Destruction Efficacy on the Change of Dynamic Behavior in Structural Elements Using Finite Elements Method

Mahdi Koohdaragh[1], Farid Hosseini Mansoub[2]

[1]Islamic Azad University, Malekan Branch, Iran
[2]Islamic Azad University, Maragheh Branch, Iran
Koohdarag@malekaniau.ac.ir

Abstract: Structures are exposed to main threats such as structure efficiency decrease and its destruction. These problems are intensified along natural or man-made threats like earthquake and sever explosion. Since the earthquake is implemented dynamically and in small distance in terms of time on the structure dynamic analyses is of high importance. In this paper, the structure is put under modal analyses via ANSYS5.4 finite elements software and natural and mode-shaped frequencies of healthy and damage samples are resulted. The results show that frequency is decreased in damage samples. As following by utilizing impact load of structure is put under dynamic nonlinear analyses and through investigating displacement-time, velocity-time, acceleration-time and moment-time graphs destruction effect on acceleration and moment-time graphs can be identified as the form of amplitude changes.

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1. Introduction

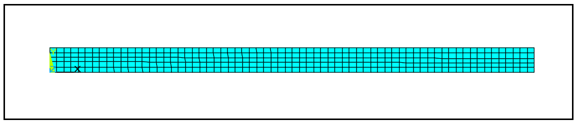
Structures are exposed to main threats such as structure efficiency decrease and its destruction. These problems are intensified along natural or man-made threats like earthquake and sever explosion. Structural deficiencies cause undesirable changes in structure efficiency. Destructions may be caused suddenly like element rupture because of earthquake loading or damage development and hardness and resistant decrease resulted from crack growth (lotfollahi, Koohdaragh, 2011). Therefore, some methods are demanded for destruction detection. In that case Structural Health Monitoring methods SHM are the subject of wide done researches. During recent years, many attempts are done to develop reliable and efficient SHM systems. These systems should answer the questions of structural damage and destruction place which can lead to coming preparations for repair and efficiency of structures. On the whole, SHM is defined as: ((gathering, assessing, technical information analyses in order to facilitating management decision making along structure age)) (lotfollahi, Koohdaragh, 2011).

The most important point in modeling an efficient SHM system is loading changes and its identification manner. The efficacy and characteristics of damages in a special structure has a key role in a SHM system's definition and establishment (Zhong, Oyadiji. 2007). Many of SHM methods are focused on modal vibration and the study of special frequency changes and the form of modals. Some damages and deficiencies such as crack, gap, volume mass decrease and elasticity coefficient will decrease the hardness. This will be caused as structure alternative nature time (frequency decrease) increases. It seems that because of non-monotonous distribution of tension in vibrated structure and its difference in each mode, the crack will have non-monotonous effect on vibrated modes. On the bases of this matter, different destruction identification methods are assessed and each one's efficiency is determined according to theoretical or experimental outcomes (Yan, Xiang, Zhu, Maosen, 2006,2006,2005,2008).

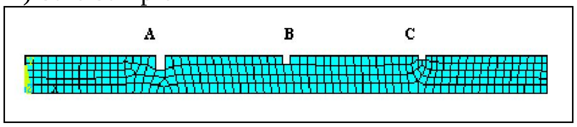
Among these, cracks are the most important reason of structural breakage which their identification and reveal are put among SHM methods. Many attempts are done in that case that are going to be pointed in continuous.

2. Modeling Structure Element

For this purpose a straight bar with a mouth of 6m, simple support and cross section of 40 $\times$40 cm is utilized for two healthy and cracked sample and it is shown in Fig.1. Density and elasticity module of structure is respectively 7850 kg/m^3 and 2.11×10^{11} pa. Square and inertia moment of cross section of element equals: 2.13×10^{-3}m^4 and 0.16m^2 (ANSYS, 1999).



A) Safe Sample



B) Cracked Sample

Figure 1. Characteristics of Modeled Structure

Table 1. Characteristics of crack place and depth in modeled samples

Sample	Crack Position	Crack Depth
1	healthy	-
2	C	10%
3	C	25%
4	C	40%
5	A, C	40%-25%
6	A, C	40%-40%
7	C, A, B	10%-40%-25%

3. Modal Analyses and Discuss Result

Modal analysis is thoroughly necessary in structural and industrial section modeling stages which are under the vibration effect because of vibration charges and kinetics. Vibrations in structure's natural frequency limit increase vibration width and disintegrate the section.

Modal analysis is utilized in assessing natural frequency and its mode shape in above frequency. The amount of natural frequency of each structure depends on the shape, material and supports of the structure. In this kind of analysis nonlinear factors are denied even in the definition. The most important options of this analyses is the number of natural frequencies and frequency limitation which goes after modeling and the analyses will be done in that distance (Chondros , Dimarogonas, 1977,1976).

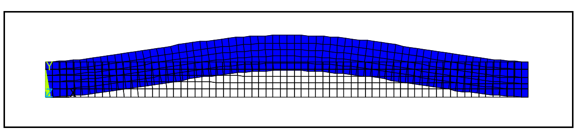


Figure 2. Deformation of structure in first mode

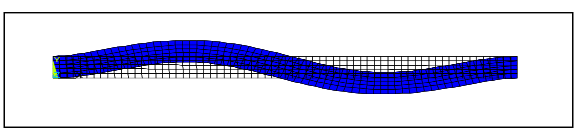


Figure 3. Deformation of structure in second mode

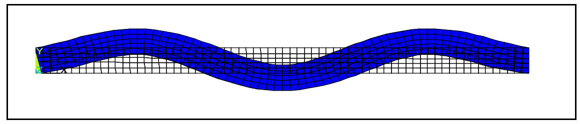


Figure 4. Deformation of structure in third mode

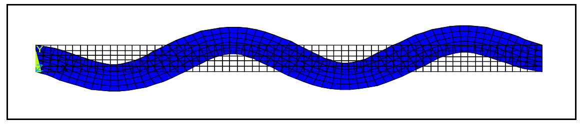


Figure 5. Deformation of structure in fourth mode

The first to forth natural frequencies for all 7 samples are shown in Table.2. Also, frequency changes of each mode in all samples are analyzed in Fig.6. Figure shows that as crack depth and number increases the amount of frequencies decreases. These decreases are tangible after 3rd mode and are shown as a disharmonious in graph.

Table 2. The Outcomes of the First 4 Natural Frequencies

Sample	Frequency of First Mode	Frequency of Second Mode	Frequency of Third Mode	Frequency of Fourth Mode
1	57.61	153.27	287.53	432.71
2	57.10	150.23	284.20	430.54
3	56.99	148.92	280.85	427.35
4	56.52	147.36	275.63	425.63
5	56.10	148.88	269.82	425.10
6	55.97	144.87	261.71	423.51
7	55.83	142.46	258.26	421.31

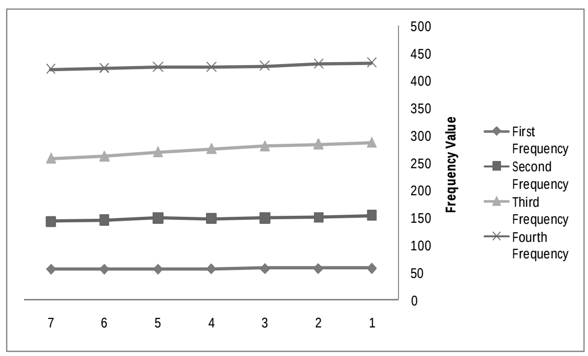


Figure 6. The Frequency Changes Graph of Samples

4. Modeling Impact Load

In order to implement impact load time-force history is utilized i.e. in a distinct distance in terms of time the load is implemented on structure and in other time distance it is removed from structure. But special attention should be paid in choosing time distance. If this distance is very small, the impact load will be explosive load and the structure will have a big surface change in its shape before vibration or a hole in the place of load implement of structure. In order to implement impact load, a triangular load like Fig.7 is implemented on the structure in the form of time-force history (Dimarogonas, Paipets, 1986).

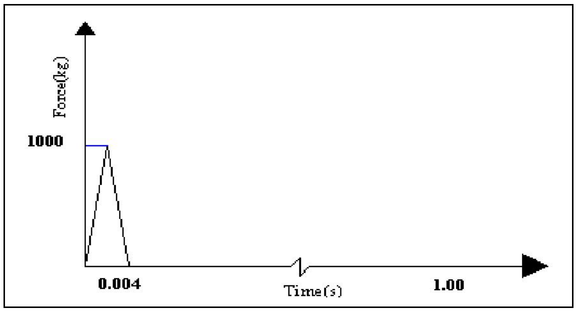


Figure 7. The History of Time-Force, Implemented Impact Load on the Structure

5. Dynamic Analyses of Structure Transitory under Impact Load

Vibration is caused when a material slips over other material. Dynamic vibration is the vibration that is caused through the movement of materials toward each other. In other words, in a dynamic vibration system the whole system is analyzed in dynamic position and all the sections are in a movable and displacement position to each other. ANSYS software in LS-DYNA environment which is dynamic environment of this software can easily analyze these vibrations and assess frequency responses of vibrated systems in the form of dynamic vibrations. The most important options of these analyses after modeling stages are frequency limitation, the number and amount of its steps, direction and the spot of load implement (Han, Ren, Sun, 2005).

As it was discussed in impact load modeling, the load is implemented on the structure in time distance of 0.002 and in the next distance of 0.002 the structure is unloaded and the structure is vibrated that these vibrations will be disappeared as time goes. But in order to view all treatments of structure after unloading to 1st second the structure treatment is investigated. The results are shown in Fig.8 in the form of displacement-time history of healthy sample.

In order to careful investigation and study of structure treatment under the effect of impact load implement, graph 8 has been studied in 3 parts. For this purpose structure vibration graph is analyzed in time distances of 0-0.004, 0.004-0.2 and 0.2-1 separately in Fig.9.

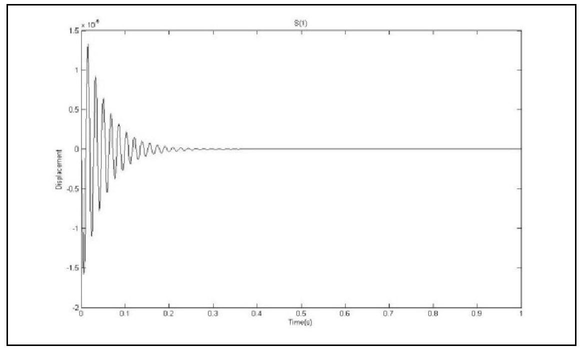


Fig. 8: displacement-time history in the spot of 3m away from left support for healthy sample

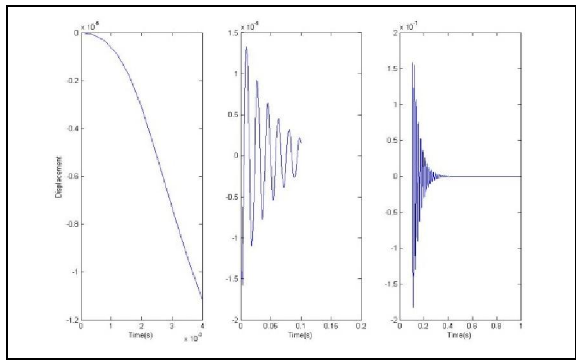


Fig. 9: displacement-time history in the distance of 3m from left support for healthy sample
a) 0-0.004 b) 0.004-0.2 c) 0.2-1

As graph 9(a) shows structure in time distance of 0-0.004 has the largest displacement in comparison to other distances which is viewed as sudden displacement increase (move toward negative). But in 0.004-0.2 structure vibrations are almost in a regular decrease and in 0.2-1 structure vibration disappears and in 1st second there is no vibration.

For this purpose mentioned samples in table.1 are put under dynamic analyses through impact load implement in the middle of bar and the results are shown in the form of displacement-time, velocity-time, acceleration-time, moment-time. The results are shown for two samples of 1(healthy) and 6 in the figures of 10 and 11.

As the graphs show displacement history for each spot of structure is the same for healthy and cracked sample. Therefore it cannot be used as a criterion for identifying cracks in structure. The velocity history is used for mentioned spots in healthy and cracked samples. But there is no difference among them as velocity graphs are gained from displacement derivations. But the effect of destruction is identifiable through being careful on acceleration and moment graphs.

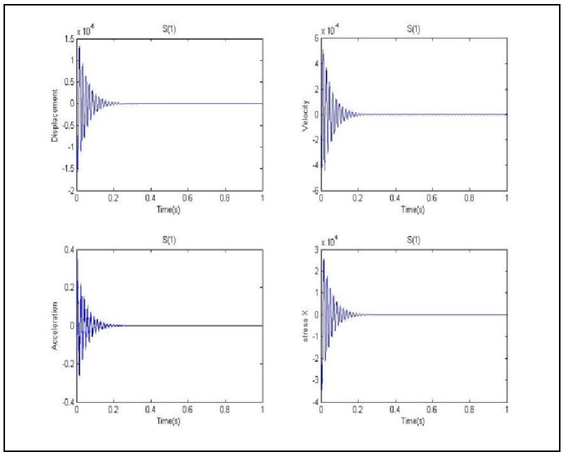


Fig.10: displacement-time, velocity-time, acceleration-time and moment-time history graph for healthy sample

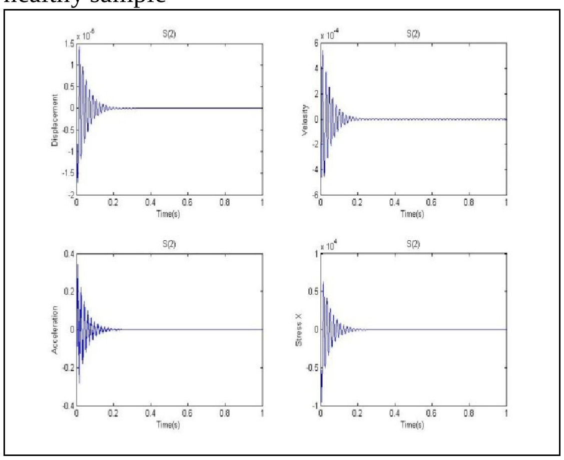


Fig.11: displacement-time, velocity-time, acceleration-time and moment-time history graph for 6 cracked samples

6. Conclusion

Investigating the effect of crack on structure which is in the form of decrease in natural frequency and disharmony among acceleration and moment graphs in healthy and cracked samples are very useful. Because the cracks are the most important reasons of structural destructions and their identification and appearance has a key role in structure resistance.

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Corresponding Author:

Mahdi Koohdaragh
Department of Civil Engineering
Islamic Azad University, Malekan Branch, Iran
E-mail: **Koohdarag@malekaniau.ac.ir**, **mehdi_k550@yahoo.com**

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