DEFECT ANALYSIS IN DIFFERENT ALLOYING BRASS BEAMS USING NON-DESTRUCTIVE TECHNIQUE

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ABSTRACT

It is very important structures must run without defects as soon as possible, since defects influence in a negative way the service life of the structures. Thus, defect detection has been considerable effort. In this study, dynamical behaviour of the a cantilever beam having a hole, has been evaluated. Two kind of on brass beams were investigated. One of them is compound of 63 %Cu, 27%Zn, the other is compound of 70 %Cu, 30%Zn. For this purpose, the vibrations as a result of impact shocks were analyzed. The signals obtained in defect-free and holed beams were compared in the frequency domain.

I. INTRODUCTION

Defects may be exist as residue from production stage or form during its service in structures. There of them vibrating components could lead to catastrophic failure. Therefore, there is a need to understand the dynamics of structures with defect. Nondestructive testing is very useful technique that, obtains information of interior region of structures without any damage to it. Although it has many branches, like liquid penetrant, magnetic particles, ultrasonic testing, radiography, eddy current, modal analysis, etc., modal analysis has been successfully applied to detect damage in structures, especially cracked beams. Natural frequencies, mode shapes can be obtained, frequency response functions can be identified and effect of damping on modal parameters can also be determined by modal analysis. Natural frequencies are relatively easier and more accurately measured than other modal parameters. The observation that changes in structural properties cause changes in vibration frequencies was the impetus for using modal methods for damage identification and health monitoring. Changes in natural frequencies of a structure has been widely used to crack detection in beam structures for many years.

Kam and Lee [1] modeled and analyzed one cracked cantilever beam using the finite elements method to determine the crack locations and magnitudes. Natural frequency of the beam has been also determined and verified experimentally. Chondros and Dimarogonas [2] conducted a number of experiments with an aluminum cantilever beam with a crack. They proved that the experiments are consisted with the mathematical formulae. For the two ends pinned beam with one crack, mathematical expressions were derived by [3] to examine the effect of the crack to the natural frequency of beam and results were proved by experiments. Matveev and Bovsunovsky[4] derived expressions for bending vibrations of an Euler–Bernoulli beam. They studied the effects of the ratio of crack location to the length of the beam and also the ratio of the depth of the crack to the height of the beam. They investigated the variation of the natural frequency of the beam. Rizos et al. [5] developed a method based on the amplitudes at two points in a structure, vibrating at one of its natural frequencies and an analytical solution of the dynamic response. Çam et al[6] investigated how the natural frequencies change with varying crack location in a cracked cantilever beam. They observed that the location of the defect increases from the cantilever end, the amplitude of high frequency vibration increases but the amplitude of low frequency vibration decreases. To identify location and depth of the crack in a cantilever beam suresh et al[7] studied artificial neural network approach that uses modal frequency parameters are analytically computed for various crack locations and depths. Çam et al[8] also studied on determining the crack location and depth in a cantilever beam having an edge crack from changes in its natural frequencies. It has seen from the studies that, crack detection is draw attention increasingly. However, other damages like a hole may be exist in the structures. In a such case, determining the hole is very important since a hole more influence in a negative way the service life of structures than crack, because it extracts more volume from the structure compared to a crack. Thus in this study the dynamical behavior of the cantilever brass beam having a holes investigated experimentally figured (1).

II. METHODOLOGY

In this study, impact-echo method that has been successfully applied[9,10,11] to detect defects in structures. The impact-echo is a method for nondestructive testing of concrete and masonry structures that is based on the use of impact-generated stress (sound) waves that propagate through concrete and masonry and are reflected by internal flaws and external surfaces. Impact-echo can be used to determine the location and extent of flaws such as cracks, delaminations, voids, honeycombing, and debonding in plain, reinforced, and post-tensioned concrete structures, including plates (slabs, pavements, walls, decks), layered plates (including concrete with asphalt overlays), columns and beams (round, square, rectangular and many I and T cross-sections), and hollow cylinders (pipes, tunnels, mine shaft liners, tanks). The method can be used to locate voids in

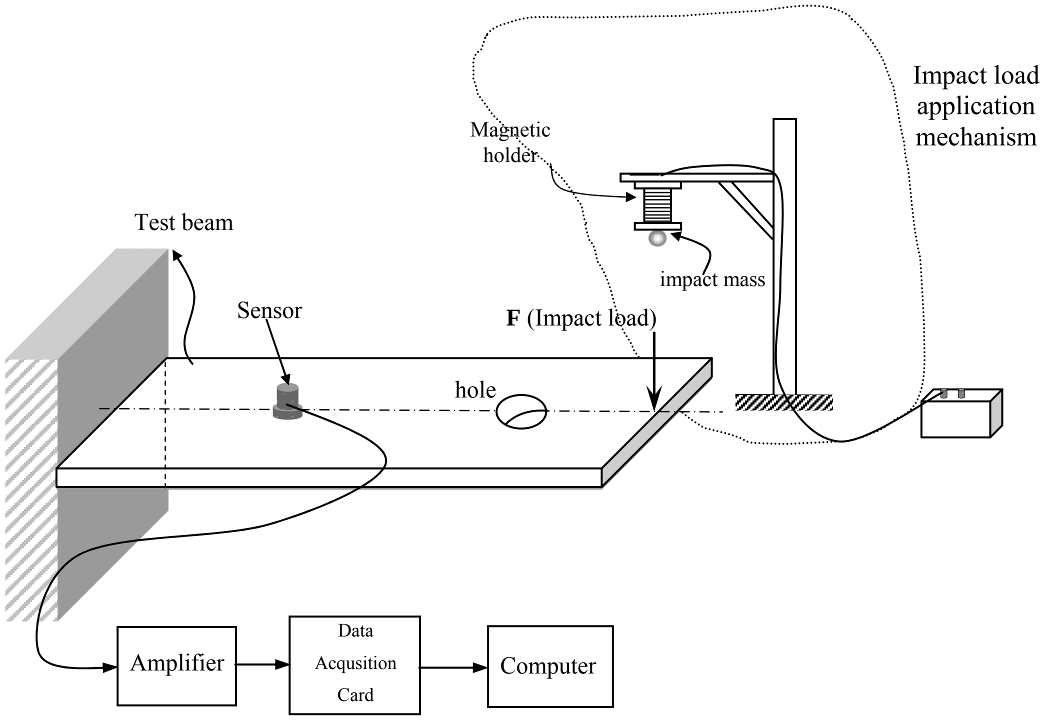

Figure 1. The experimental arrangement used

the grouted tendon ducts of many types of post-tensioned structures. It can provide thickness measurements of concrete slabs with an accuracy better than three percent, and it can locate voids in the subgrade directly beneath slabs and pavements. The method can be used to determine thickness or to locate cracks, voids, and other defects in masonry structures where the brick or block units are bonded together with mortar. The Impact-echo is based on the use of transient stress waves generated by elastic impact. A diagram of the method is shown in Figure 2.

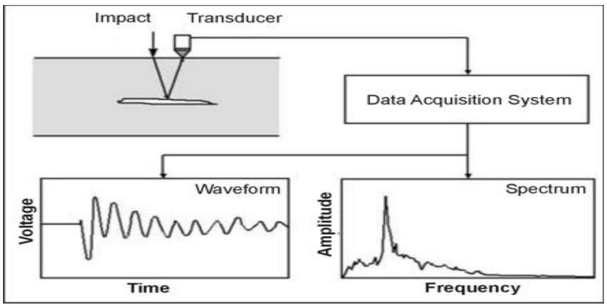

Figure 2 Diagram of the impact-echo method [12]

A short-duration mechanical impact, produced by tapping a small steel sphere against a concrete or masonry surface, is used to generate low-frequency stress waves that propagate into the structure and are reflected by flaws and/or external surfaces. Surface displacements caused by reflections of these waves are recorded by a transducer, located adjacent to the impact. The resulting displacement versus time signals are transformed into the frequency domain, and plots of amplitude versus frequency (spectra) are obtained. Multiple reflections of stress waves between the impact surface, flaws, and/or other external surfaces give rise to transient resonances, which can be identified in the spectrum, and used to evaluate the integrity of the structure or to determine the location of flaws[12].

III. EXPERIMENTS

The natural frequencies were obtained experimentally by using impact-echo method. The experimental setup is shown in Figure 1. The test beam has cross-sectional area of 3x25 mm^2 and a length of 300 mm. A metal ball was dropped on to the beam from 175 mm height in order to excite natural frequencies. Additionally, the experimental setup consists of a force application mechanism, an accelerometer, an amplifier, a data acquisition card! and a PC computer. When the metal ball hit the beam, vibration signals were collected by the accelerometer then sent them to the amplifier. Gain of the amplifier was constant and 10. The vibration signals were sampled with 100 KHz in a data acquisition card. 16384 data are transferred and recorded to the computer in 165 milliseconds. Finally, a program written in MATLAB software was used to calculate fast Fourier transform of the vibration signals.

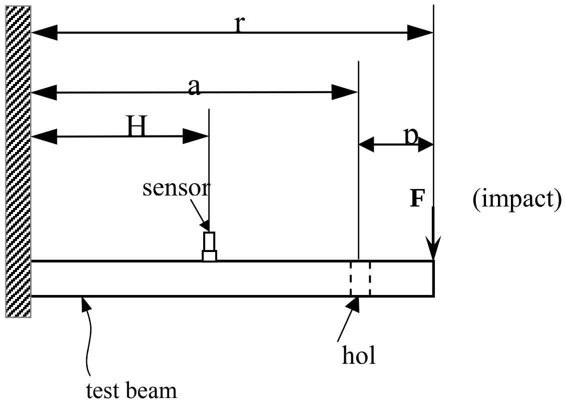

Figure 3. Illustrations of the beam with artificial defect

Ileustrations of the beam with artificial defect is shown in Figure 3 where “H” is the location of the sensor, “a” is the hole location, “r” is the impact point from left end, “F” is the impact load. In Figure 3, two different brass beams are used to compare each other that the first one is 63% Cu-Zn alloy and the second is 70% Cu-Zn alloy. Also, in this experiment, intact and defected beams were compared. experimental results are shown in Table 1 and Table 2. In the tables, results of the intact beams and results of the defected beams are given, respectively. It is seen from the Tables that all natural frequencies for the two situation were obtained in order of fundamental natural frequency. These results are in harmony with the theoretical formulae.

Table 1. Natural frequencies of the intact beams

	63%	**70%**
f1	18.75	25.3
f2	125	162.5
f3	360	455
f4	1136	1445

Table 2. Natural frequencies of the defected beams

	63%	**70%**
f1	18.7	25.05
f2	124.7	162.45
f3	350	463
f4	1144	1470

In addition, fast fourier transforms of the two results areshown in Figure 4 and figure 5. In these figures, dotted lines represent 63% and the solid lines represent 70% of brass beams.

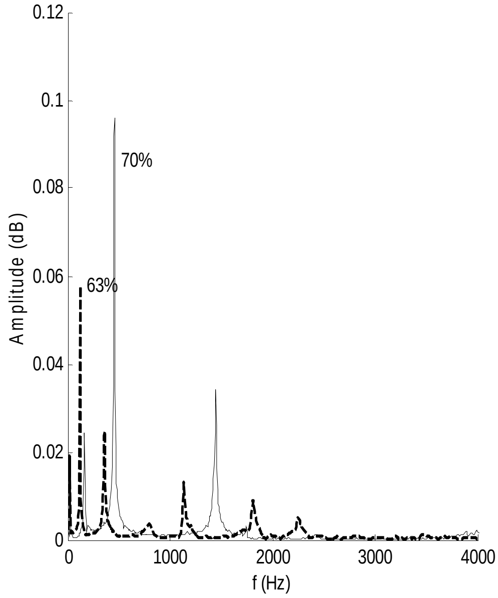

Figure 4. Fast Fourier transform of the intact beams

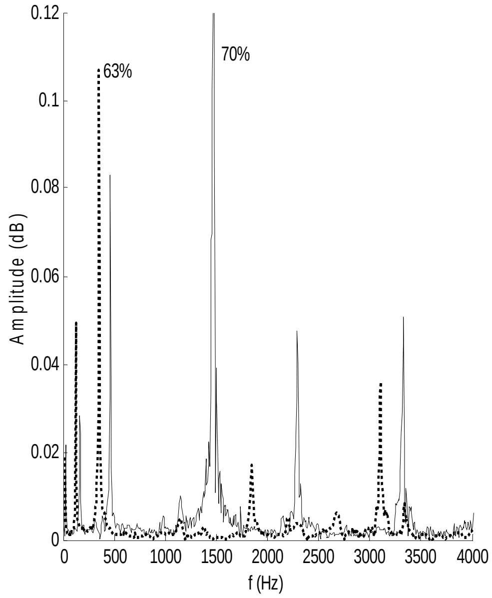

Figure 5. Fast Fourier transform of the defected beams

IV. RESULTS AND DISCUSSIONS

Test procedure is repeated for different beams made of same material and geometry, but with notch of same location The signal obtained from the defective and non-defective beams are compared both in time and frequency domain. In the time domain, differences between defective and non-defective beams are given in Tables 1 and 2. In the frequency domain, the differences were illustrated in Figures 3 and 4. As is shown in Table 1, the natural frequencies are obtained as harmonics of the fundamental frequency for two situation(63 %- 70 %). Same case is shown in the Table 2 in that the natural frequencies are given for damaged brass beams. It is known that the following natural frequency equation[13] is valid for homogenous structures.

$$\omega_r = (r\pi)^2 \sqrt{\frac{EI}{mL^4}} \qquad r = 1, 2, \ldots.$$

E Where is elasticity modulus, I is cross sectional inertia moment, m is mass, L is length of the beam. It is shown from this equation the mass, consequently density is inverse proportional to magnitude of the natural frequency. In this study, the density of the brass 70 % is greater them the brass with 63 %.

However, the obtained results shown in the Table 1 and 2 are not totally agree with theory. It can be said that there is a great effect of atomic structure on the natural frequency. Meanwhile, it was expected that natural frequencies of the damaged beams must be greater than that of intact beams. This situation has been verified in Tables 1 and T.2. Vibration spectrum graphics are given in Figures 3 and 4.

V.CONCLUSIONS

In this study it was conducted on the damage detection procedure based on impact echo method in which two different brass beam were evaluated. At the end of the experiment, it was seen that experimental natural frequency is disagree with the theoretical frequency for the brass beams. Additionally, natural frequencies of the intact beams were higher than those of the healthy beams. These results are also in harmony with the theoretical formulation results. In future, this work also can be supported by using computer simulation software.

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