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Applicability and economic efficiency of earthquake retrofit measures on existing buildings in Bucharest, Romania

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The research discussed in this contribution contains two aspects: on one side the economic efficiency of seismic retrofit measures, and on the other their applicability. The research was limited to housing buildings. Bucharest, the capital of Romania, was the object of the research. Strong earthquakes affect Bucharest about three times in a century, the damaging earthquakes of the 20th century being in 1940 and 1977. Other strong earthquakes occurred in 1986 and 1990.
Since it is a broad topic, first the building type was determined, which should serve further research. For this scope the building types of the 20th century, which are common in Bucharest, Romania, were investigated. For each building type reports have been written, which comprised the earthquake resilient features, the seismic defficiencies, the damage patterns and the retrofit measures. Each of these features was listed for elements of the building.
A first result of the research was an integrated system in order to include latter aspects in the planning in the first steps. So already at the building survey attention has to be paid on how a building is subdivided in order to be able to determine the economic efficiency of the planned action. So were defined the ‘retrofit elements‘. In a first step the characteristics were defined, through which these retrofit elements (for example column, wall part between two windows) can be recognised in the building survey. In a further one, which retrofit measures can be connected to these. Diagrams were built, in order to visualise these findings. For each retrofit element and the corresponding measure the costs were calculated. Also, these retrofit elements and the measures connected to them were modelled for the simulation with the structural software, so that the benefit of the measures could be determined.
In the part which regarded the economic efficiency, benefits and costs of retrofit measures had to be compared, so the improvement in the rigidity, ductility and/or strength of the structure at different retrofit measures with its costs. In order to investigate the improvement in the seismic characteristics numerous simulations of the earthquake impact on reinforced concrete frame buildings were conducted and in that context conventional strengthening measures with reinforced concrete and steel were considered. In these reinforced concrete frame buildings interwar buildings from Bucharest were modelled, as these proved to be the most vulnerable in the initial investigation. For the investigation of the economic efficiency also the damages through earthquakes were simulated. With help of a characteristic of the software used so called performance points could be set, so at the end of the simulation it could be seen how strongly was damaged the steel and respectively the concrete in the reinforced concrete element and so was conducted a classification of the strength of the damages in different retrofit elements. These simulations were done for the 1977, 1986 and 1990 earthquakes, as for these the strong motion records were digitally available. For two simple models alternatives of retrofit actions and their locations were fully simulated, while for real building models customised retrofit strategies considering more retrofit elements within the strategy were employed.
To the benefit belong not only the improvement of the structural behaviour, as often assumed in earthquake engineering circles. There belong also aesthetical and sociologic aspects. In order to give these aspects their rights, a decision tree was developed, in which the actors are the engineer, the architect, the investor and the user. The retrofit measures were evaluated with two different decision systems. This was the part about the applicability.
Further research would serve to see how can be used the developed method for the strategic planning, in which not only single buildings but whole urban areas build the object.
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