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CORRELATIVE ESTIMATIONS IN USING OF EFFECTIVE CONFIGURATIONS FOR VIBROINSULATION ELASTOMERIC ELEMENTS

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ABSTRACT

This paper deals with practical insulation devices, systems to provide the tradeoff between the contact with earth (in order to resist to gravitation) and the separation from earth (in order to withstand the earthquake). It was proposed to adopt for modeling and analysis an isolation system of HDRB type (high damping rubber bearings) because this system has benefits. Thus, it was chosen for analysis a number of six vibroinsulation elastomeric elements and was studied the behavior of these elements using a specialized software of finite element analysis namely ALGOR.

KEYWORDS: insulation systems, high damping rubber bearings, vibroinsulator elastomeric elements, specialized software of finite element analysis

1. INTRODUCTION

Most engineers [8], [9], [10] have minimum knowledge about what base isolation is - a system of springs installed at the base of a structure to protect against damage caused by earthquakes. The "base isolation" term [8], [10] uses the word "isolation" meaning "the condition of being separate" and the word "base" meaning "part that supports or serves as a foundation for an object or structure." Quite literally, the structure (a building, a bridge or a piece of an equipment) is separated from its base. The ideal separation should be total, but for this there are practical limitations.

This paper deals not with the ideal case, but with practical insulation systems, which provides the tradeoff between the contact with earth in order to resist to gravitation and the separation from earth to withstand the earthquake.

In Romania the seismic isolation systems are of circular or prismatic type. A specific form of seismic isolation system must be designed with internal rubber layers of the same thickness, between 5 to 25 mm each alternating with steel sheet. The choice of the seismic isolation systems [12] is based on their characteristics and benefits.

In the early 1980s, the developments in technology have led to new rubber mixtures which were called "high damping rubber" (HDRB). From these mixtures were produced isolation elements with high stiffness at small shear efforts and with a reduced rigidity at higher levels of effort.

2. THEORETICAL APPROACHES

In this paper it is proposed to adopt for modeling and analysis an isolation system of HDRB type (high damping rubber bearings), due to its benefits.

Thus, we chose a number of six vibroinsulator elastomeric elements and we studied their behavior using a specialized software of finite element analysis namely ALGOR. The elastomeric elements chosen for the study are:

- ❖ elastomeric element with rectangular geometric shape, with 532x532x230 dimensions, entirely composed of elastomers, with grip both at the top side and at the bottom side, one flange with rectangular shape with 650x650x8 dimensions (Figure 1);

❖ composite element with rectangular geometric shape, composed from elastomeric layers with 538x538x37.5 dimensions (6 layers), alternating with metal plates with 538x538x1 dimensions (5 layers), with both at the top side and at the bottom side, one clamping flange with rectangular shape with 650x650x8 dimensions (Figure 2);

❖ elastomeric element with cylindrical geometric shape, with ϕ600x230 dimensions, entirely composed of elastomers, with grip both at the top side and at the bottom side, one flange with rectangular shape with 650x650x8 dimensions (Figure 3);

❖ composite element with cylindrical geometric shape, composed of elastomeric layers with ϕ617x37.5 dimensions (6 layers), alternating with metal plates with ϕ617x1 dimensions (5 layers), with both at the top side and at the bottom side, one clamping flange with rectangular shape with 650x650x8 dimensions (Figure 4);

❖ elastomeric element with rotation hyperboloid with single surface geometric shape, with ϕ140xϕ106x70 dimensions, entirely composed of elastomers, with grip both at the top side and at the bottom side, one flange with cylindrical shape with ϕ140x8 dimensions (Figure 5);

❖ elastomeric element with cylindrical geometric shape, with ϕ124x70 dimensions, entirely composed of elastomers, with grip both at the top side and at the bottom side, one flange with cylindrical shape with ϕ124x8 dimensions (Figure 6);

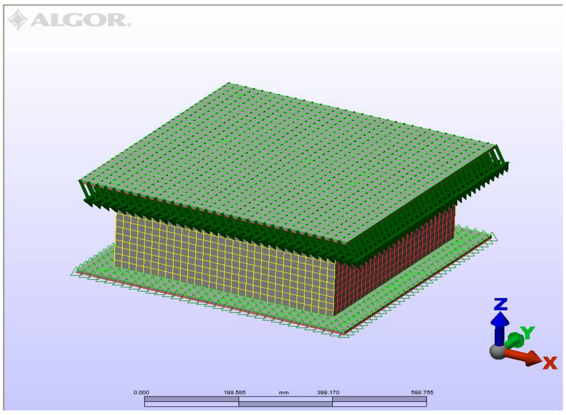

Fig. 1 Insulation element entirely composed of elastomers with rectangular shape, ALGA type

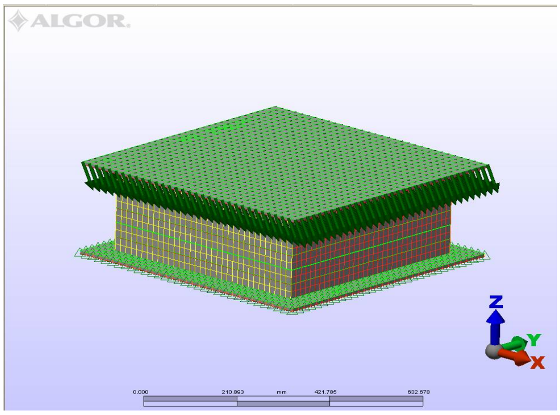

Fig. 2 Composite insulation element (elastomer - metal plates) with rectangular shape, ALGA type

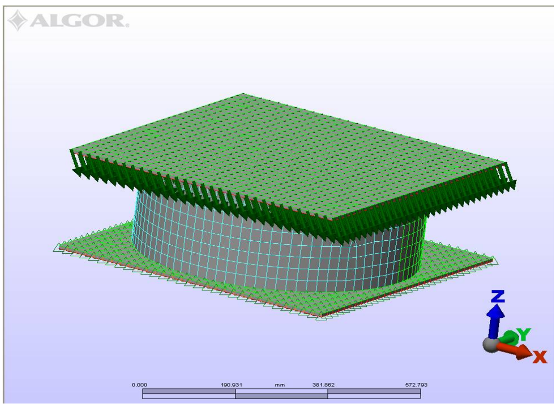

Fig. 3 Insulation element entirely composed of elastomers with cylindrical shape, ALGA type

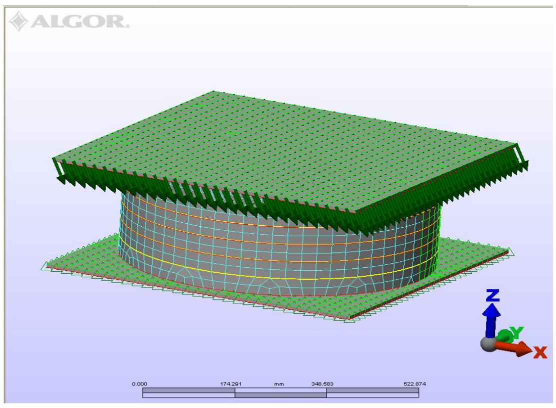

Fig. 4 Composite insulation element (elastomer - metal plates) with cylindrical shape, ALGA type

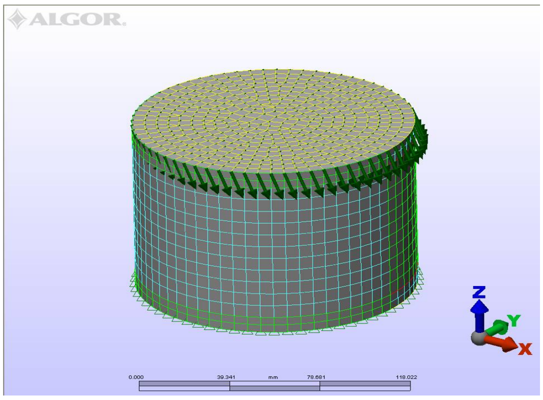

Fig. 5 Insulation element entirely composed of elastomers with cylindrical shape, ICECON type

The elements considered for analysis were divided function of size into two groups: the group of the first four items presented, manufactured by ALGA, and the group which contains the last two elements of AB4 type - ICECON SA. The results obtained from the finite element analysis can be compared when we consider the elements of the two groups separately regarded.

For the analysis of the presented bearings there has been taken into account two main criteria that have been preserved throughout the study: constant volume of the elastomer and constant height of the elastomeric system. The volume of elastomer kept constant is justified through the fact that the elastomer is the fundamental element of the insulation system and it fundamentally affects the global characteristics of the entire system. The constant height of the insulation system is justified through the installation requirements, being a basic feature on installing systems in question.

The element with the geometric shape of rotation hyperboloid with single surface was taken from the experimental section and was generated using the measured real dimensions.

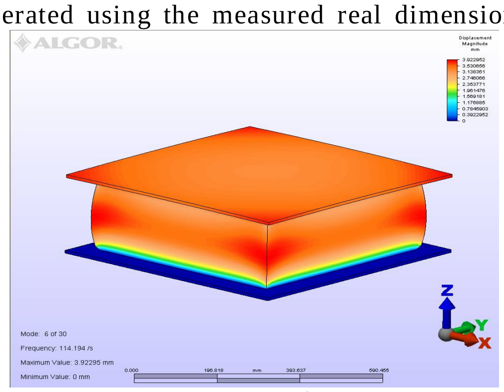

Fig. 7 The behaviour of the insulation element, entirely realized by elastomer, with rectangular shape ALGA type, in the

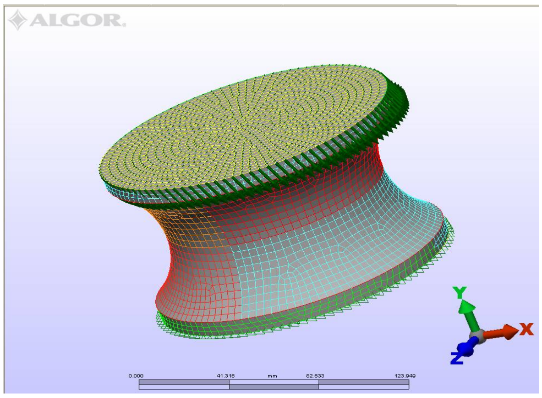

Fig. 6 Insulation element entirely composed of elastomers with rotation hyperboloid with single surface shape, ICECON type

The same mass of material was distributed in another geometric shape, a cylinder one, to observe the difference between the hypeboloid shape and the cylinder shape which is the most common shape of these elements, at least for large loads. Through the selection of the two geometric shapes for analysis (using in each case the same volume of elastomer) it was obtained a number of partial results and conclusions based on a comparative analysis.

3. CASE STUDY

The study done on these groups of elements proposes to determine the first phase of vibration eigenmodes. Modal analysis was performed in the ALGOR software and we considered that it is important to study the first 30 natural frequencies because these frequencies are significant and may influence the system behavior. For superior modes, the frequencies have higher values and the amplitudes take small values and we conclude that high frequencies are not dangerous for the system. Anyway, the frequencies with high values do not fall within the interest area of the conducted study.

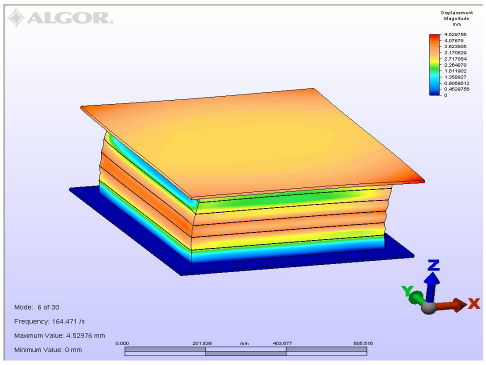

Fig. 8 The behavior of the insulation composite element (elastomer - metal plates) with rectangular shape ALGA type, in the eigenmode

eigenmode with number 6

with number 6

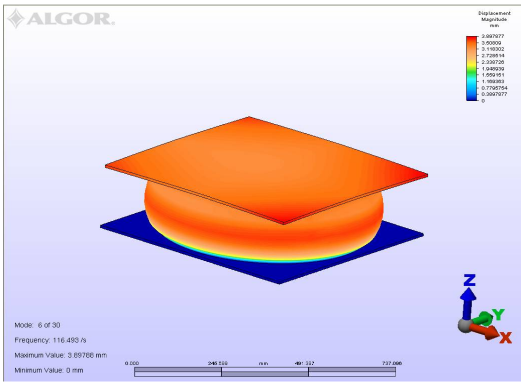

Fig. 9 The behaviour of the insulation element, entirely realized by elastomer, with cylindrical shape ALGA type, in the eigenmode with number 6

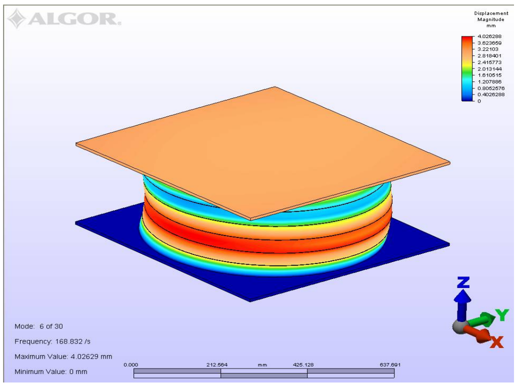

Fig. 10 The behavior of the insulation composite element (elastomer - metal plates) with cylindrical shape ALGA type, in the eigenmode with number 6

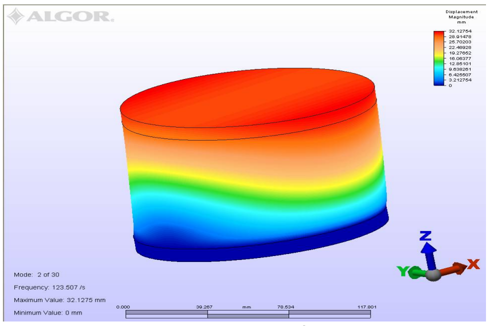

Fig. 11 The behaviour of the insulation element, entirely realized by elastomer, with cylindrical shape ICECON type, in the eigenmode with number 2

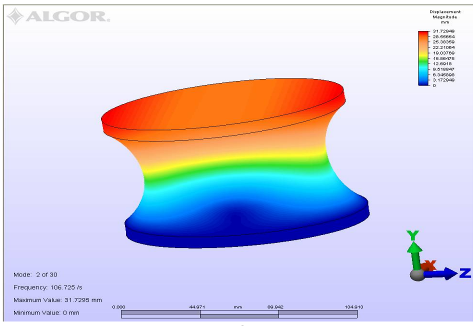

Fig. 12 The behaviour of the insulation element, entirely realized by elastomer, with rotation hyperboloid with single surface shape ICECON type, in the eigenmode with number 2

The materials proposed for the finite element analysis for the composition of the components of the elastomeric-based insulation system were chosen as precisely model the real phenomenon. Thus, for the active part of the system was chosen an elastomeric material of A4 polyurethane type, which was modeled through a rheological model of an hyperelastic type, using the Mooney-Rivlin model. For plates and flanges was chosen a material of ASTM A36 steel type, simulated with a reology of isotropic elastic material.

Figures 7 ...12 show the behavior in a suggestive eigenmode of vibration for each of the six insulation elements proposed for analysis. Thus, was chosen the eigenmode with number 6 for the insulation elastomeric elements of ALGA type and the eigenmode with number 2 for the insulation elements of ICECON type.

Having the results of modal analysis through the report given by ALGOR software, we achieved with MATLAB software for both groups of insulation elements, the evolution graphics of frequencies according to vibration eigenmodes.

It is noted in the graphic in Figure 13 that for the insulation elements group of ALGA type, both with metal plates and without plates, the behavior is similar in the sense that the frequency is increased in the same time with the transition to superior eigenmodes.

Furthermore, for the first three eigenmodes, in a first approximation, it can be said that the frequencies have a constant value regardless of the geometric shape of the element, the presence or absence of the metal plates. At a closer analysis, however, it can be noticed that the frequency values are different in the sense that for the elements without plates the frequency has a lower value and for those with plates it has a higher value. Also, between the eigenmodes with number three and four, the evolution begins to differ significantly depending on the presence or the absence of the plates. Thus, for the fourth eigenmode it is observed that the frequency value of the elements with plates is much higher than that of the elements without plates and that difference in evolution is maintained and amplified for superior modes. Interesting to note is the fact that the elements without plates have similar behavior both in terms of curves form and in terms of frequency values for the entire interval of the 30 eigenmodes considered. For the elements with plates, the evolution differs significantly in the superior eigenmodes, especially in terms of frequency values, in the sense that the cylindrical element with plates receives for frequencies significantly higher values than the rectangular element with plates.

In the graphic in Figure 14 it is observed the evolution of elastomeric insulation elements ICECON type. Both elements are made entirely of elastomer, without plates. The behavior in terms of frequency dependence on eigenmodes differs only in terms of geometrical shape (cylinder or hyperboloid).

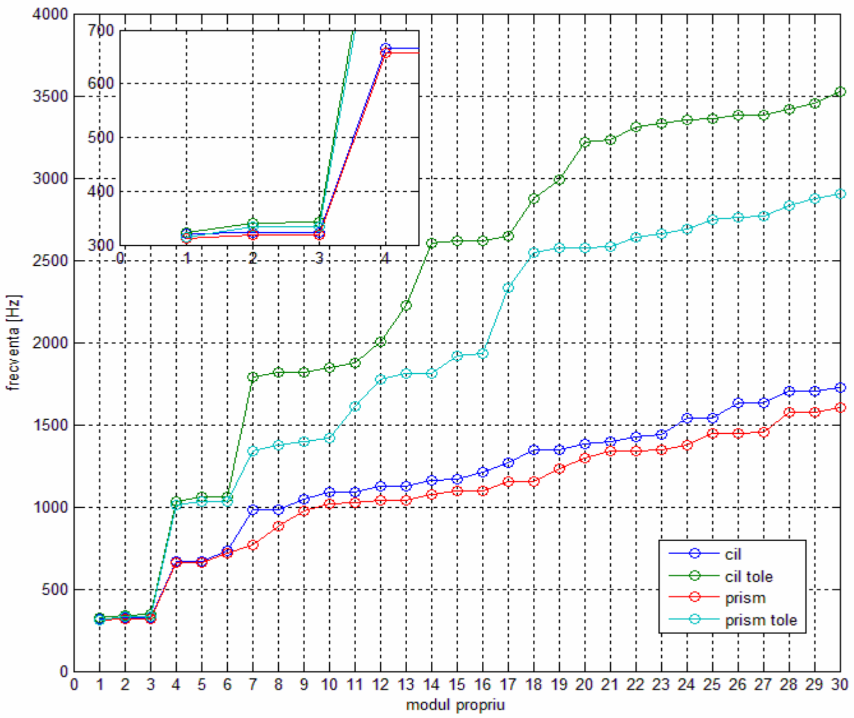

Fig. 13 The frequencies evolution according to eigenmodes for elastomeric insulation elements, ALGA type

4. CONCLUSIONS

One can see a similar evolution in the first eigenmodes, with lower values of frequencies for hyperboloid and significantly higher for the cylinder. Interesting to note is that, between the eigenmodes six and seven, the two elements change the places, and further, going to superior modes, are preserved the curves forms, while the hyperboloid shape element takes higher values for frequencies compared to cylindrical element.

Based on previous observations and specifications, we can draw an important conclusion regarding the validity and validation of the concept of form compatibility which is the central idea of this paper: the elastomeric insulation elements with metal plates have values significantly higher for the frequencies than those without plates, so these elements have high rigidity and they ensures the stability of the structure-insulator assembly.

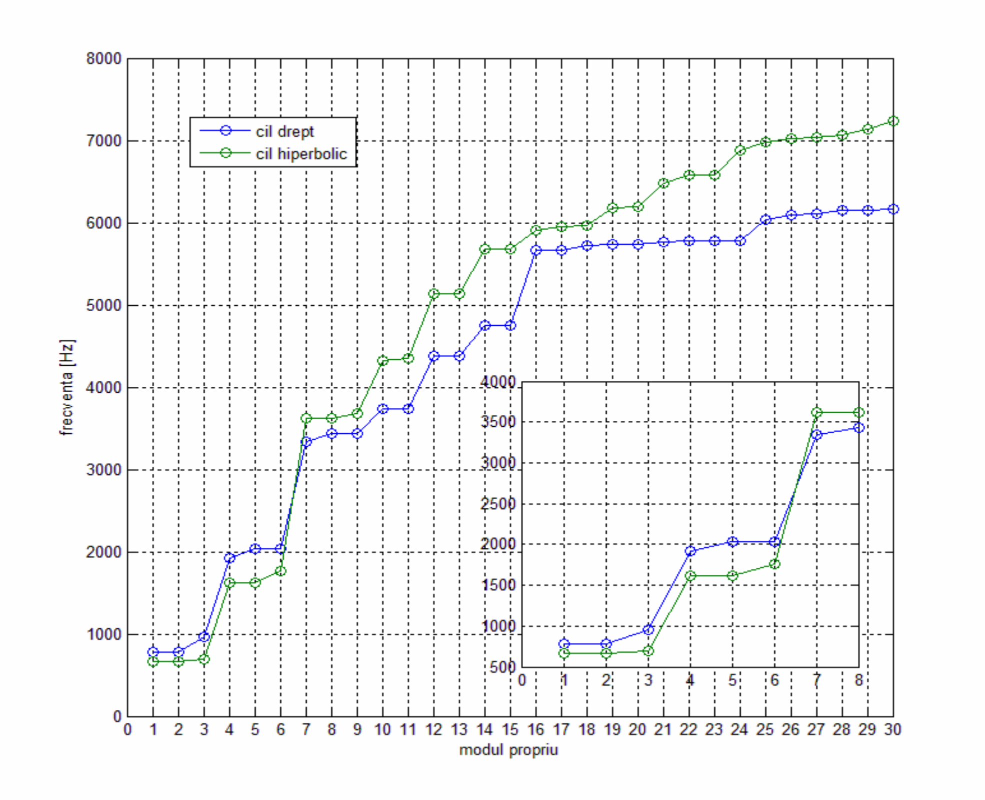

Fig. 14 The frequencies evolution according to eigenmodes for elastomeric insulation elements, ICECON type

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