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ELASTOMERIC BASED COMPOSITES INTENDED FOR IMPACT PROTECTIVE DEVICES

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Abstract: *This paper contains a briefly description of vibration and impact protective devices based on elastomeric material layers with metallic insertions for high gaining in dissipative characteristic. The combination between conservative and dissipative characteristics leads to an appropriate performances according to basic requirements of common application from the shock and vibration protection area. The study starts from theoretical estimations of performances related to mitigation of the impulsive actions effects completed with a set of relevant computational simulations. Based on comparative analysis was arranged an experimental setup for evaluation and tuning of computational models. Final research presents technical solution with numerical evaluations and some simple estimative dynamic test analysis with relevant results.*
Keywords: *shock, vibration, protection, elastomeric, dissipation.*

1. INTRODUCTION

Shock and vibration isolation area made up the main frame of this study. Particularly, new innovative materials fill this research domain. Better mitigation of dynamic effects due to different technological processes imposes improvements of isolation characteristics of base insulation devices. In fact all of these hypothesis, based on large number of experiments and "in situ" measurements, means that the problems got to the materials characterization pointing both static, and especially dynamic performances in use. Another problem appears from the working regime of these base isolation devices that can be stationary - for ordinary cases, or strong transient - for some extreme cases such as shocks and seismic actions.

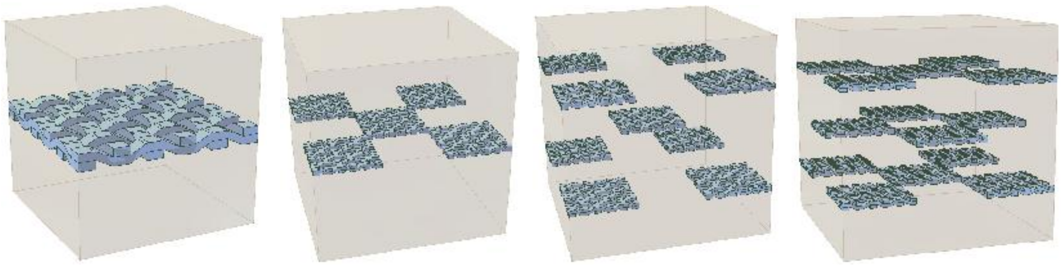
The entire category of vibration isolation materials provides a conservative characteristic that assures tuning adjustments between the operational regime of dynamic source and the receiver, and a dissipative component that enable the energy reduction during the dangerous peaks of the dynamic actions. If the conservative component usually depends by the technical system requires dynamical effects mitigation, the dissipative part can be adopted or improved thus that the entire isolation solution be able to reduce the overloads induced energy. This is the basic idea of this research, actually to improve the dissipative characteristic of a serviceable composite structure. Hereby, an adequate insertion that can grow up both the viscous and the dry friction inside the material frames the major objective.

Elastomeric materials are widely used in many applications where is utmost necessary the mitigation of vibration due to various domestic or industrial sources. Most of these materials are available by the thin sheets that were mounted between the isolated system and the base support. The combination between elastomeric array and metallic insertion generate a composite that is able to provide an improved dissipative characteristic thorough additional internal frictional component. Because of the montage configuration results also a certain gain in global stiffness for the entire ensemble. A consistent gain of viscous damping because of local phenomena at the interfaces between the array material and the insertion frame another advantage of this solution.

This paper presents a set of three solution for composite with metallic insertion base on neoprene rubber (NR), high-density polyurethane (HD-PU) and extruded polystyrene (XEPS). Theoretical hypothesis and experimental tests provide basic information for comparative analysis.

2. COMPUTATIONAL APPROACH

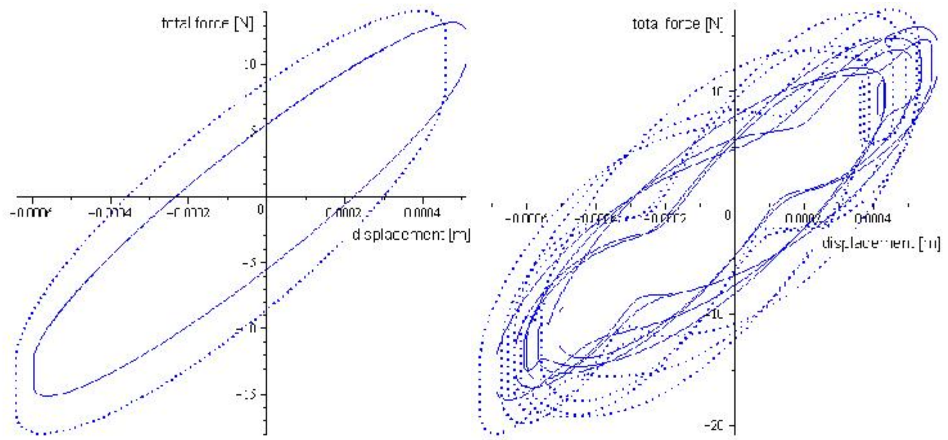
A computational approach was developed for estimation of essential parameters governing dynamic behaviour of these proposed composites. In Figure 1 are depicted the basic configuration and other three additional configurations for these sandwich materials. Finite element method analysis provides a group of estimative numerical datum that allows performing next sequence of simulation according to the entire vibroisolation system.



(a) (b) (c) (d)

Figure 1: Basic configuration of composite based on elastomeric array with metallic insertion single layer continuous insertion (a), single layer distributed insertion (b), double layer symmetrical insertion (c), and triple layer asymmetric insertion (d)

Hysteretic evolution of the system reveals the influences both of the viscous damping and of the dry friction about the isolation system behaviour. Obviously, the realistic excitation case has inaccurate traces on the hysteretic diagram, but the global evolution allows functional qualitative differentiation between dissipative component influences. In fact, this is one of the arguments for the future experimental evaluations.



(a) (b)

Figure 2: Hysteretic behaviour of a composite based on elastomeric array with metallic insertion harmonic signal input (a) and input generated by a real equipment (b)

Diagrams in Figure 2 show the hysteretic evolutions for harmonic excitation signal - theoretical analysis case, and for real excitation equipment - realistic approach, respectively for composite with and without metallic grid insertion. Insertion gains in dissipation between two cases were supposes to be around of 50% for viscous component and of 100% for dry friction component, while the global stiffness value of array material have a value of $2\ 10^5$ N/m^2. One of the hypotheses consists supposed additional stiffness of the insertion layer was neglected.

3. EXPERIMENTAL ANALYSIS

Starting from initial estimations resulted from computational analysis it was ensemble three types of composites supposing neoprene rubber (NR), high-density polyurethane (HD-PU) and extruded polystyrene (XEPS) array materials, with identical type of metallic grid insertion for each solution. In Figure 3 main samples of each composite was depicted (see figure for details). It was used a single layer continuous insertion between two layers from identical array component.

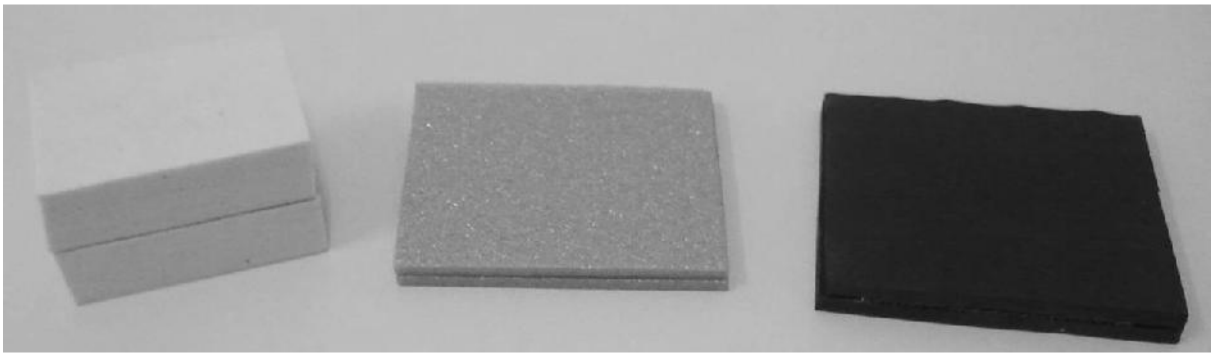


Figure 3: Composite base materials: high density polyurethane (left), extruded polystyrene (middle) and isoprene rubber (right)

Regarding the experimental tests, it has to be mentioned that many authors proposed different methods for evaluation of the essential dynamic parameters. Some of these methods are based on the classical Oberst method or modified Oberst methods. The authors of this study was considered for this first approach that behavioral differentiations between analysis cases can be dignified through transitory state evaluations in respect with the transitory regime time length both at the start, and at the end of the external dynamic excitation process.
Experimental setup for dynamic behaviour analysis is presented in Figure 4. It was used a vibratory equipment and the practical montage consists in symmetrical axial compression of each composite sample (see Fig. 4 for details). Static load was used to assure the compression dynamic charging taking into account peak value of instantaneous dynamic action supplied by test equipment. It was evaluate vibration parameters, transmitted force and displacement of the stand basic pathway.

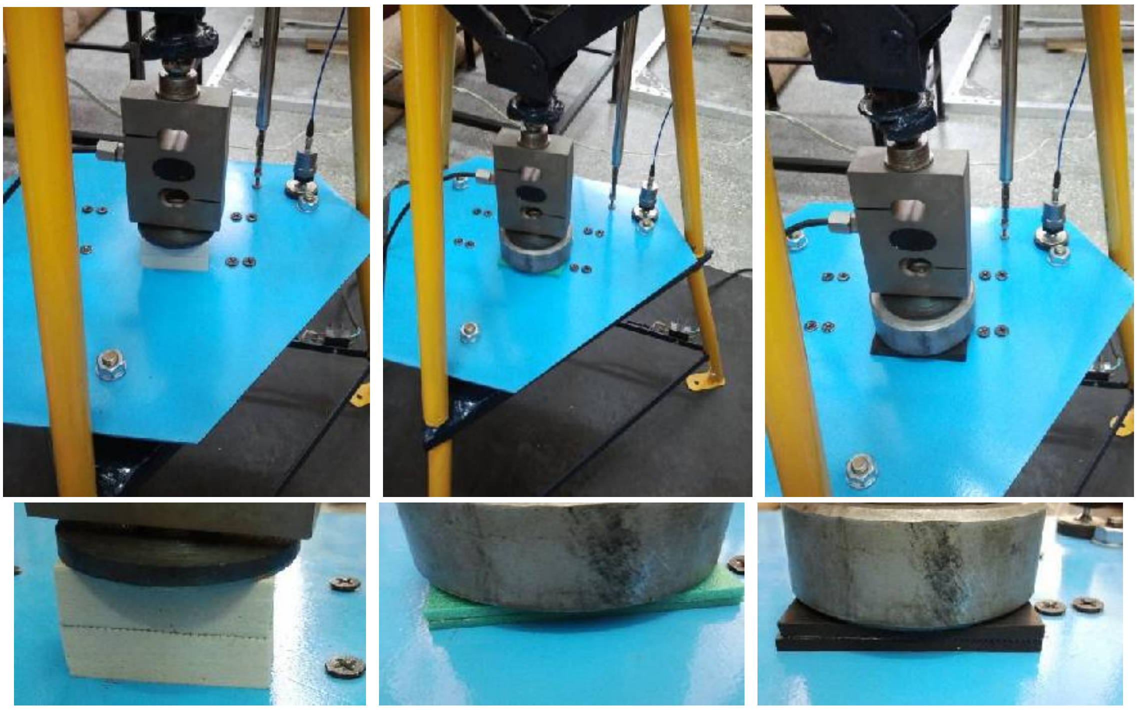
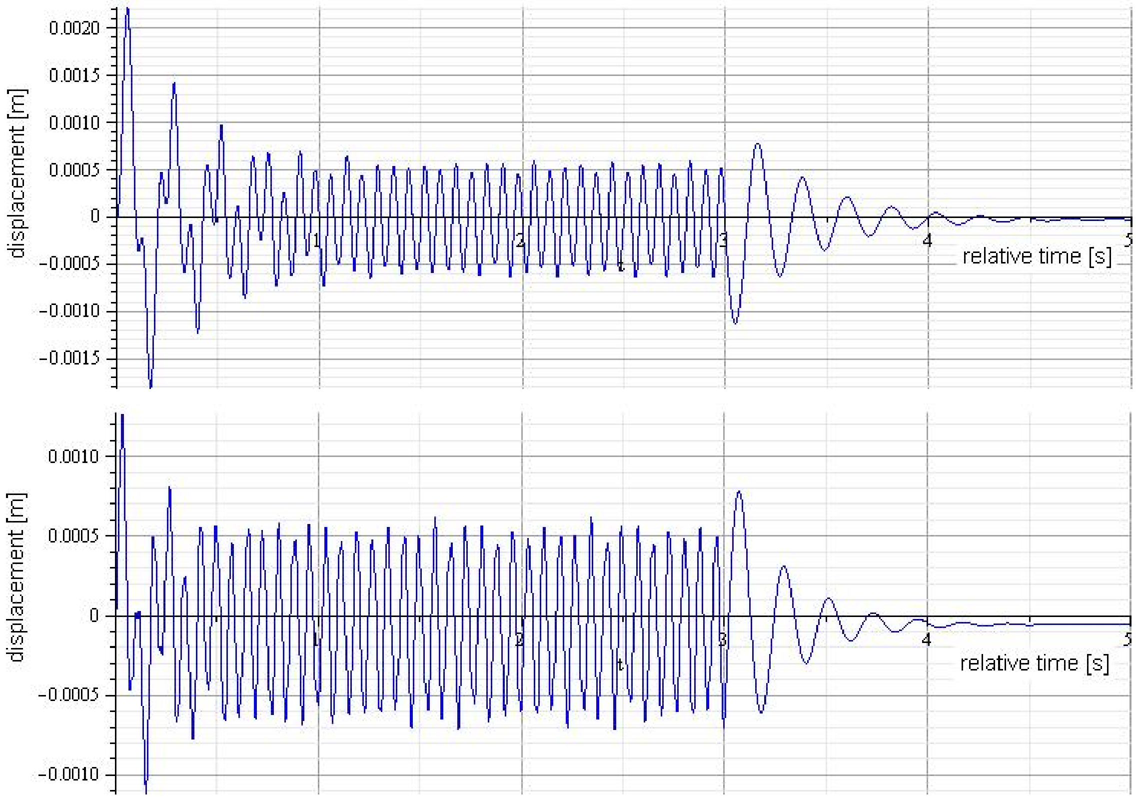


Figure 4: Experimental tests setup: for HD-PU (left), for XEPS (middle) and for NR (right); general view (top) and montage detail (bottom)

4. RESULTS AND DISSCUSSIONS

Displacement signals results in timed diagrams depicted in Figure 5. This paper presents a singular case corresponding to the neoprene rubber based composite. The diagrams was overlapped because of comparison facilitates. Note that the other two cases present similar evolutions differentiated by global time length of transitory regime and peak-to-peak magnitude of the signal.
Analysis of the diagrams in Figure 5 put into the evidence a certain reduction of the transitory regime corresponding with the case of insertion presence relative by the other case. Even if the acquired signals were

processed with 20Hz low-pass filter, resulted shape is not very smooth. Hereby, precisely evaluation of transitory state duration at the start of testing procedure become quite heavily because is not very evident the moment of time when the vibration magnitude acquires constant value (see Fig. 5). At the same time, the final transitory regime do not depends by the vibratory equipment and the signal trace into this zone enable an accurate estimation of time length from the moment of stop generator (user defined value; for presented tests *t=3s. from the process beginning*) to that when the system movement become inessential.



(a)

(b)

Figure 5: System evolution for tested composite based on neoprene rubber without (a) and with (b) metallic grid insertion

Cross correlations between the two cases reveals a good flexibility of these composites solutions, denoted by reduction of both transitory regimes in respect with time length. Hereby starting state provides 60...100% diminishing comparatively with the initial transitory regime duration, and stopping state provides 20...30% reduction. The values for starting regime were affected by uncertainty much more then the other. The differences between the two ranges of values (for initial and final transitory states) together with previous suppositions hold the idea of considering only the final free vibration regime for parameters evaluation.

5. CONCLUDING REMARKS

This is an estimative qualitative analysis which has two main advantages as follows: validates the initial hypothesis of this study and the utilization of a pure harmonic excitation can enable more sensitive qualitative and quantitative evaluations of dissipation gains for proposed solution of antivibration composite material.
Future works must be handled to perform more experimental tests, by samples with all of the structural configurations, dignify repeatability and reliability of the results and try to use different type and shape of insertion structure thus that it will be enable the optimization process of global isolation characteristic for different dynamic actions.
Next step of this research also consist by full integration of computational analysis with advanced instrumental tests thus that the final results being able to improve the global dynamic performances of this protective solution.

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