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CONSOLIDATION OF THE BRICKWORK WALLS WITH DISPERSELY REINFORCED CONCRETE INJECTED WITHIN CANALS DRILLED IN THEIR PLAN

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Abstract: *In many respects, a construction, in the present case the brickwork, resembles very well with the human body. To many internal organs, one cannot reach but removing some others. This occurs also in civil engineering. In order to repair or to consolidate a wall, for instance, most times one has to remove other elements of the respective construction (finishing, carpentry, flooring etc.). This is not always possible and, moreover, the expenses raise quite much. Therefore solutions are continuously being searched for that should reduce to the greatest possible extent the collateral works. As regards people, interventions are made within the human body by resorting to various devices (catheters, tubes, metallic parts etc.) without the necessity of opening it. Why there would not be possible such solutions in civil engineering, too?*

Key words: *brickwork walls, concrete, consolidation.*

1. Generalities

In rehabilitating brickwork structural systems, the following elements must be considered:

a. oldness of the construction;
b. type of brickwork:
   - of stone,
   - of brick;
c. type of luting material between the brickwork blocks:
   - dry brickwork,
   - mortar with clay or lime-type binder,
d. structural system:
   - simple brickwork,
   - brickwork cooperating with metallic elements,
   - brickwork cooperating with reinforced concrete elements,
   - brickwork with reinforced concrete-pillars and straps,
e. type of foundations.

Excluding the degradation of the brickwork structures as a result of the design and execution errors, the main causes of the deterioration of the brickwork structures may be:

- aging of the material in time (brickwork stone and luting binder);
- failure of maintaining the construction and occurrence of the condensation, which implicitly leads to the degradation of the materials

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used in its composition,
- structural system;
- degradation of the foundation soil as a result of the rainwater infiltration, of the losses in the culvert or sewer installations, of the rise in the groundwater level, of the modification of their trajectories because of new constructions;
- exceeding the bearing capacity of the foundation soil in case of achieving new constructions, adjacent to the existing construction;
- seismic action;
- other extraordinary actions, such as explosions, fires etc.

The specific damages of the brickwork structures may be:
- cracks and fissures in the brickwork walls following the degradation of the founding soil, fig.1;

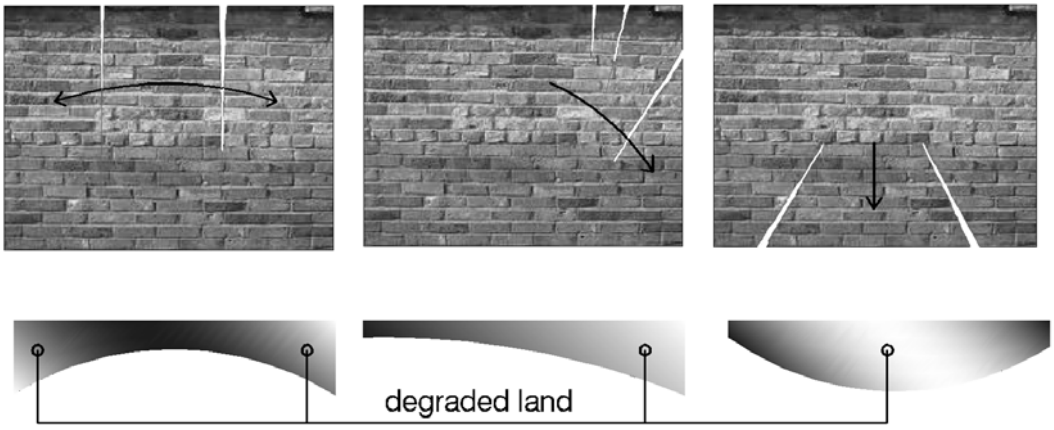

Fig. 1. *Brickwork weakening as a result of the local degradation of the founding soil [1]*

- cracking of the walls from horizontal actions after the direction of the diagonals (principal tensions) as a result of exceeding the bearing capacity during the stretching, fig.2.a;
- cracking of the embrasures at their basis from horizontal actions, fig.2.b;

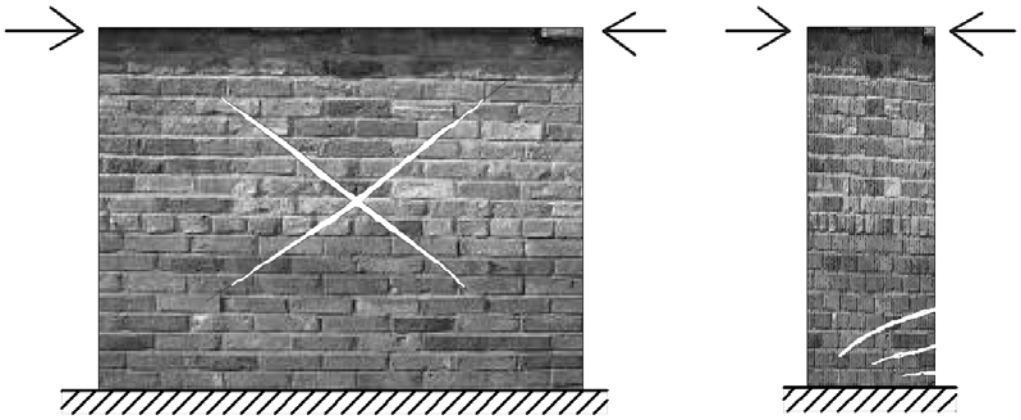

Fig. 2. *Wall cracking from horizontal actions [1]*

- fissure and crack-apparition at the intersections of the walls, following the absence of bindings that should ensure the spatial cooperation,
- decoupling of the window head-walls or apparition of oblique fissures above the door and window-vacancies, also as an effect of the seismic action,
- degraded soil
- dislocation and parallel weakening of the brickwork in areas with tension concentrations.

In fig.3, the typical weakening at the seismic action of a brickwork structure without specific measures is shown.

Fig. 3. *Degradations of a brickwork construction from Umba-Marc, Italy, during the earthquake of 1997*

2. Possible solutions of consolidation

The consolidation of the brickwork structures may be made through:

- remaking the dislocated brickwork,
- partially concreting in denticulations with concrete,
- injecting and caulking the fissures and the cracks,
- sewing the fissures with steel dogs,
- coating the walls with classical reinforced concrete, disperse reinforced (concrete), or ferrocement,
- coating from composites,
- planking the vacancies,
- binding the corner areas,
- introducing tie bars,
- introducing butt straps in metallic profiles,
- placing horizontal and vertical elements in reinforced concrete.

The concept of structural-system consolidation may impose combining the above-indicated procedures, depending on the causes having produced the damage, on the weakening mechanism and especially on the state of the building.

3. Submitted solution

Situations exist when, out of functional reasons or for protecting the internal or external ornamentations, the building must not be very strongly affected from aesthetical standpoint. In this situation, through the work herein, a relatively simple solution is submitted, which consists in realizing stiffening elements shaped as pillars, straps or diagonals in disperse reinforced concrete with fibres introduced through injecting (pumping) within canals drilled in the thickness of the wall (in its plan). Such a possible solution is shown in fig. 4.

The submitted solution consists in drilling circular canals of convenient diameters, disposed on horizontal, vertical or bent direction, where applicable, and their filling through injecting or pumping with disperse reinforced concrete with fibres (in the present case, synthetic fibres of polypropylene are proposed);

The number of canals and the drilling directions are set in relation to:

- configuration of the wall,
- technical possibilities for the utilization of the drilling machine,

- maximum effort that a section of disperse reinforced concrete may assume;

From theoretical standpoint, the calculation of such a structure might be conducted according to the principle of the structures formed of bars analogous to the one stipulated by Eurocode 2.

For exemplification, a wall in non-reinforced brickwork was chosen, being part of a building P+2E, placed in a seismic area with the acceleration a_g = 0,08g, which does not answer the resistance requirements stipulated in the codes P100-1/2006, P100-3/2008, CR6-2006.

As a result of having introduced pillars, straps, diagonals realized in canals drilled with the diameter of 100mm, through injecting disperse reinforced concrete with fibers of polypropylene, the bearing capacity of the wall improved so as to answer the requirements in the above-mentioned codes.

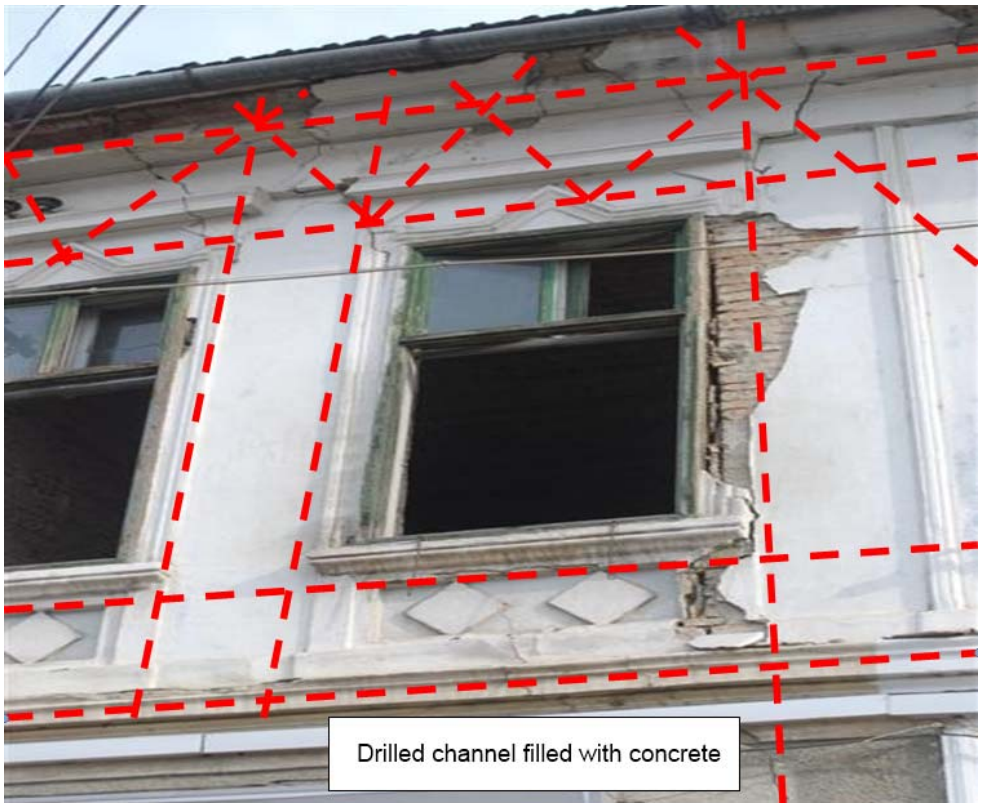

Fig. 4. *The principle of consolidation with disperse reinforced concrete injected in drilled canals*

In the effected calculations, the level and gravitational seismic loads were concentrated in the knots of the bar-network resulted from achieving the confinement elements (pillars, straps, diagonals) whereto we referred above (fig.5).

On the scheme, for exemplification, only the efforts from the most exposed (stretched) diagonals were shown.

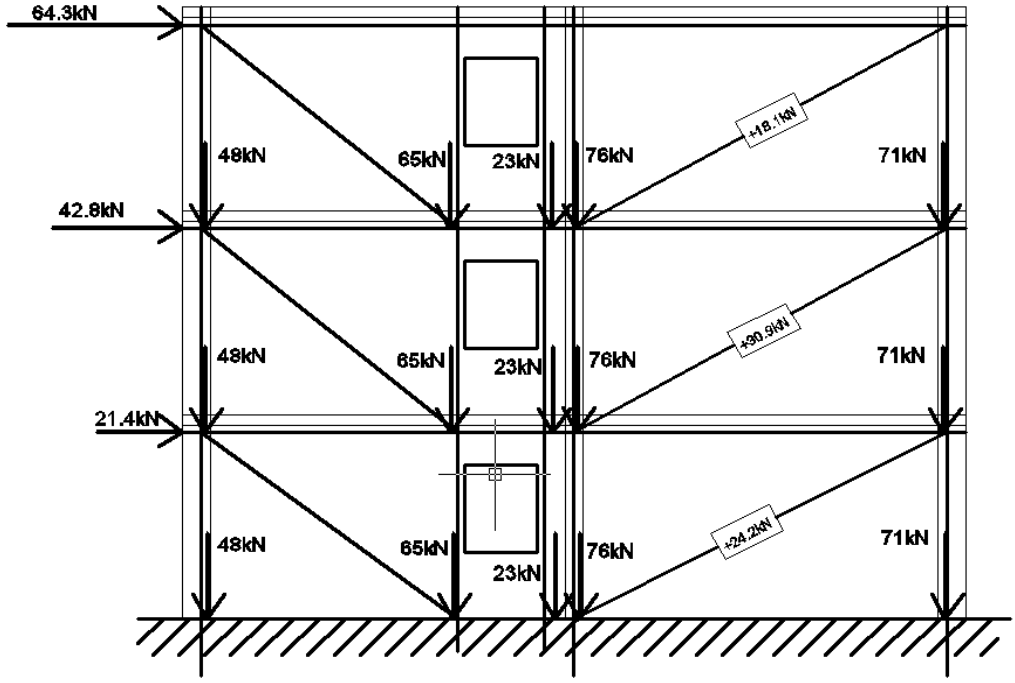

Fig. 5. *Theoretical model of calculation*

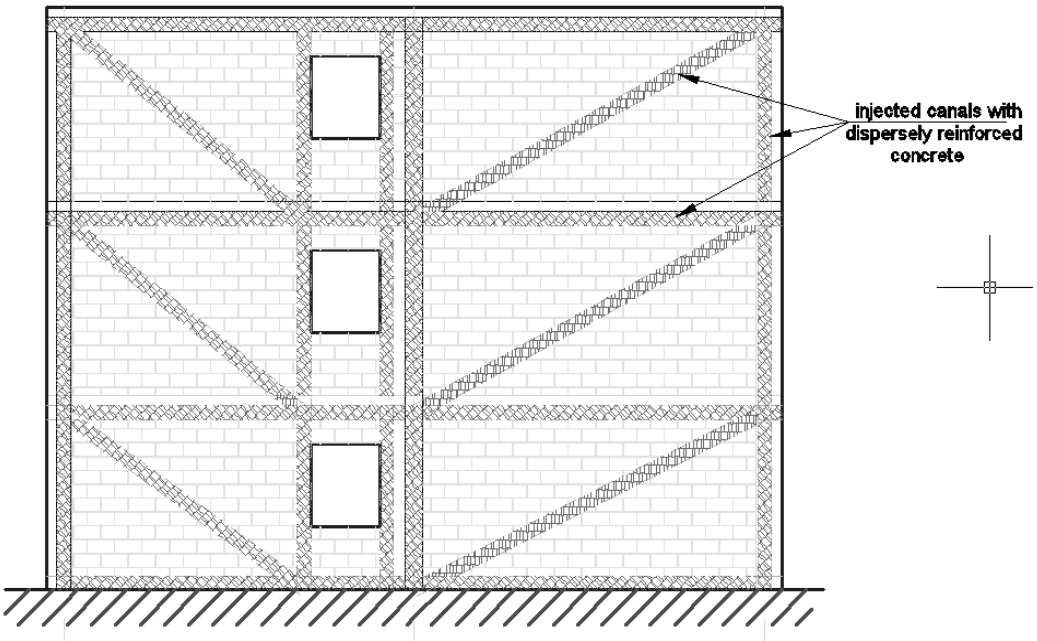

Fig. 6. *Physical model of realization*

From practical standpoint, the operations to be executed consist in:

- realizing strictly necessary releases of plastering, ornaments, woodwork;

- tracing the trajectories whereon the drills are to be made;
- identifying the installation-location line in the walls that might be damaged during execution;
- programming the drilling machine through uploading the control data of the location lines;
- executing the drillings themselves;
- controlling the continuity and the intersection of the executed drillings; making corrections where applicable;
- determining the technological order for the concrete injecting (pumping);
- execution itself of the injections with the control upon the complete filling of the drilled canals;
- executing the other elements that pertain to the restoration of the building (finishing, carpentries etc.)

The advantages of the method concretize in:

- diminishing the stripping works of the brickwork,
- diminishing the resulting quantity of quarry stone;
- keeping the section along the entire location line of the drilling;
- the deformations of the injected concrete and of the brickwork are compatible,
- the possibility of executing the drillings on the most efficient location lines,
- cheap execution without heavy machinery,
- cheap constituents, easy to get.

References

1. CR6-2006: *Cod de proiectare a structurilor din zidărie*;
2. P100-3-2008: *Cod de evaluare si proiectare a lucrărilor de consolidare*;
3. P100-1-2006: *Cod de proiectare seismica*;
4. Niculita M., Groll L.: *Consolidarea clădirilor din patrimoniu*; Ed. Societății Academice „Matei Teiu-Botez”-2007;