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Structural Assessment and Strengthening of Existing Buildings

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Summary

The existing concrete structures, through cumulative effects (earthquakes, corrosion, etc.) diminishes their bearing capacity and, therefore, their safety. On the other hand, the bearing capacity of the initial structure is strongly influenced by the state of knowledge included in the codes that govern the design. Thus, the aseismic design code P13-63 (valid in Romania in the sixties and seventies), that governed the seismic design for about 20 years, underestimated the design seismic loads, leading to structures with an initial low level of safety. If for structures designed according to aseismic codes, the safety level can be reasonably assessed, the assessment of safety level of structures designed and built before such codes have been enforced, is much more difficult. The study presents practical procedures to asses the safety level and strengthening techniques aiming at increasing this level and retrofitting the existing R/C structures.

1. Introduction

The built heritage has to be protected and preserved, in its quality of representing the society, and having to be passed to the next generation. The building component of the human activity reflects, among other things, the level of development of the society concerning the technical and economical regulations. The preserving measures of the built heritage has to be based on pertinent studies regarding the effects of negative factors (earthquakes, corrosion, etc.) and their cumulative action. The repairing, rehabilitation and retrofitting measures depend heavily of this study. The retrofitting of damaged buildings (updating the building to the current provisions of the technical codes) has to be the objective of the preserving activity. From the structural view point, some of the principal mechanical characteristics are considered in the retrofitting activity such as: strenght, stiffness, ductility and structural redundancy aiming at avoiding the whole possible failure of the structure. In this respect, the paper presents several aspects related to the possibility of increasing the safety level of existing R/C structures by way of affecting both, their infra - as well as their superstructure.

2. Fundamental concepts

The fundamental concepts that have to make up the basis of increasing the safety level are:
- the increase of local strength such that all the critical zones of the structure reach a strength level that mach the code requirements,
- avoiding any failure due to shear force of the structural elements and of the beam - column connections,
- avoiding any plastic behaviour of the foundations,
- avoiding the concentration of plastic hinges at one level only,
- ensuring a high plastic rotational capacity for all potential plastic hinges.

For the existing R/C structures (either skeletal or shear - wall structures), the most difficult problem in retrofitting consist in assessing:
- the critical zones, i. e. the zones where the plastic hinges may take place,
- the residual strength, i. e. the strength of the structural elements after they underwent cyclic deformations, due to mainly seismic actions but also after damages caused by corrosion, improper use, etc.

Strengthening of the foundation is a complex activity that requires the investigation of the structure, the foundation and the soil. A common feature of the proposed solutions is the altering of old structural statical model by introducing new structural elements of the type of elastic supports. The change of the mechanical model, as strengthening solution aims at limiting the actions upon the foundations to the available bearing capacity.

3. Strengthening of R/C structures

If the strengthening of R/C columns is achieved easily in most of the cases by applying a new R/C layer around the column, in the case of beams a careful analysis is required in order to select the optimal procedure. For instance, in the case of a frame structure, by altering the stiffness of the beam in the supporting zones, the middle span bending moment decreases by half and the displacement by 70 %. In this way, it has been avoided the strengthening of the beam along its entire span.

In Romania the number of buildings with precast large - panel structure is very high in the existing inventory. Therefore, the problem of increasing their safety level is vital and currently focused by Governmental agencies. During the repeated seismic activity in the period of 1977 - 1990, though no damages due to shear force have been encountered, the cracking of the poured in zones facilitated the corrosion of the reinforcement, which in its turn strongly affects the strength and stability of these structures. Solutions of increasing the safety level in such cases may be:
- doubling the cracked shear - walls, solution that can be applied in any situation but which requires long time and high costs,
- providing external columns with variable sections in the axes of existing shear walls. The columns are linked to each other by inclined or horizontal tensioned elements placed in narrow flutes made in the shear - walls.