Contributions to the consolidation of wooden floors to structures with load-bearing masonry walls

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Abstract. The consolidation of wooden floors is a common intervention in the practice of building rehabilitation. The necessity of this type of works comes from the sensitivity of wood to biological degradation, the existence of a significant number of heritage buildings in which the construction of the slabs was done without ensuring compliance with the requirements of the normal exploitation (limiting the deformations), the occurrence in operation of the need to increase the capable loads. It is required, in case of consolidation at earthquake of the buildings with wooden floors, the creation of rigid slab (rigid in horizontal plane). The consolidation solutions that can be adopted are different, trying to respond to the diversity of situations/particularities which are encountered in practice. The paper briefly reviews the solutions currently used for the rehabilitation of wooden floors, then presenting a solution for the consolidation of a wooden floor belonging to an intermediate floor acted by gravitational actions, respectively a solution for achieving the rigid slab of an attic, of a multi-storey building.

1. Introduction

In the paper, problems of rehabilitation of wooden floors in multi-story masonry buildings are addressed. The analysis done for some situations encountered in the practice of rehabilitation is useful by the way of approaching the problem and the way of treating the deficiencies that make the rehabilitation necessary.

The rehabilitation / consolidation of the wooden floors is done when the necessity of increasing the bearing capacity / stiffness to the gravitational actions or to obtain the effect of rigid slab to horizontal actions.

The wooden floors can be damaged over time by biological attack on the construction (insect-fungal attacks), dislocation of the supports due to mechanical vibrations, weakening the connection of the floor with the other structural elements, etc.

The need to rehabilitate the slabs results from the decrease of their performance at gravitational actions, as a result of the degradation, or due to the increase of the performance requirements given by a possible change of function.
2. Current practice in the field

2.1. Increasing of bearing capacity for gravitational actions

In current practice, the increase in the bearing capacity and the rigidity of the slabs at gravitational actions are realized in several variants:

Working from bottom up, repairing each wooden beam in order to increase its strength and reduce its deformations. Following this procedure, the following methods are used:

- steel beams are placed between the wooden beams, at half distance between them;
- the arrangement of a pair of steel profiles (double T, U, angles or cold rolled profiles) as shown in figure 1 (a, b, c);
- solutions can be adopted to consolidate the beam over its entire length through especially designed steel structures, as in figure 2 [3].

![Figure 1](image1.png)

**Figure 1.** Rehabilitation of a wooden floor from the bottom up. 1.a) U steel profile, 1.b) steel composed profile, 1.c) double T steel profile [3].

![Figure 2](image2.png)

**Figure 2.** Consolidation of the beams of wooden floors, 2.a) triangular tie-rod system, 2.b) trapezoidal tie-rod system, 2.c) anchor triangular tie-rod system 2.d) design/anchor trapezoidal tie-rod system [2].
2.2. Increase of bearing capacity for horizontal actions
At the same time, there is the necessity to ensure the behaviour of the floor to horizontal actions, as a rigid slab. This is usually not done on traditional wooden floors and interventions are needed to achieve this behaviour.

The more frequently used variants of transforming a floor into a rigid slab are:

2.2.1. The execution of mixed wood-reinforced concrete floors. The solution involves the execution of a reinforced concrete slab over the existing wooden floor, ensuring connections between the wooden structural elements of the existing floor and the concrete slab, through metal connectors as in figure 3. The solution can be used only if the existing flooring of the wooden floor can be replaced and the additional weight brought by the concrete slab can be taken over by the structure of the building.

![Figure 3. Reinforced concrete slab over the wooden floor [4].](image)

2.2.2. We can achieve a rigid slab effect using reinforced concrete tie beams and a double planking of boards at 45 degrees. The problem of connecting the reinforced concrete tie beams and the planking of boards arises. The reinforced concrete can be connected to the wood by means of metal parts like in figure 4.

![Figure 4. Realizing the rigid slab using reinforced concrete belts and a double plank of boards [4].](image)
3. Contributions regarding the consolidation of wooden floors

3.1. Increase of the bearing capacity for gravitational actions

It is proposed to consolidate a wooden floor that, under gravitational actions, has developed deflections far beyond the limit ones. The consolidation is applied, due to the imposed conditions, at the bottom of the slab. The large deformations of the floor beams do not allow the use, for consolidation, of steel elements to be attached to the floor beams.

It is proposed to intercalate between the wooden beams of the slab some steel beams from HEB profiles, located tangentially, in the middle of the opening, at the structural floor. At the bottom of these elements and arranged perpendicularly on them, two metal profiles are suspended which will become supports for the wooden beams of the slab. The support will be ensured by the introduction of hardwood feathers.

The proposed solution preserves the state of deformation of the floor is presented in figure 5, but prevents the increase of deformations. The dimensioning of the system is made by conditions of deformability and load bearing capacity of the slab. The direction of unloading of the floor on the wall is kept.

![Figure 5. Increase of the bearing capacity of a slab subjected to gravitational actions](image-url)
actions by consolidate with additional steel elements.

3.2. Increase of bearing capacity for horizontal actions

The aim is to make a rigid slab at the floor level of the attic, in a building with a structure with load-bearing walls and wooden slabs.

For this purpose, the chords of the main truss (included in the slab structure, consisting of adjacent beams) are reinforced with UPE steel profiles arranged on the two faces of the section and supported (by means of concrete bearings) on the longitudinal walls. The reinforced concrete bearings are anchored to the walls by means of rods inserted into holes made in masonry (diameter min. 30 mm, depth min. 800 mm) and fixed with injected mortar. At the bottom of the wooden floor, along the walls on which it is supported, UPE metal profiles fixed by the lower sole of the strings for strengthening the chords are arranged. These ensure the increase of the length of the wooden beams of the slab and together with the profiles for strengthening the chords and the round steel diagonals arranged in a X shape create a rigid horizontal system. The steel elements UPE placed along the walls, at the bottom of the slab, also act as tie rods of the respective walls, ensuring their anchoring at the ends.

The following are the constructive solutions that can be adopted in this case are shown in figures 6 and 7.

![Diagram](image)

**Figure 6.** Slab plane. Disposal of the rigid elements in plane.
Figure 7.a Constructive detail. Support detail – steel confection on marginal wall.

Figure 7.b Constructive details. Support detail/continued steel confection on the internal wall

Figure 7.c Constructive details. fixed detail steel profiles with the wooden beam. Lateral stiffening assemble steel profiles.

4. Conclusions
The presented solutions try to contribute to the development / diversification of the intervention modalities for the rehabilitation / consolidation of the wooden floors.

Proposed structural technique for the retrofitting of wooden slabs subjected to gravity loads is formulated for interventions at the inferior part of the slab only. Dimensioning of steel consolidation elements is undertaken in a way that the strains and stresses in the slab’s wooden elements are
controlled under post-retrofitting loads. The slab’s behavior on the vertical structural elements does not undergo any adjustment. Another important aspect is the fact that the solution does not involve important building technology.

According to the suggested solution, an accomplishment of rigid slab effect in the case of wooden floor slabs assures a compound effect of vertical structural components (masonry walls) horizontally loaded on condition that the system fully connects with the masonry walls. Recommended system also provides the support of main trusses of the framework by transforming its chords in elements capable of undertaking gravity loads. They become in this case the horizontal elements of an attic. The abovementioned solution increases the attic’s rehabilitation process.

References
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