

## CRITERIA FOR THE SELECTION OF REINFORCED CONCRETE STRUCTURES TO BE PRESERVED

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Lewis Mumford once wrote that the stones of Athens would not tell us the story of urban life in the city, hadn't the written heritage remained. But the stones in Ostia tell another story: the story of construction technique. They display the material concrete, an artificial material which could be employed to create a different type of architecture. Compared to the Greeks, the Romans introduced the vault and the dome with the help of concrete; one only has to think of the Pantheon. Existing buildings tell such stories, on construction materials and techniques.

This paper is about the preservation of reinforced concrete buildings, buildings built with the new material of the 19th century: reinforced concrete. To the artificial stone concrete iron, and then steel reinforcement was added, thus changing its structural behaviour. Not only the technology but also the acceptance of reinforced concrete influenced the generated shapes and the surface treatment. Avant-Garde architects started to employ reinforced concrete in housing construction in the years 1920-1940. During this short span of time several different architectural styles co-existed with newest developments in music, arts, physics, philosophy, economic and social theory and industrialisation. Housing was a priority programme of the Avant-Garde of the Modern Movement. Advanced construction technology was employed before the possibilities of the materials and the construction systems were researched.

In the CA'REDIVIVUS project, financed by the European Commission with a Marie Curie Individual Fellowship 2005-2007 within its mobility scheme the preservation of early reinforced concrete buildings in earthquake prone zones of Europe was investigated. The objects of the investigation were early reinforced concrete buildings in Romania, Italy, Greece and Portugal. This research is now continued in the frame of a Marie Curie Reintegration Grant, project called PIANO, running 2007-2010. The objects of the investigation are the blocks of luxurious flats from the interwar time in Romania, Italy, Greece and Hungary.

The Modern Movement introduced the concept of the free plan and that of the Raumplan. Before that, in solid structure buildings, a structural plan was employed. The latter meant that structural elements were delimiting the space. In the free plan the elements determining the space are independent of the structural elements, while in the Raumplan there is interdependence. But the employment of new technologies, such as steel and struc-

tural concrete made it possible that such shapes of plans were created. User exigencies with regard to housing are different today to those from the time when these buildings were raised. The lifestyle changed during almost hundred years. The preservation strategies of early reinforced concrete buildings address the challenge of the change. Often preservation interventions do not respect the character of the building given by the reinforced concrete structural skeleton: the free plan or the Raumplan. This happens either due to structural retrofitting or to new zoning desired by the present inhabitants.

The term 'mission' derives from a strategic approach to urban management and operations in urban planning. In this parlance carrying out a 'strategic mission' means the process of carrying the measures in order to gain the objectives of the plan. The mission is formulated based on the diagnosis. The mission includes goals without priorities. Each point is a sub-objective for an actor implied in the retrofit measure, meant to be reached through packages of measures. Within a strategic planning framework the means for reaching the envisaged goals are also assigned. A package of measures includes communication means, implementation means, and implementation plans at different levels and time horizons, forming action plans. Implementation means result in model and pilot projects for operations, which are also concretisation forms for action plans.<sup>1</sup>

In this work a decision model is developed to determine the most suitable preservation strategy. The first step in developing the decision model is the determination of the criteria employed by various actors involved in the preservation. Four groups of interests were identified: organisational, social, technical and economic. The criteria of the architect address aspects of spatial organisation. Subgroups of criteria with regard to the way historical aspects are affected, the intervention to the whole building, the building elements and the materials. The criteria of the inhabitant address the social impact of the preservation measure. They regard the execution conditions, the acceptability of the measures, the use of the building during and after the measure and its residential value. The criteria of the engineer are with regard to the technical aspects of the implementation of the preservation strategy. They accomplish the vulnerability, the structural performance, the retrofit system and the implementation strategy of the retrofit system. Finally, the investor is concerned about the economic aspects of the preservation: the management strategy, the availability of technologies, materials and funds and various indicators showing the relationship between reparation and rebuild.

In the first phase<sup>2</sup> the utility value method was applied. For each criterion a from-to span was attributed and a measurement unit. For non-measurable criteria the units and points were set and the data table contains also observations on the units. Each criterion is assigned also a weight it has in the decision tree. This utility-value method is supported by an electronic data editing environment as an MS Excell file developed by Ulrich

Bogenstätter at the University of Karlsruhe. A second step is the transition from this utility value based approach to a pair-wise comparison method, a multi-attributive decision system. For this purpose it was begun<sup>2</sup> with the development of a multimedia system. In the paper the balancing of the criteria itself will be shown.

The above mentioned criteria were determined with the method of regression<sup>3</sup> and in his work techniques were analysed useful in building planning with an emphasis on decision related aspects. The usage of some of these techniques gives adequate instruments for a systematic decision. Such one is an approach where characteristics and criteria are deducted based on analysis of existing projects, while know-how is derived by means of scientific disciplines. In this work, decision trees were modelled by regressive means using a related approach. Regression was used for determining the goals of the architect and the criteria concerning the retrofit elements. For both data sets are obtained from case studies and the hypothesis for the decision tree induced. From these individual hypotheses a single hypothesis is obtained, to be integrated into the mission/recommendation. Then hypotheses for the individual elements are derived and finally statements about them deducted. These statements are feedback compared with the induced hypothesis in order to regressively reformulate the later. The paper presents which were the data sets and the hypotheses in induction and the hypothesis, hypotheses and statements in deduction for all four categories of the actors.

An example is considered. It is a building with reinforced concrete skeleton structure, seismically retrofitted with steel braces. Steel braces are a retrofit method easier to compute in software which can compute line elements. In the case study various amounts of retrofit were proposed. The ranking of the retrofit alternatives determined through the pair-wise comparison method differ from the point of view of various actors. The balancing example given was for different locations. One can be considered also for different action (different retrofit measures). Examples known by the author of the two discussed criteria comparison methods (utility value and pair-wise comparison) are at different geographic scales but they proved suitable at building level, as this study demonstrates.

In this paper a multidisciplinary approach has been considered. However, there are also disciplinary criteria employed as survey criteria by different professionally associations with an interest in preservation. Such, the survey form developed in the World Housing Encyclopaedia considers the same categories as in this paper but not in an equal amount. The structural engineering aspects are given most space. In the survey form of the DOCOMOMO (Documentation and Conservation of the Modern Movement) the architectural preservation is predominant. No such disciplinary databases of this kind are known for the point of view of the user or of the investor. In disciplinary sociological circles statisti-

cal surveys are spread. The author of this paper proposes a case-study based approach.<sup>4</sup>

## 1. References

1. M. Bostenaru Dan, *Typological Analysis of Early Reinforced Concrete Housing Buildings in Romania*, A.J. Kappos, Ed., *Proceedings of the 4<sup>th</sup> European Workshop on the Seismic Behaviour of Irregular and Complex Structures*, 26-27 August 2005, Thessaloniki, Greece, Paper No. 16.
2. M. Bostenaru Dan, *Regression Based Criteria Determining for Preservation Strategies of Early RC Buildings*. Fédération Internationale du Béton, *Proceedings of the 2<sup>nd</sup> International Congress* June 5-8, 2006 Naples, Italy, ID 20-9.
3. J. Joedicke, *Angewandte Entwurfsmethodik für Architekten*, Karl Krämer, Stuttgart, 1976.
4. M. Bostenaru Dan, *Von den Partizipationsmodellen der 70er Jahre zu Kommunikationsformen Ende des XXten Jahrhunderts in Architektur und Städtebau*, Cuvillier Verlag, Göttingen, 2007.