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ASSESSMENTS REGARDING EFFECTIVE CONFIGURATIONS OF VIBRATION ISOLATORS BASED ON STRAIN ANALYSIS

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ABSTRACT

This paper aims to treat the case of some practical insulation systems used for buildings, systems that assure the compromise between the contact with the ground in order to resist to gravitation and separation from ground to withstand earthquake. I chose a number of six vibroinsulator elastomeric elements, classified into two groups depending on the producer, different as geometric shapes and as composition, and we studied their behavior using a specialized software of finite element analysis. After the analysis of MES - Mechanical Event Simulation type with nonlinear material models performed using ALGOR software, the global deformations for the device were chosen for visualization and graphics were made that provide information about the evolution of the system deformations according to the height of the insulation element.

KEYWORDS: insulation element, global deformation, vibroinsulator elastomeric elements, software of finite element analysis

1. INTRODUCTION

Civil engineers [13], [14], have minimal knowledge about what the base isolation is - a spring system installed at the base of a structure to protect it against damages caused by earthquakes.

They also know little about when and why - when the base isolation should be used and why. When we need to choose a system from all the possible variants, there is a set of "how" questions to be answered - how to design the system, how to connect the system to the structure, how to evaluate its performances, how to set precise tests and how to build it. And, of course, how much it costs [1], [2], [3].

The principle is simple: the separation of structure from the ground. The earth will move, but not the building. Solutions exist, but none of them solves additional problems which arise due to the lack of support or due to the stability loss.

This paper presents the case of some actual insulation systems, which provide a compromise between the structure and the ground in order to resist to the gravitation and the separation of the structure from the ground to withstand the earthquake [4], [5], [9], [10].

In the 1970s, the first applications that use rubber-based components for isolation were built. However, they have the disadvantage of a small damping amount and they were not stiff enough to withstand the operational loads.

2. THEORETICAL APPROACHES

In this paper, it is treated the case of the isolation system that uses the high damping elastomers, because of the advantages they present [11], [12].

The chosen system contains a number of six vibroinsulator elastomeric elements and we have studied their behaviour 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 from 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).

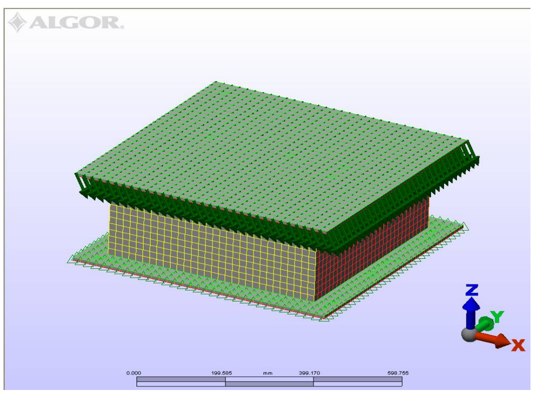

Fig. 1 Insulation element entirely composed of elastomers with rectangular shape, ALGA type

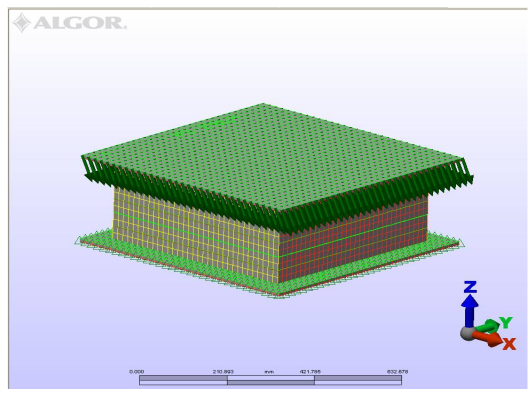

Fig. 2 Composite insulation element (elastomer - metal plates) with rectangular shape, ALGA type

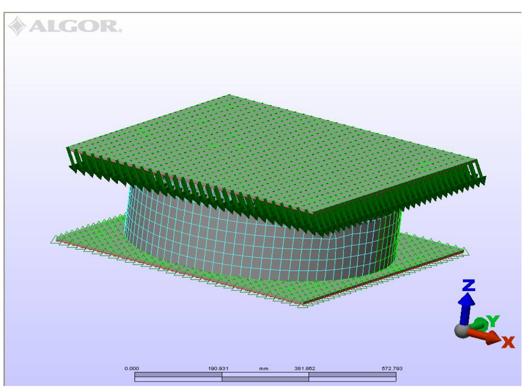

Fig. 3 Insulation element entirely composed of elastomers with cylindrical shape, ALGA type

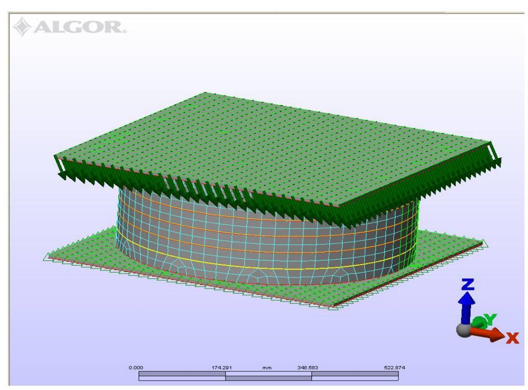

Fig. 4 Composite insulation element (elastomer - metal plates) with cylindrical shape, ALGA type

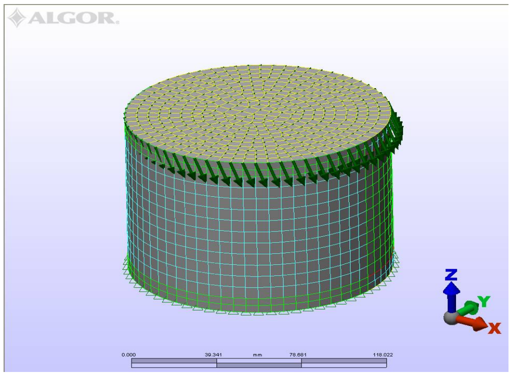

Fig. 5 Insulation element entirely composed of elastomers with cylindrical shape, ICECON type

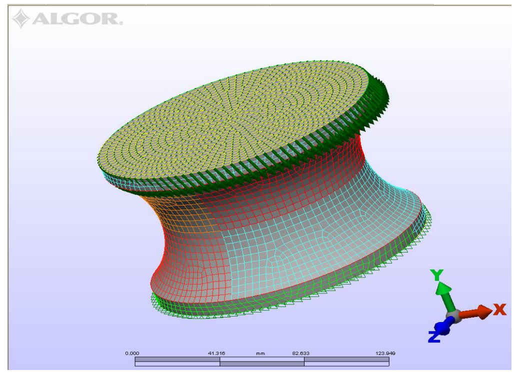

Fig. 6 Insulation element entirely composed of elastomers with rotation hyperboloid with single surface shape, ICECON type

The elements considered for analysis were divided by 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 two main criteria were taken into account and those were 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 the systems in question.

The element with the geometric shape of a rotation hyperboloid with a single surface was taken from the experimental section and it was generated using the measured real dimensions. The same mass of material was distributed in another geometric shape, of cylinder, to observe the difference between the hyperboloid 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) a number of partial results and conclusions based on a comparative analysis were obtained.

3. CASE STUDY

Then I decide to analyze the behavior of insulation elastomeric systems solicitated by actions of force type with components both on the vertical and the horizontal directions, to simulate the real effect of loading given by structure (with influence in the vertical direction) and the disruptive effect given by a seismic excitation (with influence in the vertical but especially in the horizontal direction). The loading mode simulates the global status of solicitation in a support area. The analysis is made in ALGOR MES - Mechanical Event Simulation type with nonlinear material models and the global deformations for the support device were chosen for visualization.

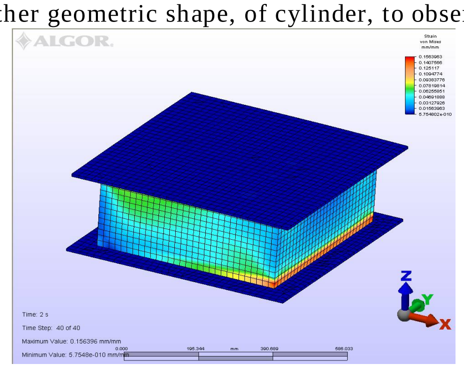

Fig. 7 Deformations in the insulation element, made entirely of elastomer, with a paralellipipedic shape, ALGA type

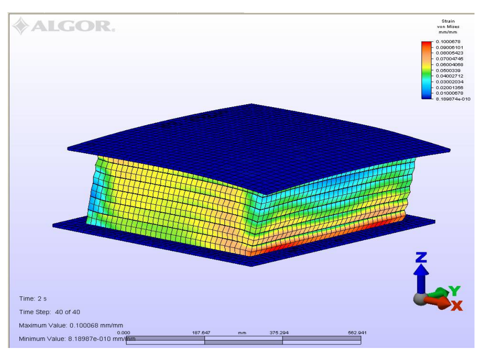

Fig. 8 Deformations in the composite insulation element (elastomer - metal plates), with paralellipipedic shape, ALGA type

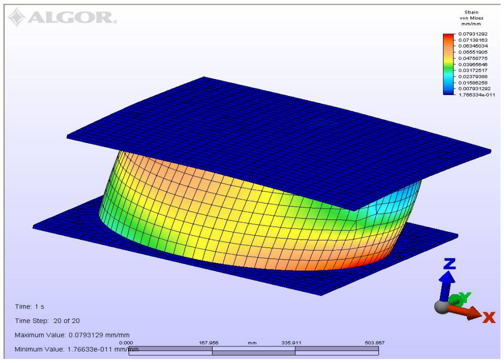

Fig. 9 Deformations in the insulation element, made entirely of elastomer, with a cylindrical shape, ALGA type

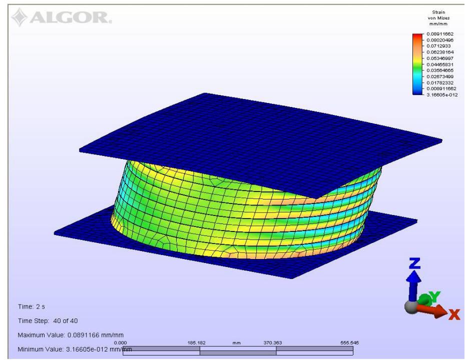

Fig. 10 Deformations in the composite insulation element (elastomer - metal plates), with cylindrical shape, ALGA type

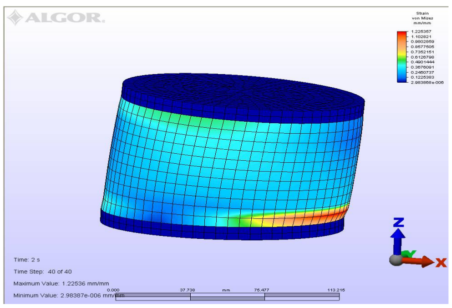

Fig. 11 Deformations in the insulation element, made entirely of elastomer, with a cylindrical shape, ICECON type

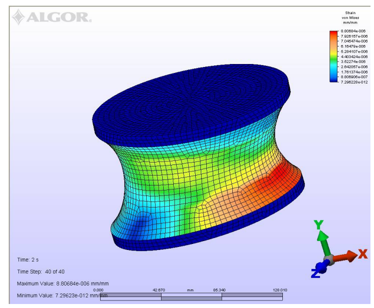

Fig. 12 Deformations in the insulation element, made entirely of elastomer, with rotation hyperboloid with single surface shape, ICECON type

The materials used to analyze the behavior of the system were: for the active part of the system an elastomeric material of A4 polyurethane type was chosen, which was modeled through a rheological model of hyperelastic type, using the Mooney-Rivlin model; for plates and flanges a material of ASTM A36 steel type was chosen, simulated with a rheology of isotropic elastic material.

After the MES analysis, we have chosen to show in Figure 7 ... 12 the global deformations of the considered system.

Based on the results offered by ALGOR, there graphics were made that provide information on the evolution of system deformations according to the height of the insulation element. The analysis was separately made for the two groups of elements taken into account.

4. CONCLUSIONS

The graphics that show the system deformations according to the height of the elastomeric element are presented in Figures 13 and 14. In figure 13 the graphics for the ALGA type elements are represented, which were made separately, due to their completely different evolution. It can be seen that in the case of the element with cylindrical shape, without plates, the evolution is continuously increasing in height and in the case of the element with paralellipipedic shape, without plates, the evolution is rapid only to low values of the height of the elastomeric element, then it becomes slow, presenting specific small deformations. In the case of the insulation elements with plates, the evolutions are specific because the plates have no deformations and they try to maintain the entire system undeformed, at the same time, the elastomer layers have deformations, hence the graphics have the shape from Figure 13 (the second and the fourth graphic).

For the insulation elements ICECON type from Figure 14, there are similar evolutions of specific deformations, such as the increase of the specific deformations depending on the elastomer height: the rapid increase at low values of height, and the slow increase when we are close to the maximum height of the elastomeric element.

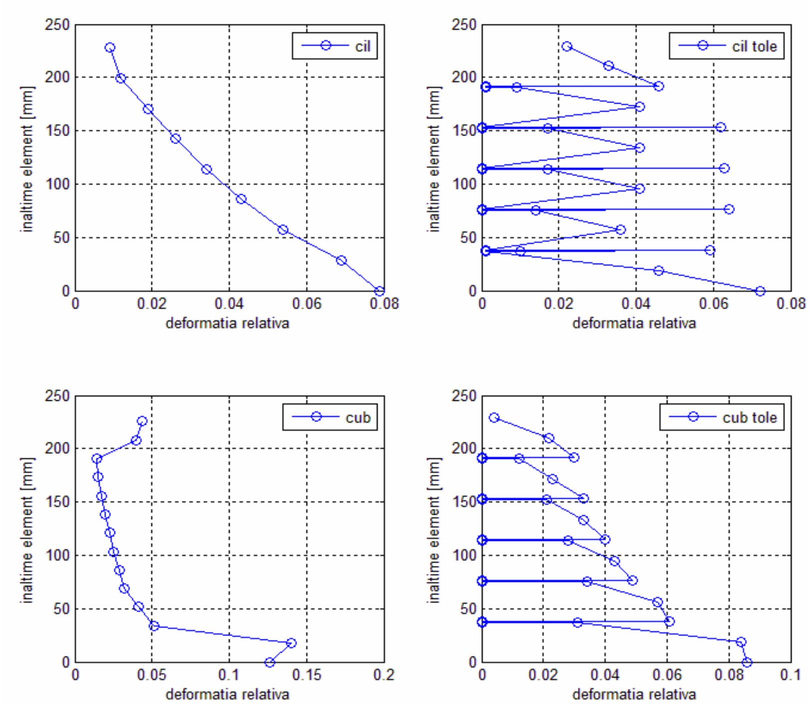

Fig. 13 Evolution of the system deformations according to the height of the elastomeric insulation element, for the ALGA type elements

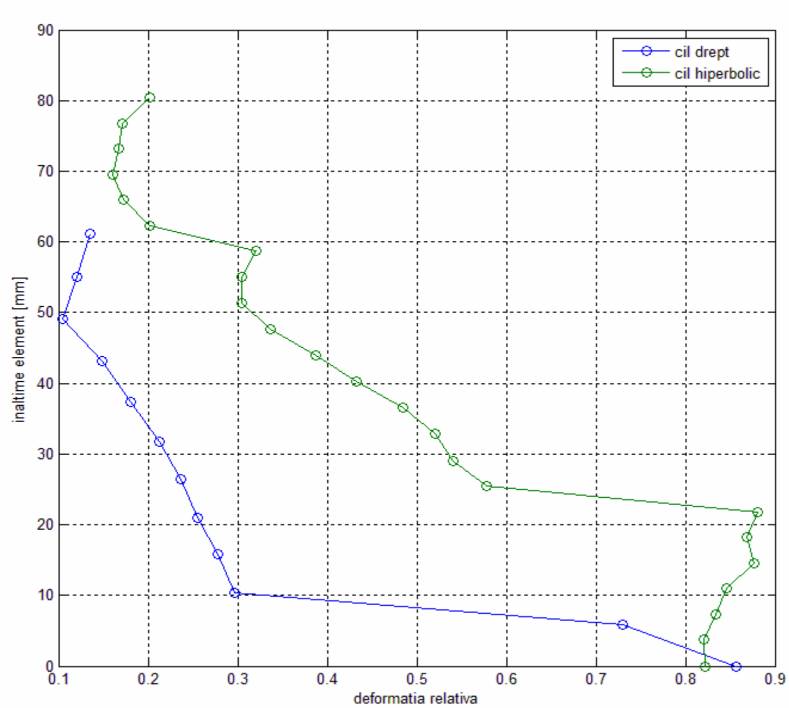

Fig. 14 Evolution of the system deformations according to the height of the elastomeric insulation element, for the ICECON type elements

The assembly of the results obtained from this study provides the necessary support for a comparative analysis of behaviour modes for the system formed of seismic action - foundation - insulator - structure. The aim of the study was the compatibilization of all the system components in order to achieve better performances of dynamic isolation.

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