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INTERVENTIONS UPON BRICK MASONRY WALLS – CONSTRUCTIVE SOLUTIONS

BY

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Abstract. The main principle in the rehabilitation of a building is induced by the qualitative and quantitative manifestation of several essential factors: components, typology and state of the construction, the economic role within the body, and restrictions, respectively opportunities provided by legislation (Stanca, 2016). Due to service, environment, physical, chemical or biological nature related conditions, constructions can damage quite early thus shortening their life. The analysis of the structural types allows knowing well the performances and their quality, data assimilation and their valorization in order to prevent degradation by interventions carried out in time and in relationship with the advances in science and technology. Diagnosis highlights irregularities in the structure, their significance and helps decide the need for structural interventions and the kind required. The evaluation of a correct intervention strategy is determined by the identification of individual differences of the structural and non-structural elements, of their mixed effect upon the seismic behavior mechanism and of the global defects regarding strength, deformability, redundancy and structural regularity (Stanca, 2019). The types of recommended types are destined to bring the structure back to the optimal parameters of operation, in agreement with the functional unit selected and the norms in force.

Keywords: structure; rehabilitation; strengthening; structural member; deficiencies.

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1. Introduction

In the course of the time, in the structure of a building, various physical, chemical and biological processes can occur and which can take place simultaneously, sometimes joined together in a cause-effect succession, with have a specific evolution, dependent upon the physical and chemical properties of the materials and on various environmental factors. The relationships between the aggressive agents are complex, sometimes being impossible to establish who or what is mainly responsible for materials degradation, though humidity is a significant generating factor that favors their alteration, in tight connection with the porosity features of the materials put to work, (Fig. 1) (Hann, 2012).

Fig. 1 – Damage encountered in masonry:
A – Corrosion of a chimney; B – An external wall cracking during an earthquake
C – Crack in the wall masonry; D-E – Florescence on the external wall;
E-I – Brick masonry delamination under the freezing-thawing effect, brick penetrating salt crystallization (Hann, 2012).

2. Interventions in the Brick Masonry Structures

The following types of interventions are distinguished in the structural rehabilitation of masonry constructions, Table 1 (*Cod de proiectare seismică*, 2008):

a) Repair works, additions, reintegration or joining of construction members or of new bodies with a different functional destination;

b) Strengthening interventions to substitute structural components san/or reintegrate existing structural components:

- individual strengthening;
- overall strengthening.

Table 1

Interventions in the Brick Masonry Structures (*Cod de proiectare seismică, 2008*)

Interventions							**Solutions/Recommendations**	
	wall	masonry	*Repairing works*	Damaged mortar			Rebuilding mortars in the joints	
				Areas with fissures/cracks	Damaged bricks		Reweaving masonry	
					Redoing the apparent continuity of the masonry	Fissures of opening <2mm	Epoxy resin injections	
						Fissures of opening 2<10mm	Concrete based injections	
						Fissures of opening 2<10mm	Reinforced injections	
				Cracks in the masonry			Concrete fillings	
				Areas with large fissures/cracks			Fitting in iron cramps	
				Increasing shear strength capacity			Local plating along the crack route with reinforced plaster	
			Consolidation works	Individual strengthening	Increasing strength to the masonry cutting force		Plating with concrete/reinforced mortar and metal welded nets	
					Increased masonry ductility, increased shear strength		Plating with fiber reinforced polymers	
					Increased bending strength, increased resistance to cutting force		Local consolidation of masonry voids	
					Increased ultimate bearing capacity to eccentric compression, increased fracture ductility		Masonry consolidation with reinforced concrete belts and pylons	
				Overall consolidation	Keeping the existing structural system	Making vertical and horizontal structural subunits work together	Joining perpendicular walls in corners and intersections	Insertion of bars/flat bars in masonry joints
							Providing structural walls stability to vertical seismic action	Insertion of tightening bolts
						Joining walls to roof framing and floors	Increasing horizontal resistance and stiffness	
					Modifying the structural system	Eliminating stiffness center eccentricity vs. mass center	Adding new structural members	
							Closing voids in façade and internal walls	
						Providing continuous vertical and seismic forces route up to the foundations	Adding new vertical elements (walls, columns), adding belts	
						Increased redundancy	Adding new structural members	

3. Case Study

3.1. General Considerations Regarding the Building

The construction presented here is as old as 1936, having a partial underground, ground floor and first floor. The elements in the structure of the building are: continuous foundations of simple concrete, bearing walls of brick masonry, 50 cm thick external walls and 40 cm thick internal walls; wooden floors; wooden roof framing and ceramic tiles cover; wooden window and door lintels and tie pieces.

The access from the street into the inner court is made through a corridor (Fig. 2), which also allows the entrance in the underground and ground floor.

Fig. 2 – Access to the inner court through the corridor.

The main cause of the degradations is the infiltration of water through the damaged roof, eaves and piping cracks (Fig. 3).

Fig. 3 – Elements of damaged roof framing, Damaged, broken eaves and pipes.

The infiltrated water ran down the walls, destroying the plastering and masonry until it finally got to the walls base (Fig. 4).

Fig. 4 – Degraded plastering.

The effect of repeated freezing-thawing and the lack of proper maintenance led to the destruction of the masonry in several areas, even up to half of the wall thickness (Fig. 5).

Fig. 5 – Destroyed masonry.

The deformations could not be taken over by the walls without belts so that crack occurred versus the voids and in the corners (Figs. 6 and 7).

Fig. 6 – Damage at the door void.

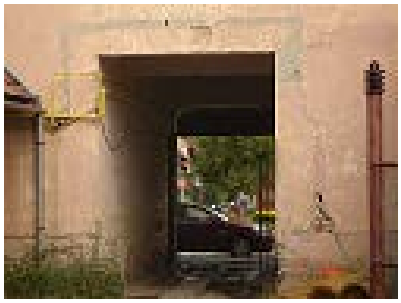

Fig. 7 – Ground floor walls with fissures and cracks.

3.2. Interventional Solutions – "Classical" Structural Intervention Methods

The types of interventions suggested here have the mission of returning the structure to its optimal operational parameters, in accordance with the norms in force.

The damage degree in the building is moderate as the following aspects were found out:

a) The infiltration water ran down the walls, destroying plastering and masonry until it got to the wall base.

It is recommended to restore the mortar in the joints when mortar is degraded under the action of environmental factors. The replacement of the mortar yields to increased compression strength in the masonry, when the walls have a moderate thickness (up to two bricks) (Fig. 8).

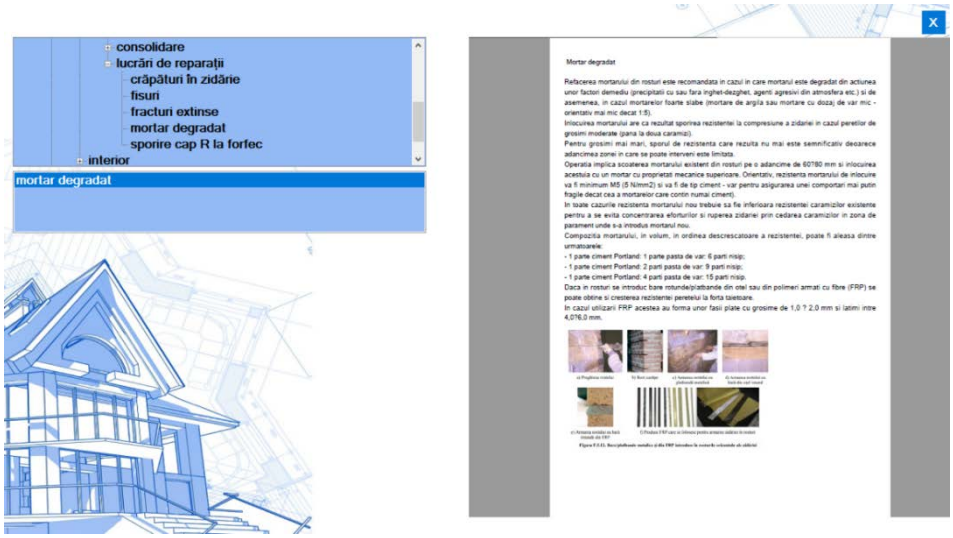

Fig. 8 – Restoring the mortar in the joints.

b) The repeated freezing-thawing phenomenon and the poor maintenance led to the destruction of the masonry, at various extents, and sometimes up to half of the wall thickness (Fig. 9).

Fig. 9 – Damaged masonry.

It is recommended to reweave/rebuild cracked and fissured areas and it consists in replacing masonry elements with wide openings or cracks as well as those which are broken. Reweaving consists in using masonry elements and mortars of features as near as possible to the original materials, in so far shape, size and mechanical strength and deformability are concerned. In this way the masonry is rebuilt along the fissure/crack route. Reweaving of elements means to use connections both in the wall plane and perpendicularly to it when walls are very thick (Fig. 10).

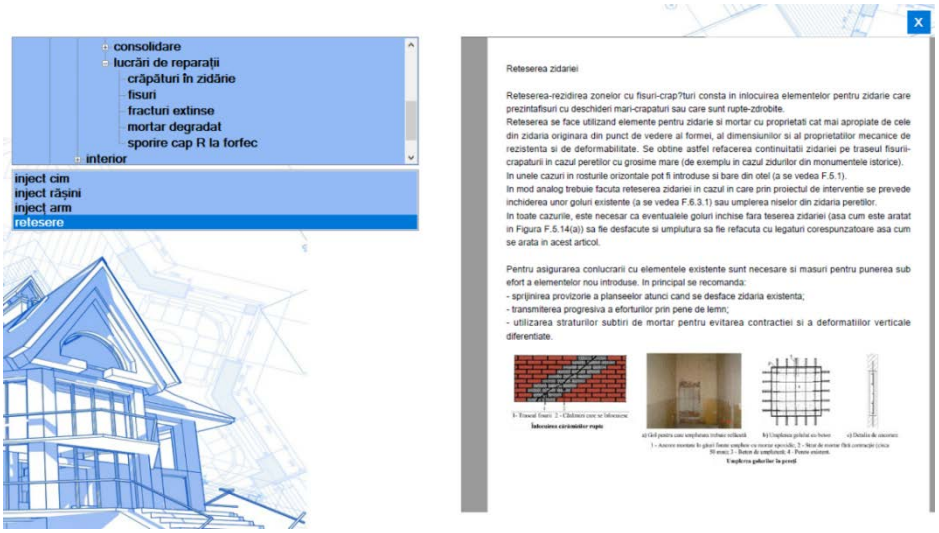

Fig. 10 – Reweaving masonry.

c) Deformations could not be taken over by walls without belts leading to cracks in the corners and versus the void areas (Fig. 11):

Fig. 11 – Damage at the door void. Ground floor walls with fissures and cracks.

Injections accompanied by the insertion of metal members (flat bars, round bars), currently named reinforced injections in the practice in Romania, increase the tensile strength and the shear strength in areas that are important for the spatial common operation of the walls placed in the main building directions (corners, branches, intersections) (Fig. 12).

The intervention can be associated with the plating with reinforced concrete on both wall sides, to improve lateral confinement and increase existing strength section. In this manner, the following aspects increase:

– the adherence between masonry layers;
– the masonry shear strength;
– the masonry ductility.

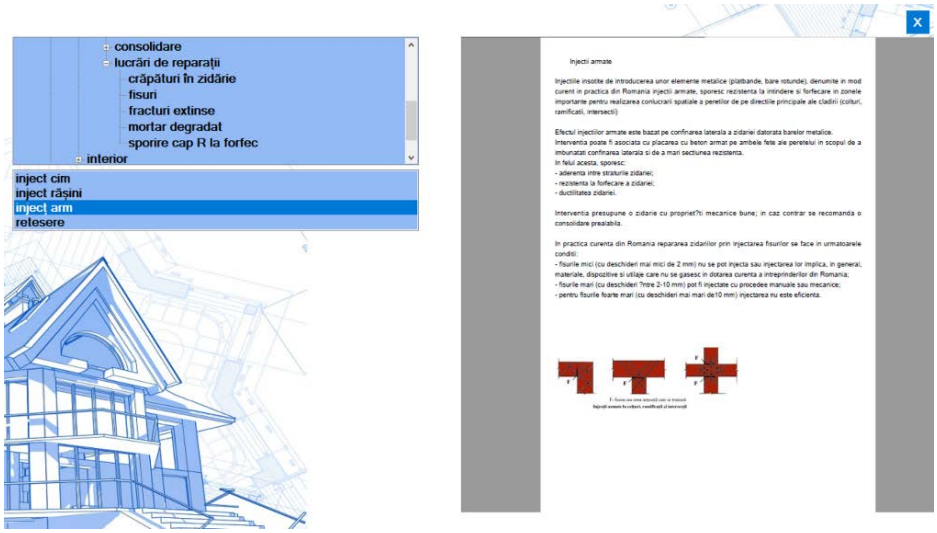

Fig. 12 – Repairing cracks – Reinforcing injections.

Recommendations regarding strengthening interventions:

Covering the walls by plating existing masonry with cement mortar or concrete (Fig. 13).

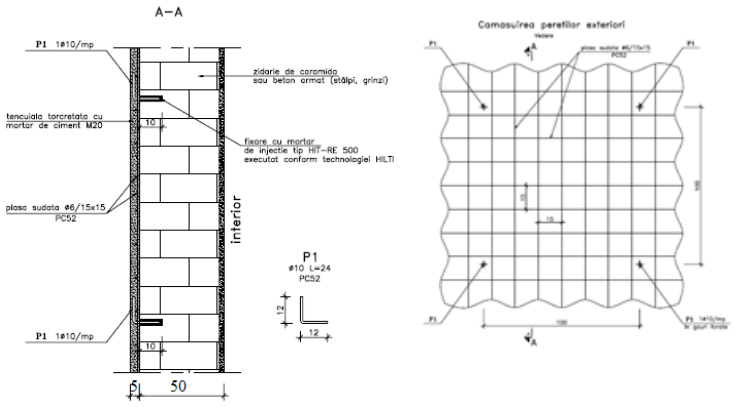

Fig. 13 – Plating structural walls made of brick masonry.

Plating existing masonry with cement mortar or concrete is a consolidation procedure used on a wide scale in Romania as well as in other countries.

Plating is applied on one or both sides after the masonry to be intervened upon is properly prepared. Obviously, plating has a relatively more important effect upon the poor quality masonry walls (for instance, for masonry with a shear strength of about 0.05 N/mm^2) where increasing the strength is

very important reaching between 300÷400%, while for good quality masonry walls, the increase in strength is of only 30%, (Fig. 14).

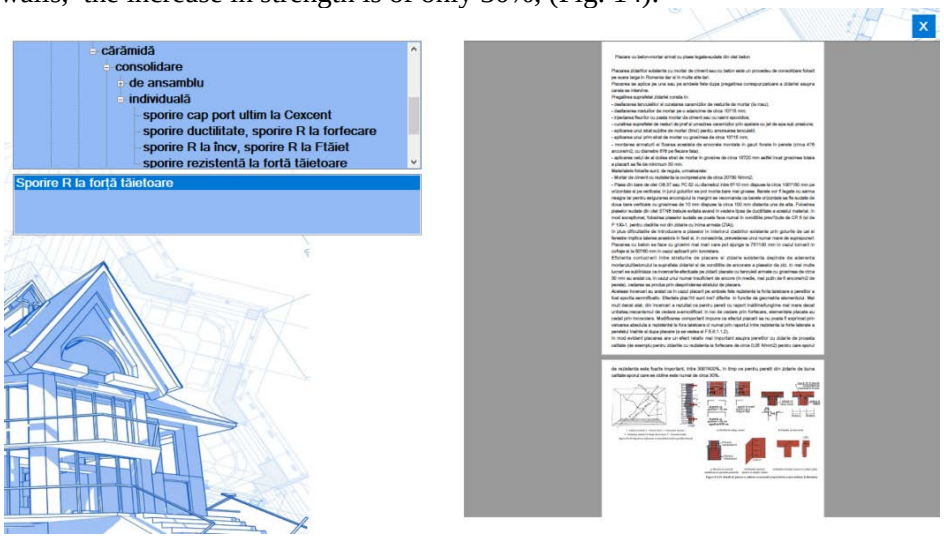

Fig. 14 – Plating masonry walls with cement mortars or concrete.

4. Conclusions

The solutions for structural rehabilitation of the buildings presented in this article approach classical and modern formulas, agreed by practitioners and which make use of traditional materials such as wood, concrete and steel, in order to establish or improve the structural performance of the construction members requiring interventions.

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⁎⁎ *Cod de proiectare seismică – partea a III-a – Prevederi pentru evaluarea seismică a clădirilor existente*, Indicativ P100-3/2008.

INTERVENŢII ASUPRA PEREŢILOR DIN ZIDĂRIE DE CĂRĂMIDĂ – SOLUŢII CONSTRUCTIVE

(Rezumat)

Principiul director al reabilitării unei clădiri este indus de manifestarea calitativă şi cantitativă a câtorva factori esenţiali: componenţa, tipologia şi starea construcţiei, rolul economic în cadrul organismului, dar şi restricţiile, respectiv oportunităţile oferite de legislaţie. Datorită condiţiilor de exploatare, de mediu, de natură fizică, chimică sau biologică, construcţiile se pot degrada timpuriu scurtându-şi durata de viaţă.

Analiza tipurilor structurale determină cunoaşterea performanţelor şi calitatea acestora, asimilarea de date şi valorificarea lor cu scopul prevenirii degradărilor prin intervenţii efectuate în timp şi ca urmare a progresului ştiinţei şi tehnologiei. Diagnoza evidenţiază neregularităţile structurii, importanţa acestora şi se decide necesitatea intervenţiilor structurale şi felul acestora.

Aprecierea unei strategii de intervenţie corecte este determinată de identificarea deficienţelor individuale ale elementelor structurale şi nestructurale, a efectului combinat al acestora asupra mecanismului comportării seismice a clădirii, precum şi a deficienţelor de ansamblu privind rezistenţa, deformabilitatea, redundanţa şi regularitatea structurală.

Tipurile de intervenţii recomandate sunt menite să readucă structura la parametrii optimi de funcţionare, corespunzător unităţii funcţionale alese şi în conformitate cu normele în vigoare.