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ENERGY DISSIPATION BY MECHANICAL MEANS IN CONSTRUCTIONS UNDER CYCLIC LOADING

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ABSTRACT
This thesis provides an analysis of strains and stresses in the proposed model for mechanical energy dissipation with and without a passive control. A numerical analysis is performed for a reinforced concrete wall of an object. The purpose of the analysis was to determine a simple way of controlling the dissipation of energy induced in the construction by earthquake loading by using a mechanical system for the energy dissipation. Introduction of horizontal forces acting on the construction under a typical earthquake loading and the subsequent numerical analysis is performed by using the SAP 2000 program. A smooth, steel reinforcement bars, positioned outside of the wall section, are proposed as the elements for the energy dissipation. The plastic deformation of the steel bars, caused by cyclic tensile loading created by horizontal displacements of the wall, enables the dissipation of the generated energy. The force distribution to steel bars also results in lower stresses in the critical section of the wall. The former presents a type of a passive steering of the construction where a system of dampers, located outside of the building section, is used as the system for a passive control of the stresses and strains induced in the construction. The numerical analysis of the wall returns the displacements caused by a gradual increase of the horizontal forces while a dynamic analysis accounts for a real earthquake loading. The outputs of the analysis are forces in the wall's cross section including bending moments at the cantilever support and forces in steel bars of the mechanical system for the energy dissipation.

Keywords: energy dissipation, dampers, steering of a construction, dynamic loading, earthquake, bending moment

1. INTRODUCTION
A new technology known as "steered constructions" in the engineering practise is being developed within the last twenty years of the last century. Also an expression that can be used is "intelligent constructions". Depending from the technological solution, these construction have controlled state of safety for both static and non static as well as additional loads produced by the influence of wind, earthquake or vibrations [1]. With steered construction we are basically providing controlled behaviour of objects what provides an lower answer in constructions for generated outside influences such as earthquake, wind or any other dynamic factor. Regulation of dynamic answer is a con trolled process that can be achieved in different ways. We can say that steered constructions are a consequence of development of engineering in general and they are giving answers to challenges of technological innovations and human knowledge in creating. We can find in literature [1] and practise

technological solutions based entirely on steered construction, then semi-active or passive steered constructions.

2. NUMERICAL ANALYSIS ON THE MODEL

This thesis, that is a part of the doctoral dissertation of the author [2], includes a numerical analysis on a model of seismic, wall of reinforced concrete of an object with six floors. Analysis should help determine that in a simple way, we simulate principle of construction steering by setting up a system for dissipation of energy that has been put mechanically into the construction during the earthquake. Simulation and numerical analysis was carried out by using SAP 2000 programme. For the system for energy dissipation, we have suggested steel reinforced bars. When analysing, the number of bars and eccentric spots where they were placed was varying. The very model is a console. Reinforced bars are placed above the cross-section. As such, they give an additional coupling that is decreasing cross section forces in the critical cross section. Therefore, this would be one type of passively steered construction where system of dampers outside of the cross - section is given as the system for passive construction steering i.e. its stress and strain characteristics. Through its deformation, dampers are carrying out the dissipation of energy that was put in by the dynamic load. Everything was carried out with the precondition that on the reinforced bars, as the system for energy dissipation, exist the system for self-adjusting so that dissipaters of energy can always remain in the regime of tension forces during the earthquake. The principle of self-adjusting is given in the MA thesis of the author where we have determined the deformation characteristics and ductility of the connection of construction elements [3].

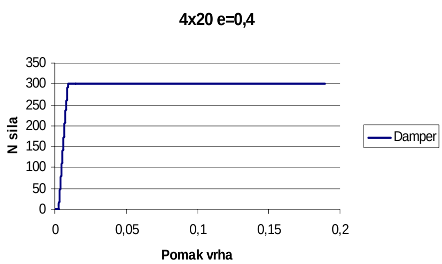

Figure 1. Force in the damper

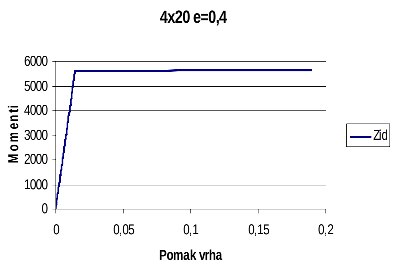

Figure 2. Bending moment in the wall

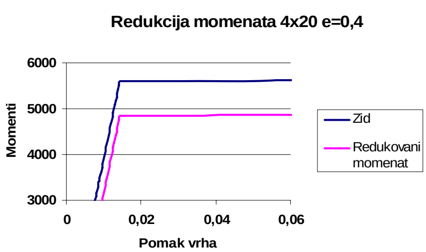

Figure 3. Reduction of bending moment

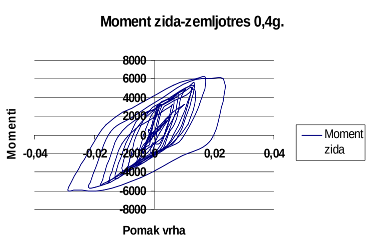

Figure 4. Bending moment in the wall - earthquake

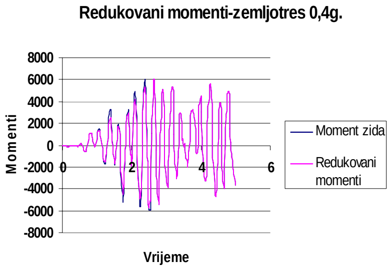

Figure 5. Reduced bending moment – time domain

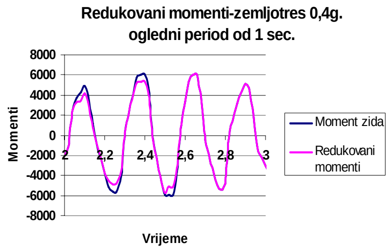

Figure 6. Reduced bending moment – 1 sec. period

Illustrated diagrams give results of numerical analysis on the suggested model with and without the damper. The model, i.e. seismic, reinforced wall of one object is 4, 2 x 0, 2 m., with 18 meters of height. It is reinforced with symmetrical reinforcement 6Φ 19 made of ribbed steel. Reinforced bar Φ 20 made of steel and placed outside of the cross - section was suggested as a system for dissipation of energy that was put in into the construction through dynamic impact. The capacity of the cross – section, expressed in the form of a bending moment is 5630 kNm (Figure 2). Through nonlinear analysis, we have obtained in the damper depending from the number of reinforced bars (Figure 1.). We have carried out an analysis for the cases of dumper of 1Φ 20, 2Φ 20 and 4Φ placed on eccentric spots of 0 m. and 0, 4 m. from the wall edge. Results given in the diagrams refer to the damper case of 4Φ 20 that is placed on the eccentric spot of 0, 4 m. as a result of the damper activity, we have obtained the reduction in bending moment and by it a increase of the capacity of critical cross section of the wall in clamp for 12%. It is shown in a form of a diagram (Figure 3) as a ratio of the wall's bending moment without the damper (blue line in the diagram) and reduced moment of wall bending with the damper (red line in the diagram). In further analysis, the impact of dynamic load through real record (El-Centro earthquake) was applied to the suggested model. We have obtained the values of the force flow depending from the shift of wall top and the time domain. In the case of aforementioned earthquake and its acceleration of 0, 4 g. we have shown the results of bending moment depending from the time (Figure 4). The damper activity on the wall model under the impact of real earthquake load is visible on the diagram of the reduced bending moment (Figure 5). In order to understand better the reduction of bending moment under the influence of damper, we have taken a single period of 1 second (Figure 6), where we can see the moment of reduction in different intervals (in the figure: ratio of moment of bending without the damper – blue line and reduced bending moment – red line).

3. CONCLUSIONS

- The wish of the constructing engineer is to try to influence as much as possible the reduction of construction movement during dynamic load. In recent years, it is applied in different types of steered construction. In this paper, we have carried out research and analysis and we have suggested one simple work principle for energy dissipation system mechanically. It can be used with cyclic load of building constructions in the case of elastic and plastic deformation of the very system.
- It is important to emphasize the possibility to foreseen in the construction the expected area of plasticisation and to influence the plasticization mechanism by using the suggested dampers.
- Due to the effect of reduction of cross section forces of the construction by setting up the system for energy dissipation, we have increased the cross section capacity and the entire construction. This would influence the increase of construction resistance during the dynamic load.
- During smaller intensity of dynamic earthquake or wind effect, we have the beginning of the process of plasticization of the critical cross section of the console foundation of construction. Due to the reduction of bending moment by using the suggested dampers that are plasticized, stresses of the construction foundations in this case remain elastic.

- The system suggested in this paper compared to systems known in the world of simple construction. The application of this system is possible with new or reinforced of existing object. Due to its simple construction and small cost prices it is applicable having in mind the situation how much funds we need to invest for the reinforcement or improvement by using classical solutions or possible building of new construction in a case of expected impact of a deadly earthquake or wind of a big intensity. By comparing the prices and invested work of such a system with other materials used in the construction, we can propose the application of such a system.
- the area of the application of the system is possible even with construction of new, reinforcement and improvement of existing elements of construction foundations such as lintels, bars and poles, etc.

4. REFERENCES

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