EVALUATION OF THE IMPACT OF THE RETROFITTING SOLUTION ON THE ACOUSTIC AND THERMAL PERFORMANCE OF FLOORS

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1. Introduction –Building renovation projects deal with many aspects of construction performance, including energetic and acoustic properties, accessibility, and structural reinforcement. Four aspects must be taken into account in building rehabilitation: proportionality, flexibility, no-deterioration and transversality. Proportionality implies that the costs and complexity of execution may be related to the level of improvement. Flexibility involves proportionality; according to flexibility criterion, a building must approach its best performance but it can be exempted from new construction regulations as its improvement depends on the current situation. No-deterioration is closely related to transversality. Pursuing no-deterioration, we must study the relations between aspects affecting habitability, in order to choose a viable solution [1]. Structural reinforcement is not usually considered in terms of transversality in building renovation, in spite of the fact it can change thermal and acoustic performance. This work studies the impact of solutions for floor structural retrofitting on its acoustic and thermal insulation, according to Spanish standards, with the aim of recalling the importance of comparative study of properties in rehabilitation works [2].

2. Methods –The work compares three common solutions to increase the load-bearing capacity of floors. In Spain, old building floor structures usually consist on one way slabs with wood, concrete or steel joists and arched lightened ceramic or concrete pieces [3]. As the goal of this work is to compare the retrofitting solutions, a one way slab with concrete joists and ceramic arches has been chosen. The retrofitting solutions that have been considered are: 7 cm conventional concrete screed on top of the original floor, 7 cm lightweight concrete on top of the original floor and retrofitting under the joists with steel of carbon plates. The three considered methods can effectively increase the load bearing-capacity. Retrofitting with steel or carbon plates does not affect the clearance height, but it cannot improve the thermo-acoustic performance of the floor. The study has been focused on section enlargement of floors. Conventional concrete screeds raises the structure stiffness, but with a considerable increase in dead load; lightweight concrete screeds contribute to strengthen with a smaller increase in dead load. Regardless the structural contribution of each solution, as there is no choice but to do what is structurally acceptable, the two retrofitting schemes have been compared in terms of acoustic and thermal behaviour.

Computer-based tools have been used for the analysis of acoustic properties of floor solutions. The first one of them was specifically created to analyse the building to compliance of Spanish regulation CTE DB-HR [3]; this program accepts only one layer of floor, with the possibility of adding a floating floor, and the main layer is described in terms of its density. The other one is the educational version of CYPECAD-MEP, which is widely used for building projects. It allows the designer to add layers with differing properties to the traditional floor structure, It uses the formulas included in UNE-12354 [4], and can be used following european or local regulations. The thermal properties have been calculated with CYPECAD-MEP and with a spreadsheet following the method proposed in UNE-EN ISO 6946 [5].

3. Results and Discussion –The results of the section enlargement techniques are presented (table 1), compared to the original properties of the floor, which are supposed to be the same as the properties with an steel or carbon plate retrofitting. The results show the capacity of both retrofitting schemes to fulfil the acoustic requirements when a floating floor is installed. The differences between computer programs are of no high significance, is spite of the generalization of layers made by the DB-HR tool.

The thermal properties reveal little difference between solutions. The thermal transmittance value (U-value) decreases when additional layers are included, but concrete is not a good thermal insulator. Installing floating floor is an effective way to improve the thermal performance. For extreme climates, more insulation is needed according to CTE [3], such as a thicker layer between the screed and the laminated floor.

The results are presented with a colour coding that is being increasingly used in renovation projects. It comes from energy ratings, and its goal is to include a gradation, accepting the non-fulfilment of the regulation in rehabilitation works. This is related to the flexibility concept.

analysis	tool	property	constructive solution						spanish regulation limit
			unreinforced floor / plate retrofitting system		lightweight concrete screed (1800 kg/m3)		conventional concrete screed (2400 kg/m3)		
			glued floor	floating floor	glued floor	floating floor	glued floor	floating floor	
ACOUSTIC	CYPECAD-MEP	impact noise	73	64	69	59	67	57	≤ 65 dB
	DB-HR tool		75	64	71	60	69	58	
	CYPECAD-MEP	airborne noise	51	49	54	53	54	55	≥ 50 dBA
	DB-HR tool		48	48	52	53	53	55	
THERMAL	CYPECAD-MEP	thermal transmittance U	1,46	1,09	1,36	1,06	1,41	1,10	1,2 W/m²·K (For climatic zones A,B,C)
	UNE-EN ISO 6946		1,58	1,20	1,45	1,13	1,52	1,17	
		$D_{nT,A} \geq 50$ dBA; $L'_{nT,w} \leq 65$ dB / U ≤ 1,2 W/m²·K							
		$D_{nT,A}$: 45-49 dBA; $L'_{nT,w}$: 66-70 dB / U: 1,1-1,45 W/m²·K							
		$D_{nT,A}$: 40-45 dBA; $L'_{nT,w}$: 70-75 dB / U: 1,46-1,6 W/m²·K							
		$D_{nT,A} < 40$ dBA; $L'_{nT,w} > 6,75$ dB / U > 1,6 W/m²·K							

Table 1. Results of acoustic and thermal performance

3. Conclusions – The thermo-acoustic performance of several retrofitting solutions for floor structures has been studied. Solutions are compared following the principles of flexibility and transversality, and considering the Spanish regulation limits. If there are no geometrical limitations, the use of concrete screeds on top of the original floor can lead to a better acoustic performance. The studied solutions have very similar thermal behaviour. The choice of lightweight concrete may be bounded to structural reasons; according to flexibility the differences between common and lightweight concrete are not too relevant. Despite this, more research is needed as the acoustic properties of lightweight concrete can be underestimated by those programs lacking technical specifications of the product. The installation of floating floors has a positive impact on all the considered properties of the solutions, regardless the retrofitting scheme.

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