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Evaluation of Damping in the Joint System of MERO with Respect to the Degree of Bolt Tightness

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ABSTRACT

One of the most common connecting systems that is used for the manufacture of space structure, is MERO connecting system. So a perfect knowledge of the behavior of this connection is the most essential problem for the engineers and designers. The results have shown that different parameters including the degree of tightness of the bolts affect both the static and dynamic characteristics on these kinds of joinings. Distinctly in this research the effect of the bolt's tightness degree and the magnitude of the vibration on the dynamic characteristics of the MERO connecting system have been experimentally evaluated. Therefore a member made by this system in the form of a cantilever beam at different degrees of bolt's tightness and by the free vibration method and by making initial displacement was experimented in order to determine the quantity of dynamic system parameters including the damping ratio, damping coefficient and the natural frequency. The obtained results showed that the magnitude of bolt's tightness is directly proportional to the structure's vibration. Also the maximum damping ratio and damping coefficient occur at 60 NM bolt tightness, and if the tightness degree is more or less than this quantity, the magnitude of damping ratio and damping coefficient would be less. Also the results showed that there is a direct relation between the initial displacement with the damping, which means that by increasing the

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1- INTRODUCTION

MERO connecting system is one of the most common existing systems for constructing prefabricated space frames. The experiences show that the real behavior of prefabricated structures with this junction is different from their analytic results. This difference is the result of the effect of junction [1-3]. The previous studies on space frames with MERO connecting system showed that the damping has a relation with the degree of bolt's tightness [4-6]. The behavior of MERO junction is complex and analytic determination of the relation between damping and the degree of bolt's tightness in this kind of junction is difficult. The most basic reasons for complex behaviors of MERO connecting system are: geometric complexity, existence of materials with different characteristics in the structure of MERO connecting system, existence of screws with different tightness degrees, existence of contact surface and discontinuities and human mistakes in construction and installation. Due to the existence of these factors, determining the relation between damping and the degree of bolt's tightness is theoretically difficult, so the relation damping – degree of bolt's tightness was determined by using an experimental method and a series of experiments.

2- METHODOLOGY, DISCUSSION, RESULTS

In this research for creating free vibration in experimented component in order to determine the dynamic parameters, free vibration experiment and creation of a primary displacement at the free end of the pipe, were used. By linking a sinker to the free end of the pipe by using a thread, the primary displacement at the free end of the pipe was created, and by suddenly cutting the thread free vibration was made in it.

Numerous studies show that there is relation between amplitude of vibration and damping [7-8]. For investigating the effect of the amplitude and primary displacement in dynamic behavior of the component, 10, 15 and 20 kilograms sinkers were used for each sample. The response of the structure was also calculated by an accelerometer. The experiment was done with 6 tightness degrees of 30, 60, 90, 120, 150 and 180 Newton meter. By suddenly cutting the thread of the sinker which is linked to the free end of the pipe, the structure starts the free vibration and then the response of the structure which is received by an accelerometer, transfers to a data logger.

In this device the response of the structure changes from analogue mode to digital mode and then the digital response transfers to a computer. The computer has the ability to represent the digital information in framework of any software which is capable of using digital form of information, and the excel software is used in this research. As it was noted, in this research, the experimented component was tested in 6 tightness degrees, and in each degree the primary displacement was tested with three different sinkers, and it was tested two times with each sinker, and it was tested 36 times at the end. The responses were recorded with the rate of 1000Hz and duration of 5 seconds. After collecting the data (response of the structure), the parameters of natural frequency, damping ratio and damping coefficient of the structure were calculated in different cases as shown in Figures 1, 2 and 3.

In order to calculate the natural frequency of the system, the response of the system transfers to the frequency domain using the application of Fourier transformation in Matlab software and considering the peak coordinates in this diagram which shows the natural frequency of the system, the natural frequency was calculated. The method of logarithmic reduction was used to determine the damping [9]. In this method the logarithmic ratio of two amplitudes of sequential or

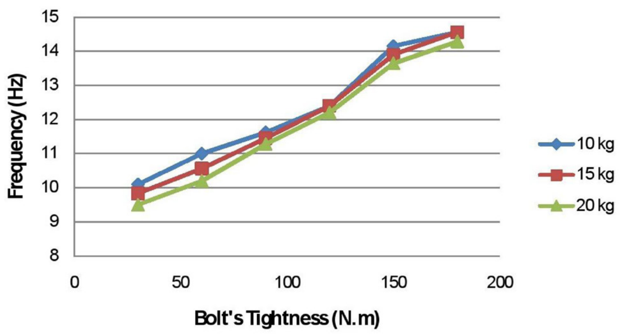

Figure 1. Diagram of Bolt's Tightness-Frequency

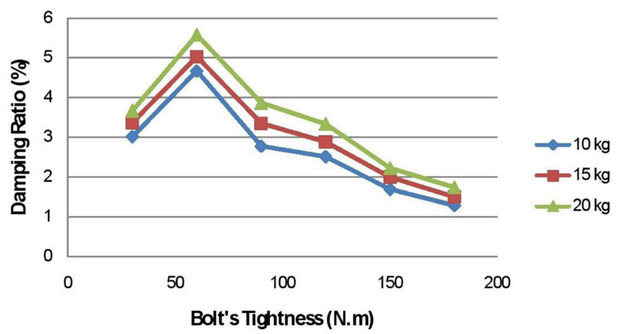

Figure 2. Diagram of Bolt's Tightness – Damping Ratio

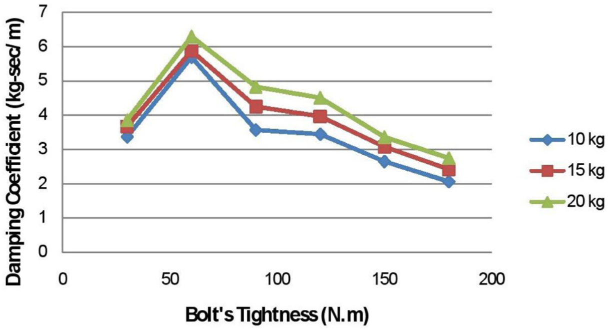

Figure 3. Diagram of Bolt's Tightness – Damping Coefficient

non-sequential (displacement, speed, or acceleration) peak should be achieved. One of the difficulties in this method is choosing amplitudes, because different dampings may be achieved for different amplitudes. So, in this method all the amplitudes of the acceptable peak were used in order to make the achieved value a criteria of the total real time of the vibration. So the chosen peak points of frequency periods and an exponential regression was fitted for this points. The regression function is like $y = pe^{-\zeta\omega nt}$, so by having the frequency, the damping ratio or ζ can be found. The damping coefficient or c can be calculated by using $c = 2m\zeta\omega n$.

3- CONCLUSIONS

This research is focused on determining the relation between the damping ratio and the degree of bolt's tightness in structures with MERO connecting system. By an accurate investigation it becomes clear that in most of cases and degrees, with increasing the tightness degree, the damping decreases. In other words, in high tightness degrees, the more a screw ties up, the less is the possibility of sliding and movement of components of the junction, and the amount of damping decreases. In fact with increasing the tightness degree, the possibility of sliding and movement between screw and orb and also between screw and pod decreases, so the coulomb or frictional damping decreases. The results also show that the highest damping ratio is in tightness degree of 60 newton meter and the farther we go from this degree, the damping ratio decreases.

Other results include the frequency direct relation with tightness degree, and this increase in frequency is due to the increase rigidity which happens because of an increase in tightness degree.

Investigating the effect of primary displacement on the damping ratio is also of other factor that was studied in this research. The achieved results show that the damping ratio changes with the amount of loadings. With increasing the amount of loadings, the damping ratio increases too. In fact increasing the amount of loading, increases the primary displacement and it causes the amplitudes of the vibration to increase. It means that the damping ratio is function from the amplitude of vibration and it has a direct relation with it.

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