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DAMAGE IDENTIFICATION THROUGH THE STRUCTURAL HEALTH MONITORING IN STEEL STRUCTURE

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ABSTRACT

In this paper using the simply supported undamaged and damage beam analyzed under the free vibration with accelerometer device measure the acceleration. After Study the performed on the behavior of simply supported beam by using finite element analysis computer package known as "Abaqus" from the theoretical and practical points of view. Similar problem is also validating with numerically using wavelet transform method. The process of work in progress analysis on the experimental investigations of the consequences of cracks and damages on the integrity of structures, with a read to detect, quantify, and confirm their extents and locations. Damage is predicted in terms of the change in frequency. The results shows, both the experimental literature results and FE analysis results shows in good agreement. The damage detection schemes employed in this study trusted the measured changes within the first to third natural frequencies and also the corresponding amplitude of the measured acceleration frequency response function. Validation of modeling procedure and analysis is done by solving problems reported in standard literature.

Key word: steel Beam, Finite Element (ABAQUS), Accelerometer, Damage Identification.

I. INTRODUCTION

In this century many structure are constructed by using the steel section. Because of they have a lot of advantage, its earthquake resistance, they construction period is short, easy to installation, good strength and ductile material, speed erection, prefabrication, and demount-ability. Main advantage is cost of steel structure is low as compare to the RCC structure. Steel structures have excellent seismic energy performances. Steel section is much better compressive and tensile strength than concrete material [1].

The number of steel structure was available approximately about 12 million in 2004. They are increase year by year about the 5 to 8 %. However, steel structures develop rapidly, many different types and techniques. The strength of structure is continuous deteriorated after their construction due to loading and environmental impact [2]. Structure is consisting of various members like column, beam, slabs, and roof etc. At the construction time, it is impossible to achieve the uniform quality and their strength at every section. Hence, there is variation of strength is different to the section by section and variation increases beyond their limit due to certain loads. It would result in to damage in structure. The damages are produced by the some change of steel structure because of the improper weld and loss of bolt is responsible of the damage. So that damage is decrease the strength and also reduce the life if structure. The structure is indentify by the using of different types of sensor is known as structural health monitoring. Damage and cracking is inhibited through the structural health monitoring (SHM). SHM is determining the damage in present structure and their geometric location of the damage. It's also the predicted of the remaining service life of the structure. SHM is improving the safety and functionality of structure. Successful health monitoring applications can be achieved by integrating experimental, analytical and information technologies on real life operating structure.
At that steel structures have optimal seismic energy performance structure can be damaged by different load source, including extreme loads and change their properties after damages. So, that monitoring of the steel structure is necessary [2]. The structural health monitoring classified, in generally global and local method. In, the SHM the global method not detect the small damages in the structure and other limitation of these techniques were have require a high fidelity model of the structure to start with, which is usually not available. The local method classified the non-destructive evaluation (NDT) method such as, Ultrasonic techniques, thermal fluid, eddy-current, magnetic field, acoustic emission, radiography[3][4].

NDT method also include modal flexibility and modal strain energy method used for SHM of structure. In the modal flexibility method, the flexibility matrix is very impressible to change in the lower frequency of the structure and flexibility matrix using for determine the presence and location of structural damage. In the modal strain energy method used for measured mode shape element stiffness matrix determine the structural health monitoring [5]. In the structure increasing the changes in curvature mode shapes with increasing the damages. The damping is increasing in structure and reduce the stiffness with decrease the natural frequencies [6]. The dynamic behavior beam investigated for a moving mass inside the framework using Euler–Bernoulli, Timoshenko and also the third-order shear deformation beam theories [7] [8]. The equations of motion of beams measured by derived equations Euler–Bernoulli beam theory and virtual work principle. Finally, the results of varied boundary conditions, power-exponent index and beam's slenderness magnitude relation measure investigated [9]. Free vibration analysis is carried out for simply supported beam subjected to a targeted moving harmonic load area [10].

The simply supported undamaged and damage beam analyzed under the free vibration with accelerometer device measure the acceleration. After Study the performed on the behavior of simply supported beam by using finite element analysis computer package known as "Abaqus" from the theoretical and practical points of view. Similar problem is also validating with numerically using wavelet transform method [11]. The process of work in progress analysis on the experimental investigations of the consequences of cracks and damages on the integrity of structures, with a read to detect, quantify, and confirm their extents and locations. Improving the performance of the structure with an excellent benefit/ cost ratio and reduce the impact of natural & man-made Disasters & increase the serviceable life of the structure through the structural health monitoring. Damage is predicted in terms of the change in frequency. The results shows, both the experimental literature results and FE analysis results shows in good agreement.

II. OBJECTIVE OF STUDY

The main objective of this study is indentifying the single and multiple damage in model of their different boundary condition in steel structure by using the Non-destructive method with sensor from different literatures. The simply supported beam is identify the damages, location of damages, and fine their property after the loading condition through the structural health monitoring. The analysis is faster and economical and securing strength provide the steel structure during their life. Structural health monitoring for steel structure could reduce the impact of natural and man-made disasters both economically and socially and also increasing the impact of steel structure.

III. EXPERIMENTAL STUDY

a. Experimental model description

Y. WANZ and X.Q. ZHU[3] anlaysed the rectangular steel bar have a dimension 0.025*0.025 m cross section and 1.5 m length under the forced vibration test with five accelerometers were attached on top of the steel beam with via their magnetic base shown in fig.1 and impact hammer was used to generating the impulsive force to excite the structure. Steel beam was hung by two flexible robber bands at the two ends for free-free boundary condition. **H.W. Shih and T.H.T. Chan[4]** analysed the flexural member beam and plate have dimension of simply supported beam is 0.040*0.020 m and length of beam 2.8 m and dimension of plate is 1*0.002 m and length is 2.5m. Initial beam and plate-like structures are first defined and developed as finite element (FE) models and their modal responses are obtained using the FE software package SAP2000. These parameters square measure then accustomed determine the modal flexibility matrix and the modal strain energy based damage index and there by assess the harm state of the take a look at structure shown in fig 2. **Shuncong and Oyadiji analysed[5][6]** 36 types of cracked simply supported beam are made of a bright mild steel of cross sectional area 0.100*0.025 m with length of 3 m. The beams are modeled victimization the twenty node 3D brick component that is denoted in the ABAQUS FE package as C3D20R shown in fig 3. **Mesut Simsek[7]** analysed the alumina simply supported beam have cross sectional area is 0.5*1 m under the forced vibration. The length of the beam is taken as L = 5; 20 m for two different values of slenderness ratio, L/h = 5; 20 shown in fig.4 and Displacements and stresses obtained according to EBT, TBT and TSDT are compared with each other. **G.M. Owolabi and A.S.J. Swamidas [8]** analysed the two sets of atomic number 13 beams were used for this experimental investigation. Every set consisted of seven beam models; the primary set had mounted ends, whereas the second set had merely supported ends. Each beam model was fabricated from aluminates bar of cross-sectional area 25.4mm * 25.4mm with a length of 650 mm show in fig. 5. **Alshorbagy and M.A. Eltaher [9]** analysed the functionally graded material (FGM) of the beam made of steel and alumina (Al2O3) have a width of beam was 0.4m and length of beam 20m shown in fig 6. The free vibration test using for FG beam was investigated using numerical finite element method. **M. Simsek and Kocatürk [10]** investigated the simply supported beam under the free and force. The parameters of the beam are as follows: b = 0.4 m, h = 0.9 m, L = 20 m shown in fig. 7.

In the free vibration analysis, the primary 3 dimensionless frequencies of the beam square measure calculated and given in tabular type for various material distribution, the magnitude relation of the Young's modulus of the higher material to lower material of the beam, and also the slenderness magnitude relation. In the forced vibration analysis, functionally hierarchic material (FGM) of the beam consists of steel and aluminates (Al2O3) and its properties changes through the thickness of the beam according to power-law and exponential la

S. Chandravadani and R. Balagopal [12] analysed the two different cantilevers hollow rectangular section 70×70×4.5mm and 26×26×3.5mm was subjected to vibration shown in fig.8. Numerical evaluation and mathematical modeling of measuring natural frequency is analysed in ANSYS Workbench. **K Ramesh Kumar and S Narayanan [14] analysed** the cantilever beam with distributed PZT sensor and actuator. The width of beam 0.030* 0.002 m and length is 0.5m shown in fig 9. A strategy of determinant the best location of sensor–actuator pairs in active vibration control of structures victimization the linear quadratic regulator (LQR) performance criterion is planned during this paper. **S. Kitipornchai and L.L.Ke[15]** analysed the FGM Timoshenko beam of length L and thickness h, containing a foothold crack of depth a situated at adistance L1 from the left finish shown in fig.10.. Its Young's modulus E(z) and mass density r(z) follow exponential distributions through thickness direction shown in fig. The properties of all the section were density of beam 7850 kg/m3.

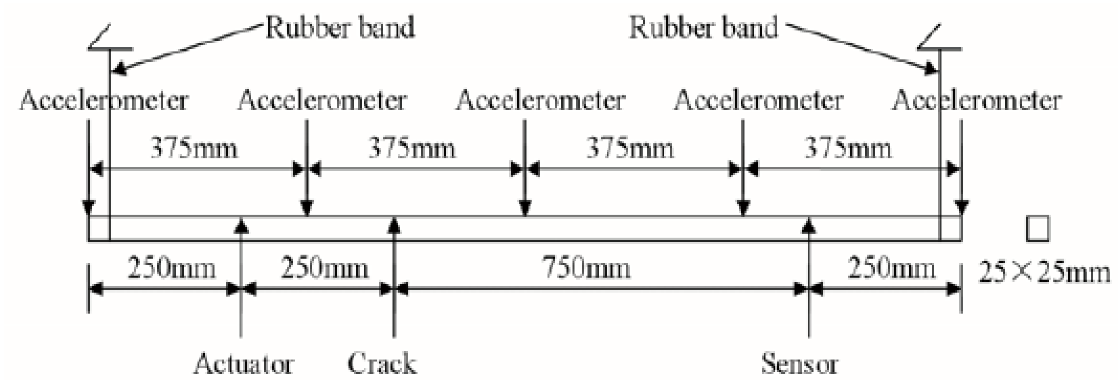
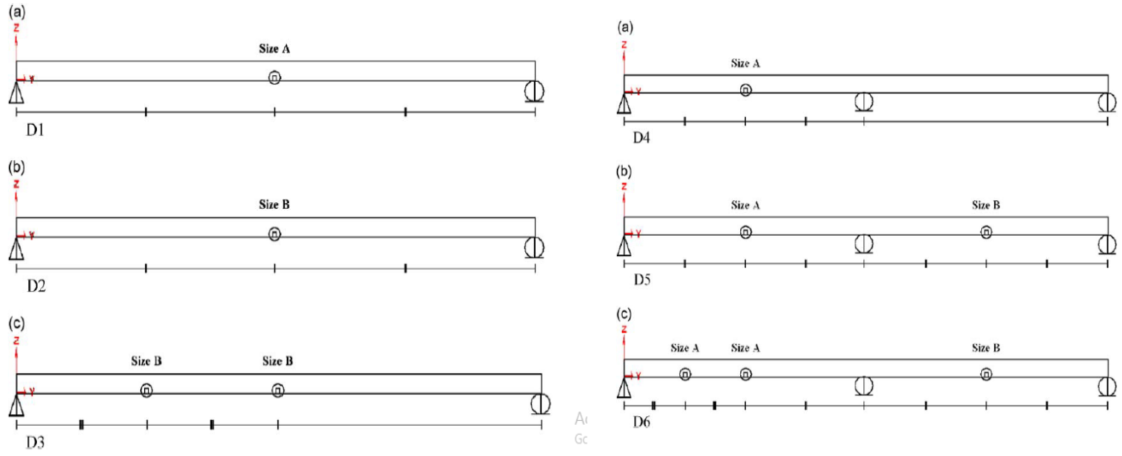
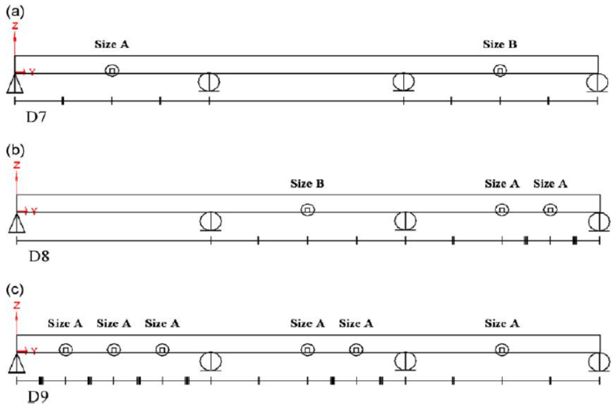


Fig.1 The specimen of steel beam [3]



(a) (b)



(c)

Fig.2 (a) Damage Case (D) for single span beam. (b) Damage Case (D) for 2-span beam. (c) Damage Case (D) for 3-span beam [4]

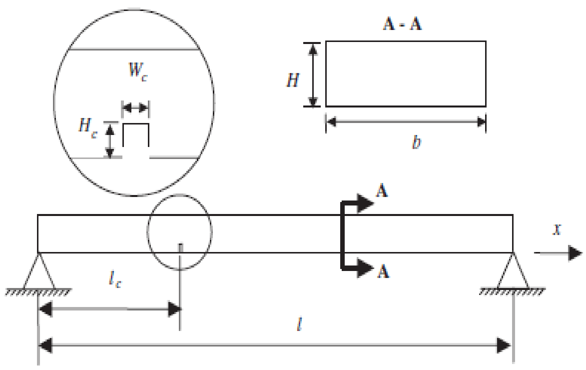


Fig.3 Model of cracked simply supported beam [5][6]

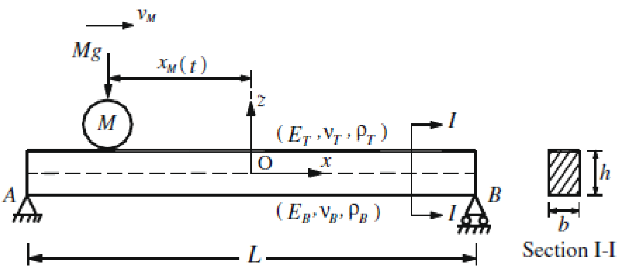


Fig.4 A functionally graded simply-supported beam subjected to a moving mass [7].

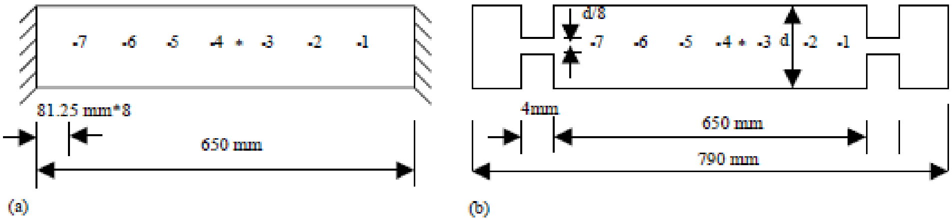


Fig.5 Locations of accelerometers: (a) fixed–fixed beam, (b) simply supported beam (*, point of excitation; accelerometer point) [8]

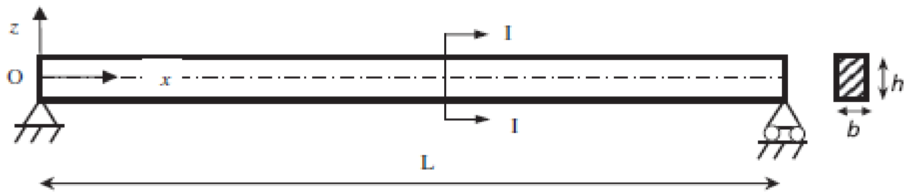


Fig.6 A functionally graded simply-supported beam [9]

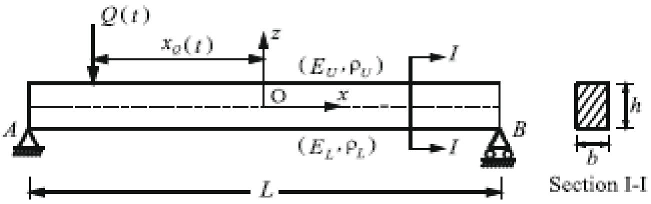
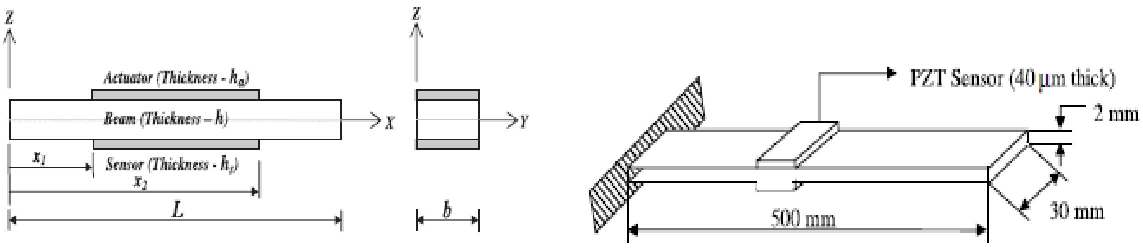


Fig.7 A functionally graded simply-supported beam subjected to a concentrated Moving harmonic load [10]

Fig.8 Experimental Setup of Cantilever Beam of Section (a) SHS1 (b) SHS2 Angle [13]



(a) (b)

Fig.9 (a) Layout of beam with partially covered distributed (b) A cantilever beam with distributed PZT sensor and Actuator piezoelectric actuator and sensor [14]

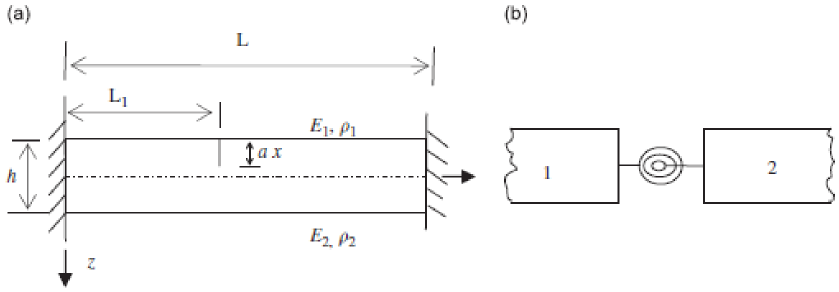


Fig.10 (a) An FGM Timoshenko beam with an open edge crack and (b) rotational spring model [15]

b. Experimental procedures

In this paper [3] using the vibration tests for measure the acceleration time histories of beam under the impulsive loading. In this test, computer connected with unit box and unit box connected with test, the sensing data were transmitted by signal conditions connected by several unit boxes and data was recorded in dark disk of the computer shown in fig.11. The actuator connected with surface of beam. In this study, only 1 ceramic layer was applied with the electrical input thus that it might generate the longitudinal waves. nickel USB-6251 was wont to give the short-time Marlette ripple for activating the structure by a linear power electronic equipment. The frequency and therefore the number of cycles will be adjusted to optimize the wave propagation on the structure.

a) Impact hammers b) Accelerometer c) Unit boxes and computer

Fig.11 Photos for vibration test system [3]

In this paper [4] beam was tested under the vibration method by the impact hammer and the tested the simply supported beam to validate the initial FE beam model. After the test beam was cut to small flaw at mid-span and the testing is pre damage modal parameter. Finite element models (FEM) of the undamaged and damaged simply supported beams, tested previously, having a span length of 2.8m are generated using the FE program SAP2000. In this paper SWT method [5] and CWT method [6] for the cracked simply supported beams, shown in Fig. 3, square measure studied during this paper by victimisation the ABAQUS finite element code. The simply supported beam features a single-sided transversal crack with a depth Hc, a crack breadth Wc, and placed at distance lc from the left support. The breadth and depth of the beam square measure b and H, respectively. Within the gift work, solely beams with tiny crack whose crack quantitative relation ($H_{cr} = {}^{H_c}/_{H}$) is a smaller amount than two 20% were investigated. This paper [7] using the forced vibration method for functionally hierarchic simply-supported beam below a moving mass by mistreatment numerous beam theories. The mass was moved in the surface of beam for measure the cracked in beam. The mechanical phenomenon effects of the moving mass together with the centripetal and therefore the Coriolis effects are thought-about. In this paper [8] the fixed–fixed beam model was clamped at every finish, between 2 thick sq. steel plates, supported over a brief and stiff steel H-section column. Each model was excited by a fast sine sweep signal made by the function generator, which was then amplified, and wont to drive the exciter, that eventually transmitted the force to the beam model through the load cell. The dynamic responses of the beam model were measured by exploitation seven light weight accelerometer placed at **completely different** points on the model as indicated in Fig. 1.and measure the frequency with different mode shape. This paper [10] was research the free and made vibration of a functionally ranked simply-supported beam subjected to a concentrated moving harmonic load. Within the dynamic responses of the beam, the space-dependent functions square measure chosen because the polynomial functions. The free vibration [11] characteristics of both thin and thick-walled box beams are investigated. The variations in natural frequencies of FGM box beams for different power law indices p and the following tree boundary conditions (B.C): clamped–clamped(C-C),clamped-free(C-F)and simply supported(S-S)are given in this section. The system of equations of motion comes by using Lagrange's equations underneath the assumptions of the Euler– Bernoulli beam theory. Determine the time and displacements, velocities and accelerations of the beam at the considered point. In this paper [12] using the free vibration was applied on the beam and acceleration response is measured by uniaxial measuring instrument and multichannel information acquisition system instrument. Exploitation quick Fourier rework technique the frequency response is measured.

IV. Conclusion

In the steel structure, structural health monitoring is increasing their important and also testing and monitoring of steel structure, are decision of disaster prevention. In this literature survey using the steel beam analysed under the vibration system to focuses on the measure of modal parameters, which can be employed in model modification. The vibration behavior of the beam is shown to be very sensitive to the crack depth, crack location ad number of mode and also measuring the frequency and stiffness which is reducing with increasing the depth of crack in literature survey.

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