picture of concrete piers with reinforced steel corrosion problems. Available from: https://www.researchga te.net/figure/Concrete-structure-deteriorated-by-the-corrosion-of-steel reinforcement fig 1_265553963

[9] Picture of a bridge of structural steel with corrosion problems. Available from: https://www.researchgate.net/ figure/Corrosion-of-steel-a-Extremecorrosion-in-a-bridge-b-Railway rolling-stock-being fig 6_323826793

[10] Picture of a bridge concrete construction joint damage. Available from: https://www.researchgate.net/ figure/Damage-at-a-joint-onthe-bridge-deck fig 3_281864780

[11] Picture of a girder with fatigue fracture. Available from: https://www. researchgate.net/figure/Fatiguefracture-failure-of-composite-beam2-images-by-S-S-Badie-and-M-KTadros_fig 1_262973062

[12] Zhang H, Wei X, Ding Y, Jiang Z, Ren J (2019e) A low noise capacitive MEMS accelerometer with anti-spring structure. Sensors Actuat A Phys 296:79–86 Elsevier Science SA, Lausanne

[13] Carreras L, Renart J, Turon A, Costa J, Bak BL, Lindgaard E, Martin de la Escalera F, Essa Y (2019) A benchmark test for validating 3D simulation methods for delamination growth under quasi-static and fatigue loading. Compos Struct 210: 932–941 Elsevier Sci Ltd, Oxford

[14] Sun J, Zhen Z (2019) Application of infrared thermal imaging technology to steel structure coating inspection for bridges. World Bridge 47(05):69–73

[15] Su S, Ge J, Wang W, Guo H, Li C, Hu J (2019b) Experimental research on the corresponding relationship between stress concentration and magnetic memory effect of steel I-column of gabled framed. J Xian Univ Architect Technol Nat Sci Ed 51(06):771–774+796

[16] Ghassemi P, Toufigh V (2020) Durability of epoxy polymer and ordinary cement concrete in aggressive environments. Constr Build Mater 234:UNSP 117887 Elsevier Sci Ltd, Oxford

[17] Zhou J, Zhao Y, He Q, Zhang P, Zhang H (2019b) Corrosion test of galvanized steel strand based on magnetic memory. J Chang'an Univ Nat Sci Ed 39(01):81–89

[18] Macho M, Ryjacek P, Matos J (2019) Fatigue life analysis of steel riveted rail bridges affected by corrosion. Struct Eng Int 29(4): 551–562 Taylor & Francis Ltd, Abingdon

[19] Gao Z, Ruan H, Qin S, Ma R, Mei D (2019) Technical status, challenges, and solutions of marine bridge engineering. Eng Sci 21(3):1–4 (In Chinese)

[20] Cui C, Zhang Q, Bao Y, Bu Y, Luo Y (2019a) Fatigue life evaluation of welded joints in steel bridge considering residual stress. J Constr Steel Res 153:509–518 Elsevier Sci Ltd, Oxford

[21] Y.C. Yang, S. Nagarajaiah, Blind identification of damage in time-varying systems using independent component analysis with wavelet transform, Mech. Syst. Signal Process. 47 (1) (2014) 3–20.

[22] N.E. Huang, The Hilbert-Huang Transform in Engineering, New York, NY, USA: Taylor and Francis Group, 2005.

[23] Y.F. Dong, Y.M. Li, L. Ming, Structural damage detection using empirical-mode decomposition and vector autoregressive moving average model, Soil Dyn. Earthq. Eng. 30 (3) (2010) 133–145.

[24]C.X. Bao, H. Hao, Z.X. Li, Multi-stage identification scheme for detecting damage in structures under ambient excitations, Smart Mate. Struct. 22 (4) (2013) 045006.

[25] J.P. Han, P.J. Zheng, H.T. Wang, Structural modal parameter identification and damage diagnosis based on Hilbert-Huang transform, Earthq. Eng. Eng. Vib. 13 (2013) 101–111.

[26] H. Aied, A. Gonzáleza, D. Cantero, Identification of sudden stiffness changes in the acceleration response of a bridge to moving loads using ensemble empirical mode decomposition, Mech. Syst. Signal Process. 66 (2016) 314–338.

[27] H. Li, D.W. Tao, Y. Huang, Y. Huang, A data-driven approach for seismic damage detection of shear-type building structures using the fractal dimension of time– frequency features, Struct. Control Health Monit. 20 (9) (2013) 1191–1210.

[28] D. Hester, A. González, A wavelet-based damage detection algorithm based on bridge acceleration response to a vehicle, Mech. Syst. Signal Process. 28 (2012) 145–166.

[29] N. Roveri, A. Carcaterra, Damage detection in structures under traveling loads by Hilbert–Huang transform, Mech. Syst. Signal Process. 28 (2012) 128–144.

[30] A. Kunwar, R. Jha, M. Whelan, K. Janoyan, Damage detection in an experimental bridge model using Hilbert–Huang transform of transient vibrations, Struct. Control Health Monit. 20 (1) (2013) 1–15.

[31] S.J.S. Hakim, H.A. Razak, Structural damage detection of steel bridge girder using artificial neural networks and finite element models, Steel Compos. Struct. 14 (4) (2013a) 367–377

[32] A.C. Neves, I. González, J. Leander, R. Karoumi, Structural health monitoring of bridges: a model-free ANN-based approach to damage detection, J. Civil Struct. Health Monit. 7 (2017) 689–702.

[33] Kim C. Y., Jung D. S., Kim N. S., Kwon S. D., Feng M. Q. Effect of vehicle weight on natural frequencies of bridges measured from traffic-induced vibration. Earthquake Engineering and Engineering Vibration, Vol. 2, Issue 1, 2003, p. 109-115.

[34]Fu C. Dynamic behavior of a simply supported bridge with a switching crack subjected to seismic excitations and moving trains. Engineering Structures, Vol. 110, 2016, p. 59-69.

[35] Dimarogonas A. D. Vibration of cracked structures: a state of the art review. Engineering Fracture Mechanics, Vol. 55, 1996, p. 831-57.

[36] [4] Haisty B. S., Springer W. T. A general beam element for use in damage assessment of complex structures. Journal of Vibration and Acoustics, Vol. 110, Issue 3, 1988, p. 389-394.

[37] Narkis Y. Identification of crack location in vibrating simply supported beams. Journal of Sound and Vibration, Vol. 172, Issue 4, 1994, p. 549-558.

[38] Christides S., Barr A. D. S. One dimensional theory of cracked Bernoulli-Euler beams. International Journal of Mechanical Sciences, Vol. 26, Issues 11-12, 1984, p. 639-648.

[39] Chondros T. G., Dimarogonas A. D., Yao J. A continuous cracked beam vibration theory. Journal of Sound and Vibration, Vol. 215, Issue 1, 1998, p. 17-34.

[40] Yang F., Swamidas A. S. J., Seshadri R. Crack identification in vibrating beams using the energy method. Journal of Sound and Vibration, Vol. 244, Issue 2, 2001, p. 339-357.

[41] Saavedra P. N., Cuitino L. A. Crack detection and vibration behavior of cracked beams. Computers and Structures, Vol. 79, Issue 16, 2001, p. 1451-1459.

[42] Lin H. P., Chang S. C., Wu J. D. Beam vibrations with an arbitrary number of cracks. Journal of Sound and Vibration, Vol. 258, Issue 5, 2002, p. 987-999.

[43] ANSYS Workbench Library

[44] Radek Wodzinowski, “Free vibration analysis of horizontally curved composite concrete-steel I girder bridges” Journal of Constructional Steel Research 140 (2018) 47–61

[45] M. Avalle, G. Chiandussi, and G. Belingardi, “Design optimization by response surface methodology: application to crashworthiness design of vehicle structures,” Struct. Multidiscip. Optim., vol. 24, no. 4, pp. 325–332, 2002, doi: 10.1007/s00158-002-0243-x.

[46] A. Y. A. E.-V. Silva, “Utilization of Response Surface Methodology in Optimization of Extraction of Plant Materials,” Rijeka: IntechOpen, 2018, p. Ch. 10.