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INFLUENCE OF DUCTILITY CLASSES TO SEISMIC RESPONSE OF REINFORCED CONCRETE STRUCTURES

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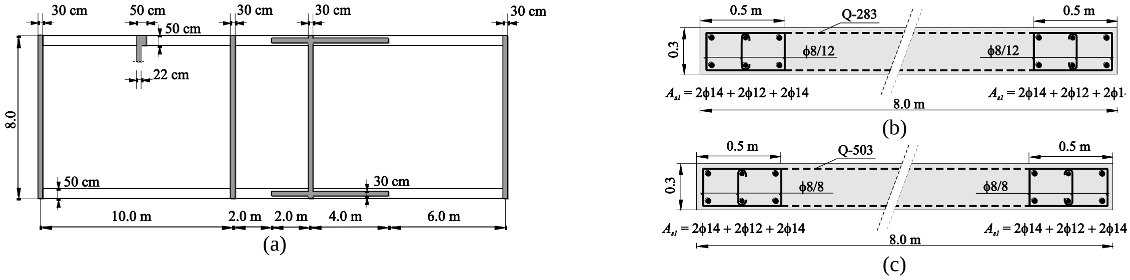
One of the main aims of the design of earthquake resistant structures is to ensure that the design seismic action do not cause collapse of the structure. Eurocode 8 [1] includes prescriptions in order to guarantee ductile behaviour and adequate bearing capacity of the structure. According to Eurocode 8, concrete buildings in high seismic area are classified in two ductility classes, DCM (medium ductility) and DCH (high ductility), to predefine the behaviour of the structures, leading to different responses. However, the behaviour of the structure cannot be fully predetermined due to many factors that play a key role in such a problem. Specifically, the diversity of the nature of the earthquake can produce significant differences in structural behaviour with respect to the same ductility class. On top of that, each of the ductility classes implies completely different perspective regarding the design of the building. Thus, one needs to make a judicious choice between the two classes balancing between the desired response of the structure, costs and complexity of design and construction.

Powerful numerical models stand as significant tools to obtain more insight into the peculiarity of each structure. The model of this kind should be able to produce highly nonlinear effects which are dominant in the behaviour of RC structures under the seismic loading until collapse. In this paper influence of ductility classes to seismic response of RC structure was performed by finite-discrete numerical model for RC structures [2, 3]. The model considers discrete representation of the cracks, the interaction between the reinforcement and concrete considered by steel strain-slip relation with the influence of adjacent cracks to the slip of reinforcing bar, local slip of reinforcing bar due to a high plastic deformation under reversed cyclic loading and the influence of the curvature of reinforcing bar to yield stress reduction of the steel. The structure is assumed to behave as a linear elastic continuum until the initiation of the cracks and discontinuities, which are allowed to propagate through the joint elements of concrete, leading to the deformation in the reinforcing bar joint elements [2, 3].

Analysis of the influence of ductility classes to seismic response was studied on a five-storey RC building with uncoupled wall system (Figure 1a). The vertical load of the building consists of own weight, an additional dead load of 2.5 kN/m^2 and impose load of 4.0 kN/m^2 at floor slabs. The building was previously designed according to EC8 [1] for importance factor II (γ_I=1), type 1 response spectrum, damping ξ=5%, ground type B, design ground acceleration a_g=0.3g and ductility classes DCM and DCH. The behaviour factors equal to q=3,0 for DCM and q=4,4 for DCH are adopted.

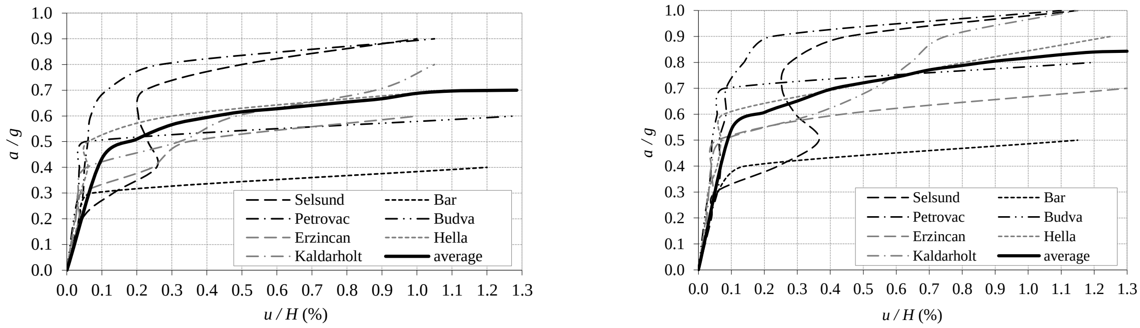
Incremental dynamic analysis of the left boundary wall with reinforcement shown in Figure 1b and 1c was performed using previously described finite-discrete numerical model [2, 3]. Seismic loading is represented by a time function of horizontal ground acceleration recorded on the soil class B during real earthquakes. The set of seven ground motion records are chosen from the European Strong-Motion Database [4]. Average acceleration response spectrum of applied earthquakes corresponds to elastic response spectrum for peak ground acceleration of 0.3g and soil class B according to EC-8 [1].



(a) (b) (c)

Figure 1. RC building: (a) geometry, (b) reinforcement for DCM, c) reinforcement for DCH.

Analysis of the average dynamic response of the wall for a series of seven records of real earthquakes (Figure 2) shows that the behaviour of the wall designed for DCM class is linear up to the ground acceleration a=0,30g. Significant non-linearity starts for a=0,48g, while the collapse of the wall happens for a=0,70g. Wall designed according to DCH is in linear elastic region up to the a=0,40g, followed by the occurrence of nonlinear behaviour. Average collapse acceleration a=0,84g was observed for DCH class.



(a) (b)

Figure 2. The ratio between the maximum roof displacement *u* and the wall height *H* for RC wall in dependence to the peak ground acceleration: (a) DCM, (b) DCH.

The most destructive earthquake for both ductility classes is Bar, with ultimate collapse accelerations a=0,40g and a=0,50g for DCM and DCH classes respectively. The least destructive earthquakes, considered through the aspect of collapse accelerations, are Petrovac and Selsund, which produced the collapse of the wall for a=0,90g (DCM) and a=1,0g (DCH).

It can be observed that the wall reinforced according to the DCH possess average seismic resistance 20% higher with respect to DCM. It is interesting to emphasize that the longitudinal flexural reinforcement in the boundary elements is same for both ductility classes in order to satisfy condition of the minimum percentage of reinforcement. The differences pertain to confining reinforcement in boundary elements and web shear reinforcement cause higher seismic resistance of the high ductility wall. The average responses for both ductility classes still remain linear before they reached design ground acceleration.

Acknowledgments

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