STUDY OF THE PROBLEMS IN THE SEISMIC RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS

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1. INTRODUCTION AND PROBLEMS

1) Usually the existing standards are addressed to the new buildings and very often they are not applicable to the existing buildings and especially to the historical buildings.

In the case of heritage buildings (with “monument of culture” statute according to the Bulgarian legislation) the problem “what standard is correct to be applied” is sometimes insoluble. While during traditional rehabilitation and strengthening of buildings various approaches could be used, the limitation of the high statute of the considered type of buildings is decisive for the overall approach.
1. INTRODUCTION AND PROBLEMS

2) Bulgaria is entirely positioned in the seismically active area - the Mediterranean, where more than 15% of the earth’s seismic energy is released. Important feature for Bulgaria is that more than 98% of the territory is zone of seismic activity higher than grade VII according to MSK-scale and approximately 20% - IX grade.

The described conditions impose the task that the Bulgarian structural engineers have to prove the seismic structural safety for both the newly designed and the existing structures.
1. INTRODUCTION AND PROBLEMS

3) Older design concepts mostly focused on the effects of gravity loads and they did not dedicate enough attention to provide the lateral resistance and ductility.

4) One of the main problems in the case of retrofitting is related to the accepted degree of the interventions and the necessity to reach the safety of the new buildings.

5) Evaluation of the risk, in case of lack of interventions for upgrading the performance of the building.
1. INTRODUCTION AND PROBLEMS

When it is necessary to make a project for retrofitting?

- Preservation
- Functional changes
- Raising additional stories
- Construction of underground levels
- Mistakes in the design and construction process
- Modifications improperly carried out
- Damages
- Reduction of the bearing capacity for seismic and gravity loads.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

2.1. Safety versus historical preservation and upgrading of the seismic performance

- Condition of the building

If the building is well preserved that indicates that it have withstood the test of time and therefore its structure is adequate and could be trusted to be safe, even if it does not meet current code provisions. Of course, past conditions should be compared and to be expected future conditions. Seismic actions are more problematic, because of the random nature of the earthquakes.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

-Cultural value of the building

If a structure is of great cultural value it might even be considered not to be used at all but to be left as a monument of the historical time it represents. If there is need of any structural interventions, they are to be chosen with great care so that any impact is minimized.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

- Current use of the building

Sometimes the significance of the function of the building (that might be its original function) prevails over its cultural value. Safety should be considered primary to historical preservation, because in the case of an extreme action (e.g. earthquake) the social cost could be much higher than the cost of affecting the cultural value of the building.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

-Continuity of history.

The main question here is why the building is valuable. It is always better to make some changes to a building, that has curtain cultural value, even if they are significant, and keep it living this way, than to leave it into ruins or even demolish it.
2.2. Choice of interventions

- Transparency of the interventions

The interventions should be as inconspicuous as possible. For example seismic isolation of the foundation is highly transparent interventions, as it could not be seen unless a detailed inspection of the building is performed. External steel braces are at the other end – they would dominate the façade which makes them highly inappropriate for strengthening of heritage buildings.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

- Reversal of the interventions

In the case that better decision is available in the future, or if the interventions proof themselves inappropriate, there should be the possibility to undone them without any lasting damage to the original building. The examples above are on the opposite sides here: seismic isolation is almost irreversible, while external steel braces could very easily be dismantled without any significant lasting effect on the façade.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

- Compatibility of the interventions

Any new materials and structures that are used should be compatible with the original structure. The compatibility has several aspects: appearance, stiffness, deformation capacity, modal modes, etc. If the new structure is not compatible, in the case of an earthquake the original structure may suffer significant damage even if the new structure behaves splendidly on itself.
2. CHALLENGES OF RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS IN SEISMIC REGIONS

-Durability of the new materials/structures
Not only the initial durability is to be considered but also future survey and maintenance of both original and new structure.

-Avoidance of historical forgery
If there are visible structural elements that are to be replaced (because it is damaged beyond repair or because it no longer exists) or added this should be done in such a way, that the new elements could not be confused with the original structure.
3. SEISMIC RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS- PROBLEMS AND RECOMMENDATIONS

1) The existing technical regulations in Bulgaria are mainly turned on new structures. Only particular articles in the actual national codes give some general recommendations which are not enough for a detailed and correct design.

2) The application of Eurocodes in the case of existing buildings is a very good possibility for regulation of the process of seismic retrofitting of existing buildings. Some additional development for practical application is required.
3) The standards “Eurocode” do not address the specific case of historical buildings. The use of some other codes and guidelines (Italy, Japan, New Zealand, etc.) creates many troubles in the real design and application in the national construction practice. Special codes and guidelines for structural preservation of historical buildings are needed. It is necessary to continue working on creating specific rules for the buildings with ‘monument of culture’ statute within the framework of the present and future technical regulations valid in Bulgaria.
3. SEISMIC RETROFITTING OF EXISTING AND HISTORICAL BUILDINGS- PROBLEMS AND RECOMMENDATIONS

4) The application of Eurocodes in the Rehabilitation and Strengthening of existing and historical buildings requires the elaboration of specialized national guidelines for the different techniques for retrofitting.

5) It is necessary that the work for investigation and modeling of the structure to be continued in order to analyze the effects of the local modifications on the overall behavior of the building both for vertical and seismic loading.
6) Very often providing new structure for seismic action is the only possibility. Using the existing elements sometimes is very expensive solution and very often this solution is contrary to the original vision of the historic buildings.

7) The review of some innovative technologies for seismic retrofitting shows that those solutions are not suitable for every case. Technical and economical reasons can be leading in the final decision for seismic retrofitting.
8) The most important factor for the existing and historic buildings is occupancy. Not every building is suitable for every occupancy. The inappropriate occupancy may dictate inadequate interventions.

9) The project for historical buildings must take into account the position of the building, the type of structure and used materials, the constructive system, the damages in the structural elements, etc. Sometimes the change of those factors may make the project infeasible.
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