Detection Of Crack In A Beam By Vibrational Analysis And Artificial Neural Network: A Review

Indrajeet agrhari[1] ,Akshay Kulkarni[2] ,Aditi Pandit[3] ,Sandip Khade[4] Prof. Prasanna Raut[5]

[1]Student, Saraswati College of Engineering, India, *inderenggi@gmail.com*
[2]Student, Saraswati College of Engineering, India, akshaycool234@gmail.com
[3]Student, Saraswati College of Engineering, India, aditi212181@gmail.com
[4]Student, Saraswati College of Engineering, India, sandipkhade.67@gmail.com
[5]Assistant Professor, Saraswati College of engineering, India, rautprasanna7@gmail.com

Abstract:

This paper focuses on the used for crack detection in structure which have a scope to be used in future crack in structural member lead to local changes the stiffness ,flexibility and consequently. there static and dynamic behaviour is affected. The influence of cracks on dynamic characteristics like natural frequency modes of vibration of structure has been the subject of many investigation present work deals with Vibrational Analysis and ANN for detection of crack beam using ansys & matlab the effect of various parameter like crack location, depth of crack, on changes in natural frequency of the beam is studied. It is found that presence of crack in beam decreases natural frequency which is more pronounced as the detection of crack is very difficult through naked-eye so present prediction method which we are used

Keywords: ANN; Crack detection in beam vibrational analysis; oscillator .

1..Introduction

Damage detection and location, and condition assessment of structures have always been important subjects. Damage in a structure generally causes a local increase in flexibility, which depends on the extent of the damage

This reduces the natural frequencies of vibration and affect the natural mode shapes-effects which have been used, with somewhat mixed success, to evaluate the deterioration Crack present a serious threat to

The performance assessment of structures most of of the structural failure are due to material fatigue. For this reason, methods allowing early detection and localization of cracks have been the subject of intensive investigation the last two decades. Artificial Neural Networks (ANN) has emerged as a promising tool for monitoring and classification of fault in machine and equipment. This technique is well prepared for solving inverse variation problems in the context of monitoring and fault detection because of their pattern recognition and interpolation capabilities. ANN also successfully approach and classify the problems associated with non-linearity's, provided they are well represented by input patterns, also can avoid complexity introduced by conventional computational methods. Furthermore, the learning capabilities of neural networks are well suited to process a large no. of distribute sensors, which is ideal for smart structures.

2 Literature Survey :

The survey considered in this work are categorized in the following subsections separately as crack detection by Artificial neural network (ANN) and detection of crack by vibrational analysis.

2.1Literature Survey on Detection of crack by Artificial Neural Network (ANN):

The following literature review is based on detection of crack in beam by artificial neural network:

OguzhanHasanzebi [1] presented on experimental study on linear and non-linear model updating of reinforced concrete T-beam bridges using artificial neural network. They used FEA models of Sample Bridge for its linear and nonlinear response analysis and later experimental studies and FEA models were compared with updating studies of artificial neural network. The present study implements an in -depth research on the use and application of artificial neural network for a parameter estimation of real and large T-beam Z. Tan et al. [2] studied on damage detection in steel beam using modal energy based damage and artificial neural network. In this study ANN that utilizes modal strain energy based damage index (β) as input layer are used in process. Thus, as a result we can predict the locations and severities of single and multiple damages in a steel beam structure. S. J. S Hakim et al. [3] has done result diagnosis on beam like structure from nodal parameter using artificial neural network. In this study, first five natural frequencies for undamped beam based on FEA are done and finally the damage identification for I-beam structure with 2 different damage points using Artificial Neural Network is developed. A combination of natural frequencies and mode shapes were used as suitable datasets for artificial neural network training. A. Seibi et al. [4] shows that ANN model is developed that predicts fracture toughness values and also it act as an analytical tool. Thus this study concludes that Artificial Neural network model was capable of determining the contribution of each parameter than influences value of the average fracture toughness Andrew deck et al. [5] had detected damage using artificial neural network with consideration of uncertainties. It shows that probability of damage existence is calculated based on probability density function of existence of undamaged and damaged state. Thus they conclude that numerical and experimental result demonstrate that statistical artificial neural network could be more reliable than normal ANN approach NatilDawood et al. [6] had detected crack width in concrete using artificial neural network where method for the use of neural network for proper estimation of crack width in thick concrete element at serviceability stress limit state. Thus it shows from radial basic neural network and feed forward propagation network gives better results. Paulray N. P et al. [7] studied the structure steel plate damage detection using non-destructive testing, energy based statistical feature and artificial neural network. In this method a simply supported boundary condition based experiment arrangement to capture the vibration signal from stainless steel plate in normal and fault condition is developed. Thus a feed forward neural network model shows to classify the condition of steel structure using the features extracted from vibration signals so network model shows promising results Z. H Ding et al. [8] studied an approach for artificial bee colony (ABC) algorithm with hybrid search based on the modal data is presented. A novel swarn intelligence technique called A Bee colony algorithm presented in context of structural system identification. Thus this method is considered to be very efficient for damage identification M. Dilena et al.[9] studied use of anti-resonance for crack detection in beam by identification of single crack in a vibrating beam under axial of bending vibration. From the knowledge of damage induced shaft in suitable set of frequency and anti-resonance frequency. so we can say that only crack detection of symmetrical beam is possible, efforts should be made to detect unsymmetrical beam W. T. Yeung et al. [10] studied damage detection in bridge using neural network for pattern recognition of vibration signature where damage detection is highly attractive for monitoring bridges because it provides possibility of electronic recording combined with digital processing and report generation. FFT algorithm using MATLAB is used for detection of damaged and undamaged state. This is a method for striking a balance in between sensitivity and misclassification was proposed, and reliable damage identification rate of about 10% could be achieved even with moderate amount of noise added to dynamic response signals. Umeshpendharkar et al. [11] studied neural network for bending moment in continuous composite beams considering cracking and time effects in concrete. From studies we came to know that this neural network is used to estimate inelastic moment in continuous composite beams and by using this methodology we can predict inelastic moments with reasonable accuracy from elastic moments, within a small fraction of time. hung ban yun et al. [12] had studied structural identification using neural network and the Latin hypercube sampling and component mode synthesis method are used. So this approach doesn't require any complicated formulation for model reduction of system. Thus estimation accuracy

can be improved significantly chung ban yun et al.[13] had studied joint damage assessment of framed structure using a network technique and thus joint damage identification in steel structure is carried out based on modal data using neural network . Neural network technique uses data perturbation scheme where this scheme is used to improve estimation for cases with as small as measurements data sets. So the results obtained by this technique is found to be very reliable Mehmetavcar et al[14]studied artificial neural network application for estimation of natural frequencies of beams and so four different boundary conditions are determined using ann. Here first ten parameters of beam are found with BernoulliEuler beam theory and then natural frequency are computed theoretically. By using this technique solution to the existing problem is developed Marta Rosales et al[15] studied crack detection in beam like structure by inverse probe of crack parameters are solved by using two approaches (a) power series technique (b) use of artificial neural network. Both these methods are used simultaneously and by comparing two techniques results are concluded Dong-so hung et al [16] studied sequential detection approaches for beam using time modal features and artificial neural network. Thus sequential damage detection approaches using time modal feature and ANN for structures. These methods follow two phases time domain damage alarming and modal domain damage estimation. so from this the feasibility of proposed methodology was verified from numerical tests on simply supported beams. The proposed sequential approach was evaluated from well controlled test conditions. S liu et al [17] had studied detection of cracks using neural network and computational techniques where methods of direct and inverse problem were implemented. Solution to define this problem was defined by 2 methods a ultrasonic nondestructive testing by artificial neural network and by computational mechanics thus these methods used gives more precise performance for both classification and identification of cracks.

2.1.2 Literature Survey on detection of crack by Vibrational Analysis:

The detection of crack by vibrational analysis technique is considered in this literature review and is categorized in the following subsection separately.

D. Kennedy et al. [18] studied free vibrational analysis of beam and frames with multiple crack for damage detection. Cracks are modeled either by reduction in a stiffness extending over the damaged length or by rotational spring representing single cracks. While the rotational spring model is used and cracks are assumed to be always open thus the problem is described as the linear one. In this study we can see a new method discovered to measure a natural frequency of cracked beams and frames. The wittricks Williams method is used to calculate natural frequencies if cracks multiply in beam and frames. To evaluate higher order frequencies and to avoid missing any additional sign counts removed by partial Gaussian elimination must be accounted Bhagwate V. B et al. [19] had detected crack present in composite cantilever beam by vibrational analysis. This study shows vibrating machine is used, further transducer pick up the vibration end and gives signal to signal converter to convert the input vibration signal into frequency, after that analysis of collected data is carried out and displayed. Thus we conclude that detection of crack in cantilever beam by using vibrational analysis in order to optimize the performance of the structure faster. First is the crack near fixed end gives greater reduction in natural frequency and the crack away from fixed end gives higher frequency range. JeslinThalopil et al. [20] has done the detection of longitudinal cracks in ling and short beams with change in natural frequency. Beam with longitudinal cracks shows a coupling of axial and transverse vibration. In this method mathematical formulation is done. The accuracy of this method of natural frequency is given by both long and short beam with known longitudinal crack details. The natural frequency show good agreement with the ANSYS results. Both internal and edge crack have been studied. For long beam:-range of crack size considered is 5 % to 45 %.Maximum error in prediction of crack is 4 % and error prediction of crack size is 2%.short beams:-maximum error crack location is 3% and error prediction of crack size is 6%. The method has been used to predict the parameters of cracks offsets with respect toaxis in both long and short cantilever beams.

D. Broda et al. [21] studied generation of higher harmonics longitudinal vibration of beam with breathing cracks. This method includes experimental and numerical investigation in longitudinal vibration of beams with breathing cracks are presented. Here numerical modeling

is performed by two dimensional finite element approach. Thus as a result various crack models were analyses, including those based on the second order term on elastic module, bilinear stiffness and breathing crack. The numerical FE model of breathing crack was capable to capture most of nonlinear phenomena found in the experiments. Santosh. J. Chauhan et al. [22] detected damage in cantilever beam using vibration based methods where the natural frequencies are being carried out using exact method. A cantilever beam model representing continuous system based on Euler Bernoulli beam theory. The damage detection using change in natural frequency and change in mode shape studied using modal analysis by simulation and experimentation procedure. The damage detection in cantilever beam using vibration method is successfully implemented. K. Sambasivarao et al. [23] had analyzed the vibration of beam with varying crack location and thus natural frequency of simply supported beam with a triangular crack investigated numerically by FEA using FEA analysis software of Ansys. The natural frequency and mode shapes of beam are determined. In this study a slender elastic steel beam of length 0.5m, width 15mm and height 25mm is considered for numerical analysis. The natural frequency for beam without any crack are found and lowest frequency is found to be 232.62 Hz qing -zu min et al.[24] studied optimization method of test conditions for fatigue crack detection during lock in vibrothermographwhere it is a thermograph method where it utilizes lock in signal excitation to achieve detection. In present study a set of metallic plates with artificial fatigue crack have been used to experimentally investigate the effect of test conditions. Thus we obtain that a specific metal plate with an artificial fatigue crack is tested to find out the optimized test conditions of LVT inspection. It is concluded that temperature rise increases with the engagement force and excitation intensity but little influence can be made by modulated frequency. G. E Carr et al.[25] studied on detection threshold for fatigue crack in welded steel beam using vibrational analysis and here the natural frequency and mode shape both are affected when a crack exist because the stiffness is lowered. Both effects can be used to identify cracks. Mainly it uses modal testing, vibration based method and nontraditional methods. Comparison of experimental data with two or three dimension numerical modelling result was done observing a good level of agreement between them. It is necessary to advance in this topic on to take into account the influence of the component width on both the detection. Arun Mohan et al. [26] detected crack in beam by using image processing where initially collect the image of the structure which will be send to crack detection process in camera. After the image acquisition the collected images are preprocessed within which methodologies like segmentation are done. The measurement in transverse direction does not show enough accuracy. It is impossible to predict the depth of open surface crack based on sequence of images with different materials. Ahmet can Altunisk et al.[27] shows nodal parameter identification and vibration based damaged detection of a multiple cracked cantilever beam. The FEA models are constituted in Ansys software for numerical solutions. So it can be seen that cracks strongly affect the natural frequencies of the beam. It is necessary to use the modal updating process to maintain the exact boundary condition for the used model. G carr et al.[28] had studied on detection threshold for fatigue cracks in welded steel beams using vibration analysis and thus three methods have been used such as modal testing, vibration based method, nontraditional methods. Fatigue crack on oscillation frequency analysed and compared to 2-3 dimensional numerical modeling results.crack depths are measured on line by means of an indirect technique

R behera et al[29] had analysed simply supported beam with multiple breathing crack and the influence co efficient are calculated by using eigen value. Thus position of crack is identified from deviation of mode shape between cracked and uncracked one. Jiuzeng et al. [30] studied dynamic characteristics analysis of cracked cantilever beam under different crack types and thus vibration responses and crack level identification of system under 3 cases are discussed. Here the crack region is simulated by solid elements. Beam elements are adopted in crack free regions. Aminthalami et al. [31] used a modal energy based method and presented in order to detect the location, severity and even type of crack is multiple crack beam. Simple methods have been used for detection of multiple edge crack. Thus by usi9ng simple methods, relationship between natural frequency and crack parameters is demonstrated and solved. Jose Fernandez et al.[32] had unique determination of a single crack in uniform simply supported beam in bending vibrations. Here the determination of crack position and severity is solved by means

of constructive algorithm, without any assumption smallness of damage, frequency equation

Method also has been used. Thus this present analysis is based on reduction of crack identification problem.

Conclusion

The detection of crack can be done by using Ann using prediction technique. In this we are studied in detail about how matlab pred

Future Scope:

There is no work found on the detection of crack by using prediction technique
this work is useful for predetermination of crack hence it save time &cost . The further work on this can make this process time efficient and adaptive.

References:

[1] O.Hasancebi, T.Dumlupinar,"Linear and nonlinear modal updating of reinforced concrete T-beam bridges using Artificial neural networks,"Computer and structure, vol.119, issue 2013, PP 01-11.

[2]Z.X.Tan,D.P.Thambiratnam,T.H.Tchan,H.Razak,"Detecting damage in steel beams using modal strain energy based damage index & ANN," Engineering failure Analysis,vol.79,issue 2017,PP 253-262.

[3]S.J.S.Hakim,H.Razak,S.Ravanfar,"FaultdiagnosisonBeam–likestructuresfrommodal Parameters using ANNs,"Measurement, issue 2015, PP 241-263.

[4] A.SEIBI, S.MALAWI,"Prediction of failure toughness using ANNs,"Engineering fracture mechanics, vol.56, issue 1997, PP 311-319.

[5]BakharyN, HaoH, DeecksAJ,"Damage detection using ANN width of consideration nuncertainties, "Engineering structure, issue 2007, PP 01-19.

[6]A.Elshafey,NabilDawood,H.Marzouk,M.Haddara,"CrackwidthinConcreteusingANNs,"Engineering Structure, vol.52, issue 2013, PP 678-686.

[7]PaulrajM.P,SazaliYacob,MSAbdulMajid,Mohd NorFakhanMohdKazim,PraneshKrishnan,"Structural Steel plate damage Detection using Non-Destructive testing, Frame energy based stastical features and ANNs,"Procedia Engineering,vol.53,issue 2013,PP 376-386.

[8] Z.H.Ding, M.Huang, Z.R.Lu,"Structural damage detection using artificial Bee colony algorithms with hybrid search strategy,"Swarm& Evolutionary Computation, vol.15, issue 2015, PP 01-10.

[9] W.T.Yeung,J.W.Smith,"Damage detection in bridges using Neural Networks for Pattern recognition of Vibration Signature, "Engineering Structures,vol.27,issue 2005,PP 685-698.

[10] W.T.Yeung,J.W.Smith,"Damage detection in bridges using Neural Networks for Pattern recognition of Vibration Signature, "Engineering Structures,vol.27,issue 2005,PP 685-698.

[11] A.Labib, D.Kennedy, C.Featherston,"Free vibrational analysis of beams and frames with multiple cracks for damage detection, "Journal of Sound and Vibration, vol.29, issue 2014, PP 01-13.

[12] Khalate A.B.1, Bhagwat N.B.2,"Detection of crack present in composite cantilever beam by vibration analysis techniques, "International Journal of Innovative Science Engineering and Technology, vol.3, issue 2016, PP 01-11.

[13] J.Thalapil, S.KMait,"Detection of longitudinal cracks in long and short beams using changes in natural frequencies, "International Journal of Mechanical Science, vol.14, issue 2014, PP 80-109.

[14] D.Broda,L.Pieczonka,V.Hiwarkar,W.JStaszewski, V.VSilberschmidt," Generation of higher harmonics in longitudinal vibration of beams with breathing cracks."Journal of Sound and Vibration,vol.57,issue 2016,PP 01-14.

[15] Santosh.J.Chauhan, NileshYelve,Veda P.Palwamkar,"Damage detection in cantilever beam using vibration based method,"Fr.CRoudrigues Institutes of Technology.

[16]P.Yamuna,K.Sambasivaro,"vibration analysisofbeamwithvarying crack location,"International Journal of Engineering research and General Science,vol.2, issue 2014,PP 01-16.

[17] Qing-xuMin,Jun-Zhen,Fu-zhouFeng,chao xu,Ji-weisun,"study of optimization method of test conditions for fatigue crack detection using lock-in vibrothermography,"Infrared Physics and Technology,vol.17,issue 2017,PP 50-95.

[18] G.E Carr,M.D.Chapetti,UNMDP,"On the detection threshold for fatigue cracks in welded steel beams using vibration analysis,"International Journal of Fatigue,vol.33,issue 2011,PP 642-648.

[19]J.priyadumkol,C.Kittichaikarn,S.Thainimit,"Crackdetectiononbeam using image processing,"Journal of Food Engineering,vol.209,issue 2017,PP 76-82.

[20] A.Aitunisik,F.Okur,V.Kahya," Modal parameter identification and vibration based damage detection of a multiple cracked cantilever beam."Engineering Failure analysis,vol.16,issue 2017,PP 01-39.

[21] U.Pendharkar,S.Chaudhary and A.K Nagpal,"Neural Network for bending moment in continuous composite beams considering cracking and time effects in concrete,"in Engineering Structure, vol.29,issue 2007,PP2069 -2079.
[22] Chung-Bang, and Eun Young Bahng," Substructural identification using neural network," in computers and structures,vol.77, issue 1999,PP 41-52.
[23] Chung-Bang Gun,Jin-Hak Yi and EunYoundBahng," Joint damage assessment of framed structures using a neural network techniques, " in engineering structures,vol.23, issue 2000, PP 425-435.
[24]A.aucar and K.Saplioglu," An Artificial neural network Application for Estimation of Natural Frequencies of Beams," in International Journal of Advanced computer science and application, vol.6,issue 2015, PP 94-102.
[25] G.E Carr, M.D Chapetti and UNMdP," on the detection threshold for fatigue cracks in welded steel beams using vibration analysis," in International journal of fatigue ,vol.33,issue 2011, PP 642-648.
[26] Marta.B. Rosales , Carlos P. Filipich and Fernando. S. Buezas," Cracks detection in beam-like structures,"in Engineering structures,vol.31,issue 2009, PP 2257-2264.
[27] J.Park, J.Kim,D.Hong and J.Yi," Sequential damage detection approaches for beams using time-modal features and artificial neural networks," on Journal of sound and vibrational, vol.323,issue 2009, PP 451-474.
[28]S.W.Liu,J.Huang, J.C Sung and C.C. Lee," Detection of cracks using neural networks and computation mechanics, "in computer.Method appl. Engg.,vol.191,issue2002,PP 2831-2845.
[29] K.vigneshwaran and R.K Behera," Vibration analysis of a simple supported beam with multiple breathing cracks, " in procedia Engineering, vol.86,issue 2014, PP 834-842.
[30] J.zeng,H.Ma,W.Zhang and B.Wen,"Dynamic characteristics analysis of cracked cantilever beams under different crack types,".
[31] M.Behzad,A.Ghadami,A.Maghsoodi and J.Michaelhale,"Vibration based algorithm for crack detection in cantilever beam containing two different types of cracks,"journal of sound and vibrations,issue 2013,PP 01-09.
[32] J.saez,A.Morassi,M.Pressacco and Lourdes Rubio,"Unique determination of a single crack in a uniform a simply supported beam in bending vibration," journal of sound and vibration,issue 2016.