Abstract

School facilities play a key role in civil society. They are first and foremost the place where everybody learns, grows and shapes the future, and where students spend a significant part of the day. Besides, schools provide strategic functions for local communities. Therefore, ensuring their safety should be a paramount concern, even if, in Italy, school buildings are too frequently neglected. However, the numerous collapses occurred in schools, have widely proven that this attitude represents a serious risk to the safety of students. Structural deficiencies are closely related to the ageing of Italy's school building stock, which in turn depends on the fact that the trend of new school constructions has always been closely linked to demographic trends. As a result, about 60% of Italian schools were built before 1975, i.e., according to codes rules that did not consider the current safety and structural standards. In addition, energy performance is also generally fairly low, resulting in a waste of money, and in a high environmental impact as well.

The relationship between the historical evolution of pedagogical models on the design approach of school buildings is evaluated herein by analysing both the worldwide context and the Italian case. In particular, the role of the standard module (classroom) and the organisation of teaching and connection spaces on the structural layout is investigated, also considering the technological evolution of structural materials and of construction techniques. The advancement of Italian structural and school building regulations, as well as the improvements and shortcomings progressively introduced, are also reviewed.

A survey on concrete and steel reinforcement extracted from reinforced concrete (RC) existing schools located in the Provincia di Torino is then carried out, comparing the results with a database of tests performed at Politecnico di Torino. The results reveal that the compressive strength of the extracted concrete is significantly lower than expected, especially in schools built between 1970 and 1990. Afterwards, the most frequent degradation factors and structural deficiencies in school buildings, alongside the relevant repair and retrofitting techniques, are illustrated. For each techniques, the pros and cons are discussed, focusing on the troubles in their implementation in schools.

A new and more affordable technique for reinforcing existing beams against bending moment using precast UHP-FRCC panels is also proposed. According to the results of the tests, this method proved to be promising also from a sustainability point of view.

Concerning environmental impact, a comparison of the equivalent CO_2 (CO_2 - eq.) emissions assessed with the LCA methodology of a new timber school and of a refurbished existing RC school is proposed. The aim is to define a solution that ensures the lowest greenhouse emissions over the life of the buildings. Despite the lower volume of new materials required for the refurbishment of the existing school, resulting in lower embodied CO_2, the long-term impact of this building is higher than that of the new school. However, the energy retrofitting enables offsetting the CO_2 - eq. emissions of the new materials within 14 years, while saving on the energy demand costs.

Finally, best practices are proposed on design approaches, retrofitting methods for structural and non-structural elements, along with recommendations on data collection and sharing between authorities, school building owners and Universities.