ICSV13 - Vienna
The Thirteenth International Congress on Sound and Vibration
Vienna, Austria, July 2-6, 2006

ANALYSIS OF THE VIBRATION ISOLATION CHARACTERISTICS IN CASE OF ELASTIC SYSTEMS HAVING POLYGONAL SHAPE

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Abstract

This paper is a part of the ample and complex approach developed by the authors since 2002 and treats the matter of antivibrating elastic systems behaviour considering the natural loads, like various types of harmful vibrating waves, seismic waves, shocks, and so on, particularly the case of the antivibrating elastic systems having polygonal shape. The principal aim of this study is to present the procedure for analysis the isolation characteristics of the anti-seimic and anti-vibrational passive elastic support systems, basing on the numerical simulation and the experimental tests.

INTRODUCTION

This paper is a part of the ample and complex approach developed by the authors since 2002 and treats the matter of antivibrating elastic systems behaviour considering the natural loads, like various types of harmful vibrating waves, seismic waves, shocks, and so on, particularly the case of the antivibrating elastic systems having polygonal shape.

The anti-vibrational and anti-seismic passive elastic isolation systems have a very large area of constructive and functional composition. In this paper the authors presents an innovative solution for enlarge the static and dynamic deflection under the external loads. The main aim of this complex constructive shape is to enlarge the deflection of the general support system, in the time that the maximum deformation on the each constitutive elastic element, remain in the admisible domain (which have, in usual cases, small values). The authors tested o lot of elements and devices, more or less complex, basing on the rubber elements, with the final purpose to determine the optimal configuration which could assure the best isolation against the vibration and/or seismic type waves [3], [5], [6].

These are the innovative systems aiming to isolate vibration and/or seismic waves and they incorporate rubber elastic elements, arranged as polygonal shape nodes (e.g. regular hexagon, regular octagon) and connected together by means of stiff elements. The main purpose of this elastic elements structure arrangement, resulted from the most important requirements for antivibrating or antiseismic systems is to obtain very low values for the natural frequency of the entire ensemble: basement - isolation - structure. This means that the isolator has to assure very large displacements under the dynamic loads. The proposed arrangement of the elastic elements aims to increase artificially the values of the elastic elements displacement.

One of the very important steps of the systems analysis, is represented by the experimental estimation of the dynamic behaviour, particularly the transmissibility and the isolation degree taking into consideration the actual state and marking out the practical working zone. The dynamic analysis has been developed for two types of elastic isolation systems: with six and, respectively, eight elastic nodes. The tests have been carried out in laboratory simulating of the actual static and dynamic loads.

ELASTIC ISOLATING SYSTEMS WITH POLYGONAL SHAPE

In the Figure 1 it was presented the two proposed types of elastic isolating devices with polygonal shape, basing on the rubber torsional viscoelastic elements. This devices have six, respectively, eight rubber elements, hanged between them with metallic rigid levers. This kind of montage assure the very high deformations under the static and dynamic loads, at the low values of the rubber elements deformations - thus the elastic elements working at the linear zone of their characteristics.

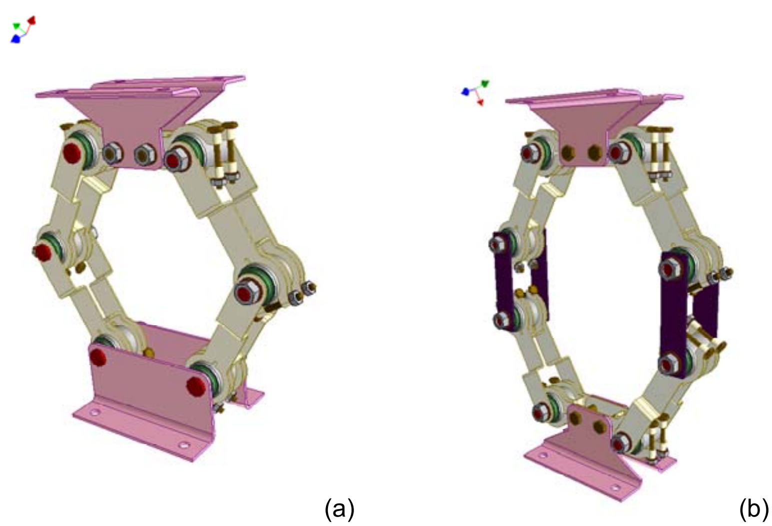

Figure 1 – Poligonal shape elastic isolation devices (simulating models)

Using this isolating devices, there is assure that the natural frequency of the entire ensemble - vibratory source/isolators/receiver - acquire lower values under the nominal loads.

In the Figure 2 it is presented a practically case of using the previous devices. The mountage of the four identical devices into a rectangular shape, assure the suitings conditions for practically using of the poligonal shape isolation devices, taking into account both the working instabilities, and the relative low values for serviceable loads (specific aspects for a singular device utilization).

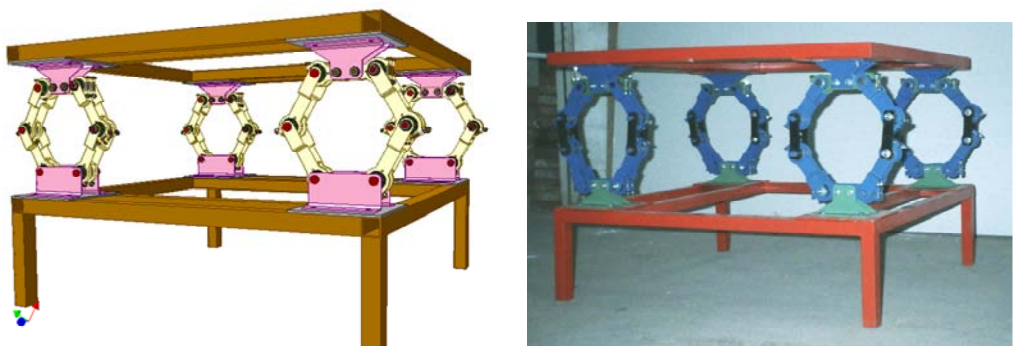

Figure 2 – Poligonal shape elastic isolation systems (simulating model and photo)

It is necessary to cite that all the proposed isolating devices in this paper have protection under the Romanian copyright laws at the OSIM Bureau.

THE DYNAMIC CHARACTERISTICS

The dynamic performances of the polygonal shape isolation ensemble could be characterize with the transfer characteristics of the system [1], [2], [4]. For this reason, it was developed a set of experimental tests, with the variable excitation frecquency. In the Figure 3 it is presented the diagrams of the accelerations that are acquires both from the support frame of the system - that means the input of the isolation system, and from the upper frame - that denote the output of the system. On the right side of time diagrams, it has presented the power spectral densities, for both acquired signals.

There is remarked, on the diagrams, that the output of the isolation system provide a modified composion of the signal, comparative with the input, meaning the diminution of the dominant frequency values. Also, on the output time evolution diagram there is remarked the resonance phenomenon, that is happened at low value of the input frequency. This fact lead to the partial conclusion that this kind of isolation devices furnishing the best performances for the most cases of the vibrational sources antivibrating isolation - characterized by less working frequency domain. In the next paragraph it will be demonstrate this fact, basing on the simulation on the SDOF numerical model, and transmisibility/isolation diagram.

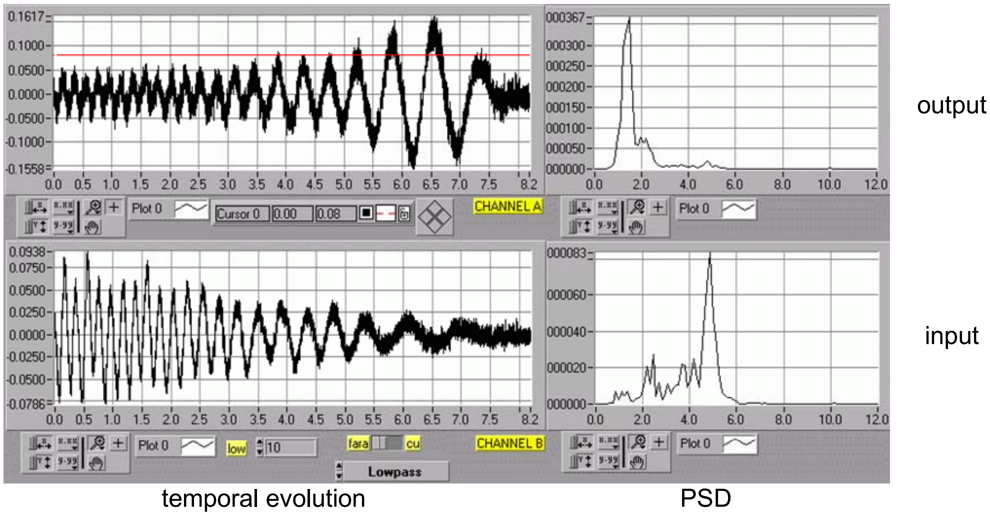

Figure 3 - The acquired signals for input and output of the isolation system

THE ISOLATION PERFORMANCES

Considering the SDOF model and using the transmisibility as a analysis parameter, for a low value of damping characteristic [1], [4], it was obtained the diagram presenting in the Figure 4. On this diagram it was drawn the global isolation limit (at unitary transmisibility), and also, it was drawn the useful isolation limits - over the 90% isolation degree, for most common applications, and over the 99% isolation degree, for special and sensible applications [2].

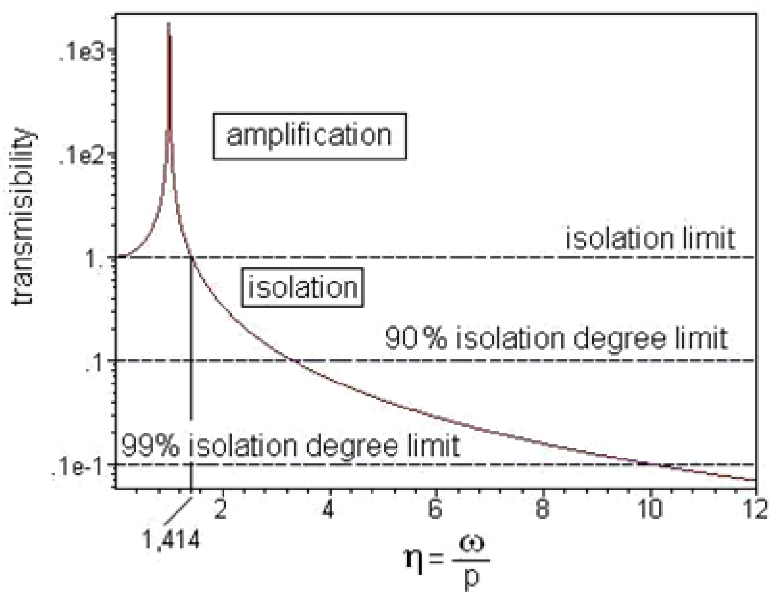

Figure 4 - Transmisibility diagram.Practical isolation limits

Analysing the transmisibility diagram (Fig. 4), there is remarked that the condition for 90 % isolation degree assurance imposing the pulsations ratio over the four value. For 99 % isolation degree it is necessary the pulsations ratio over the ten value. Considering that the common excitation sources frequency domains have the minimum value at 100 Hz, this imply the minimum value of the natural frequency of the isolation device at the 10 Hz, for the 99 % isolation degree, and at the 25 Hz for 90 % isolation degree. Experimental tests performed both for the six, and eight nodes, indicate a maximum eigen frequency of the isolating systems at the (6 ... 8) Hz, dependent by the working conditions.

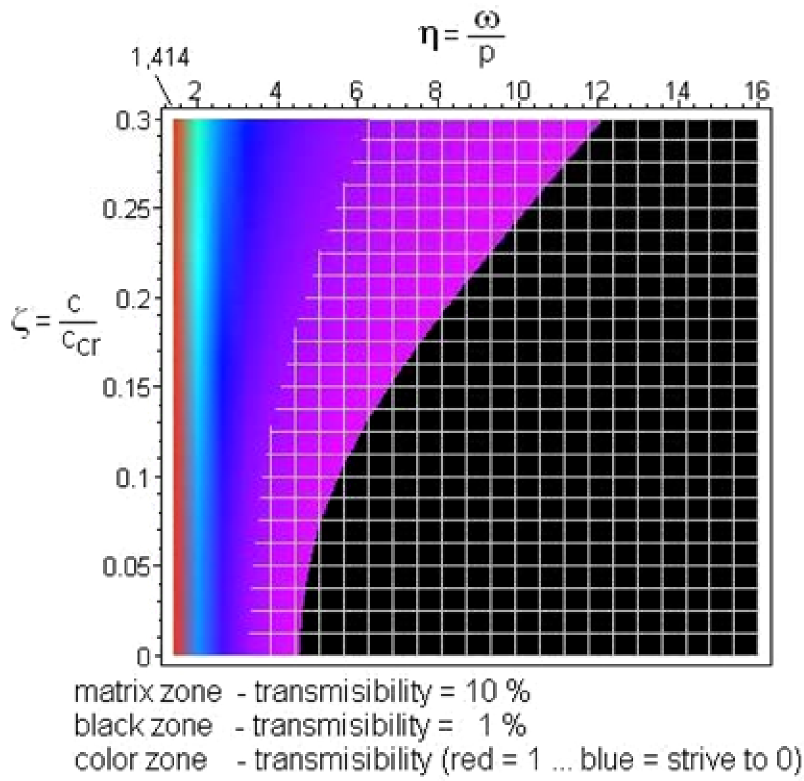

Figure 5 - Transmisibility diagram.Damping influence about the isolation degree limits

Even though the damping ratio of the elastic elements, and of the entire montage of these (devices, systems), have lowest values, the existence of dissipation have a bad influence on a isolation characteristic. This relationship between the pulsation ratio, damping ratio, and isolation degree, has presented on the Figure 5. On this diagram, the color area denote the transmisibility evolution, as a function of damping ration and pulsation ratio - red zone indicate a maximal values of transmisibility (unitary value), and blue/violet zone indicate a null striving transmisibility. Over this area, it was overlaping the two limits of the trasmisibility: 10 % - hatched area, respectivelly 1 % - black area. Analysing this diagram, result that for the imposed value of transmisibility or isolation degree, it is necessary a highest value of pulsation ratio, with increasing of the damping ratio. These means that for the common equipments with fixed low limit of working frequency (about 100 Hz), it is necessary to decreasing the eigen frequency of the isolating device, for framed into the specified lowest isolation limits. There is obvious that the diagram on the Fig. 4 has drawn for 0.24 damping ratio - experimental obtained medium value for the proposed isolating systems.

SUMMARY

The isolating devices presented in this paper have the main advantage of the lowest value of the natural frequency, relative with a constructiv and functional simplicity. Also, the elastic elements from their composition working at the primary zone of their characteristic, with low deformations, low dampings, and aproximative linear bearing under the external loads. All of these advantages enjoins these type of isolating devices both for a common, and for a special isolating applications.

Besides the rest of the experimental results - obtained from static and dynamic tests, these informations help to complete evaluation of this type of innovative and high performance antivibrating elastic systems.

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ACKNOWLEDGEMENTS

Experimental tests have been performed at the *Research Institute for Construction Equipment and Technologies - ICECON SA Bucharest, Romania*. The numerical computations and the behavioural analysis have been performed at the *Research Center for Machines and Technological Equipments Mechanics at the "Dunarea de Jos" University of Galati - Engineering Faculty of Braila, Romania*.