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Repair and Consolidation of the Masonry Structure of a Building

Réparation et consolidation de la structure d'un bâtiment en maçonnerie

Sanierung und Verstärkung der Mauerwerkskonstruktion eines Gebäudes

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SUMMARY

The paper presents a study of a case about the damages caused by the 1977 earthquake to the structure of a building in Craiova, Romania, as well as repairing and consolidation solutions for this structure. The proposed solutions intend to restore the initial bearing capacity of the structure and its safety.

RÉSUMÉ

L'article porte sur le dégâts provoqués par le séisme de 1977 sur la structure d'un bâtiment à Craiova, Roumanie, ainsi que sur les solutions proposées pour sa réparation et son renforcement. Les solutions proposées tendent à rétablir la résistance initiale du bâtiment ainsi que la sécurité dans son exploitation.

ZUSAMMENFASSUNG

Diese Arbeit berichtet über die Schäden, die am Gebäude der Fakultät für Landwirtschaft von Craiova, Rumänien, infolge des Erdbebens vom 1977 aufgetreten sind. Auch einige Sanierungsmassnahmen wurden vorgeschlagen. Diese Lösungen sollten die ursprüngliche Tragfähigkeit und Sicherheit der Konstruktion wiederherstellen.

1. INTRODUCTION

Statistical analyses of the damage in masonry buildings show that the damage depends mostly on the quality of the materials used and on the quality of the construction, and only a little on the structural geometry of the building. However, the practical experience demonstrates that, during violent earthquakes, the conception of structural geometry is very important for the building survival.

Thus, it is very important weather the plane form of the masonry structure is regular or irregular, symmetrical or non-symmetrical and weather the building has a pronounced asymmetry of the volume, mass and rigidity distribution or not. In the same time, it is very important weather the building has one or two storeys or it is a multi-storey building.

In general, the seismic resistance of the masonry buildings is assured mainly by a number of large shear walls, in each principal horizontal direction, that are able to support the most important damages during the earthquake.

The correct design of the new masonry structures supposes not only an adequate calculus, but also the adoption of the constructive measures that will give to the structure an increased security against seismic actions, ensuring the structure's survival and the avoidance of causing victims and exaggerated damages.

The old buildings structures were not designed to resist to violent earthquakes because at the time they were designed and erected, the problem of antiseismic design and measures for the buildings was not properly considered and there were any norms or instructions for the antiseismic protection of the structures.
Therefore, in the world there is a large number of such old buildings, damaged during the earthquakes, that no longer present security in strong seismic loads and that have become a

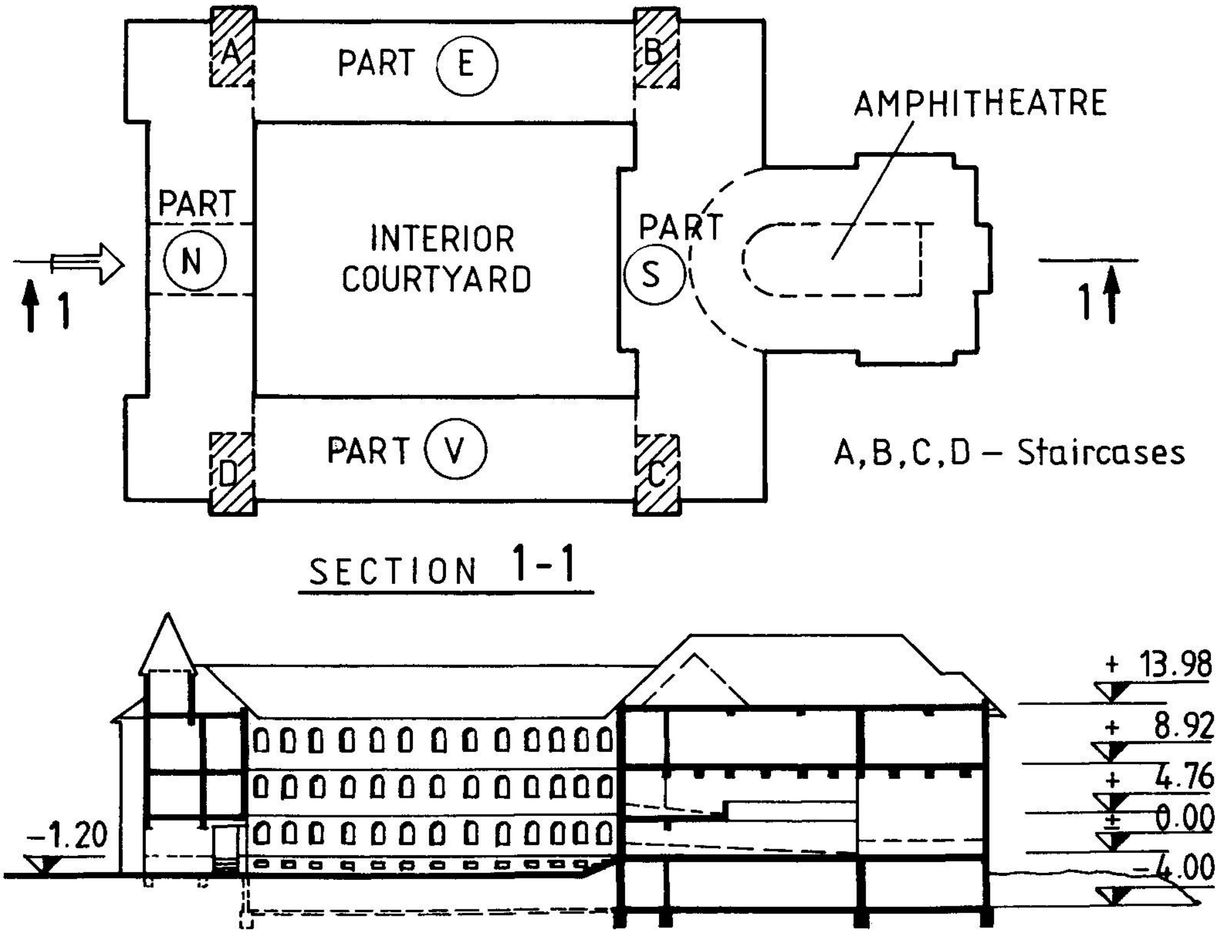

Fig. 1 The geometrical characteristics of the building

permanent threat for human lives [1].

One of these old buildings, damaged during the earthquake from March 4, 1977 with the epicentre in Vrancea - Romania, is the building of the Faculty of Agronomy from Craiova - Romania.

2. SHORT DESCRIPTION OF THE BUILDING

The building was erected in three stages, from 1928 to 1954, and its structure is made of resistance walls with a full brick masonry, placed after two principal horizontal directions, for the ground floor and the storeys, whereas the basement walls and the foundation are made of simple concrete.

Having a quadrilateral principal plane form, with an interior courtyard, and with an amphitheatre in the South part (see Figure 1), the building is developed on three levels (ground floor and two storeys) in the North part and four levels (basement, ground floor and two storeys) in the South, East and West parts.

The floors of the building are made of monolith reinforced concrete in all the wings and at all the storeys of the building, except the one that covers the amphitheatre from the South part of the building, which was replaced by a lath and plaster ceiling, suspended by the soles of the roof trusses.

The building has a timber roof with a covering of gutter tiles. For the vertical circulation, the building has four reinforced concrete stairs.

3. THE DAMAGES OF THE BUILDING DURING THE EARTHQUAKE

The main damages (as described in detail in [2]) were the followings:

- the cracking of the majority of the resistance walls (longitudinal and transversal walls), with the following characteristics: horizontal cracks under the floor girdles, vertical cracks at the appearance of the floor joints, crossed cracks from the shearing loads and cracks in the lintels of doors and windows (see Figure 2);

- the appearance of a number of joints in the floors, caused by the cracking of the floors in the connection area between the transversal and longitudinal wings of the building;

- the settlement of the South wing walls foundation and the cracking of these walls;

- the cracking of the walls and stair elements of the staircases "B", "C" and "A" (see Figure 1), with partial wresting of the stair landings from the exterior walls of the staircases "B" and "C";

- the fall of the chimneys, causing damages of the roof and of the altic floors;

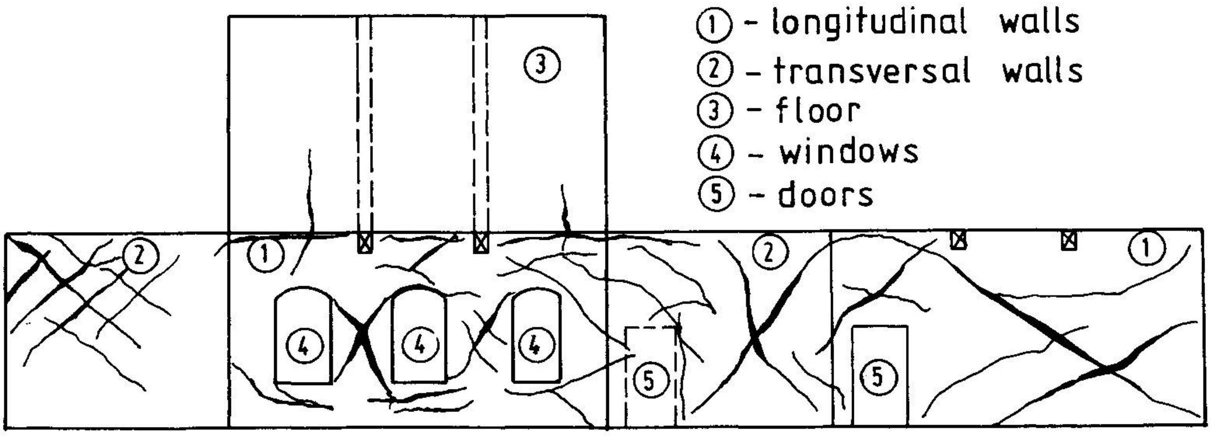

Fig. 2 An example of walls cracking

4. PROPOSALS FOR THE STRUCTURE CONSOLIDATION OF THE BUILDING

Because the masonry structure rigidity was diminished by the cracking and damaging of the walls and floors, the verification of the bearing capacity after the earthquake action was made according to the current Romanian norms: P2-85 [3] and P100-92 [4], with the following relation:

$$\eta S_0 \leq m \sum T_{cj,\min} \tag{1}$$

where:

ηS_0 - represents the calculated load of the structure, under the effect of a violent earthquake (7.5 degrees on the Richter scale);

$m \sum T_{cj,\min}$ - represents the minimum bearing capacity, calculated with a simplifying assumptions acceptance [5].

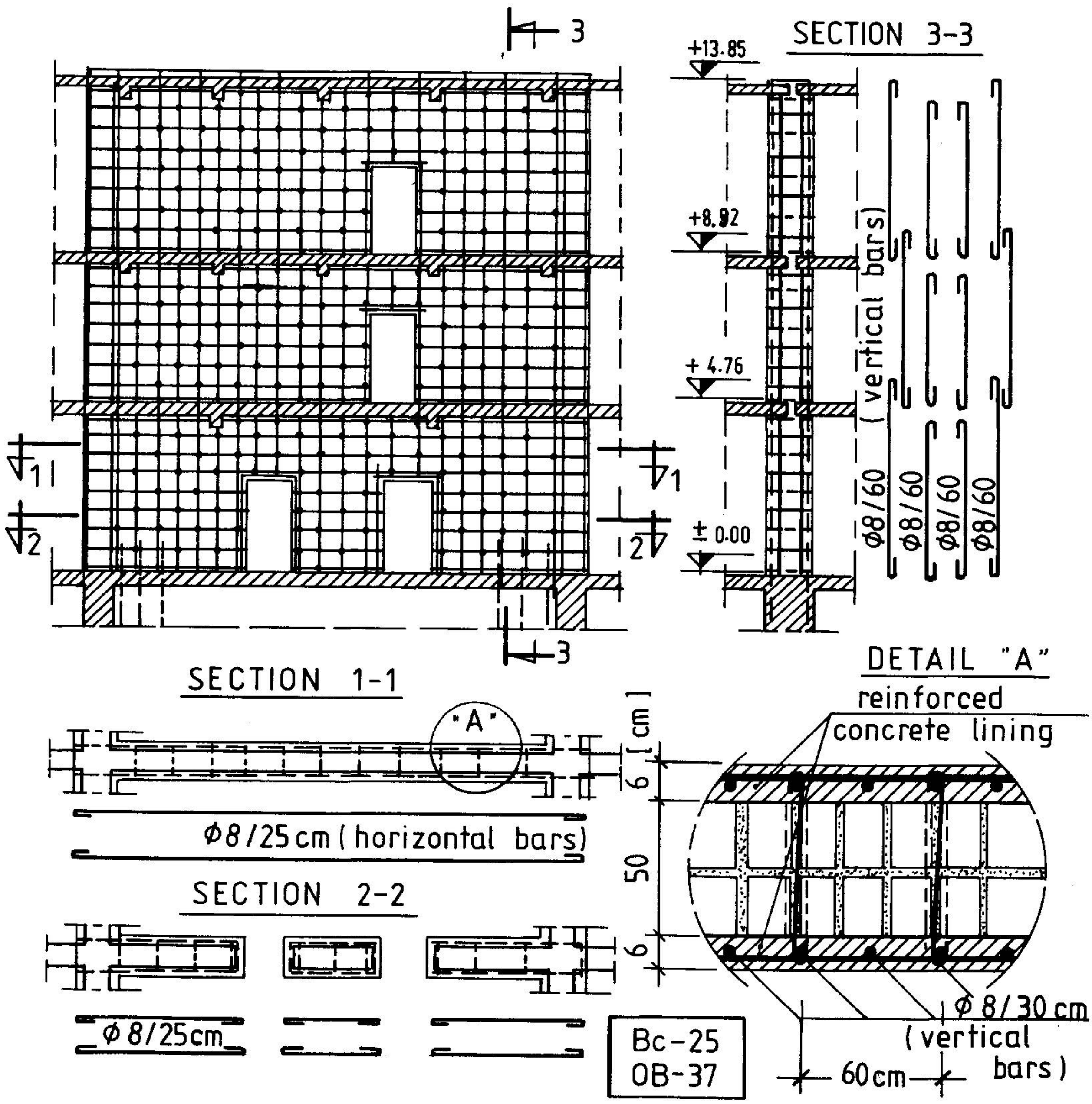

Fig. 3 The lining of the resistance masonry walls

The result of the calculus pointed out that masonry structure of the building does not comply with the antiseismic requests and that it cannot resist to a strong seismic load corresponding to the antiseismic protection degree in which Craiova is included.

The most important recommendations regarding the repairing and the consolidation of the structure were:

- the lining on both sides of the longitudinal and transversal walls of the structure, with thin monolith reinforced concrete shear walls (having a thickness of 6 cm). There must be pointed out the necessity of the continuity of the vertical reinforcements from the concrete shear walls on both sides of the masonry wall (by piercing the floors), and the linking of the steel reinforcements on both sides of the masonry wall, with reinforcement nets traversing the wall (see Figure 3).

- the making of eight reinforced concrete transversal frames in the South wing linked to the masonry walls and the existing floors (see Figure 4). The beams of these frames can be made including the existing monolith reinforced concrete beams of the floor, in the new beams of the frames and the monolith reinforced concrete columns can be made inside the two large rooms having their own foundations linked to the existing foundations of the walls.

- the consolidation of the amphitheatre by introducing the reinforced concrete transversal frames on the height of the basement, ground floor and first storey (see Figure 4). These frames will be linked with the exterior walls and with the existing transversal beams of the reinforced concrete floor above the amphitheatre;

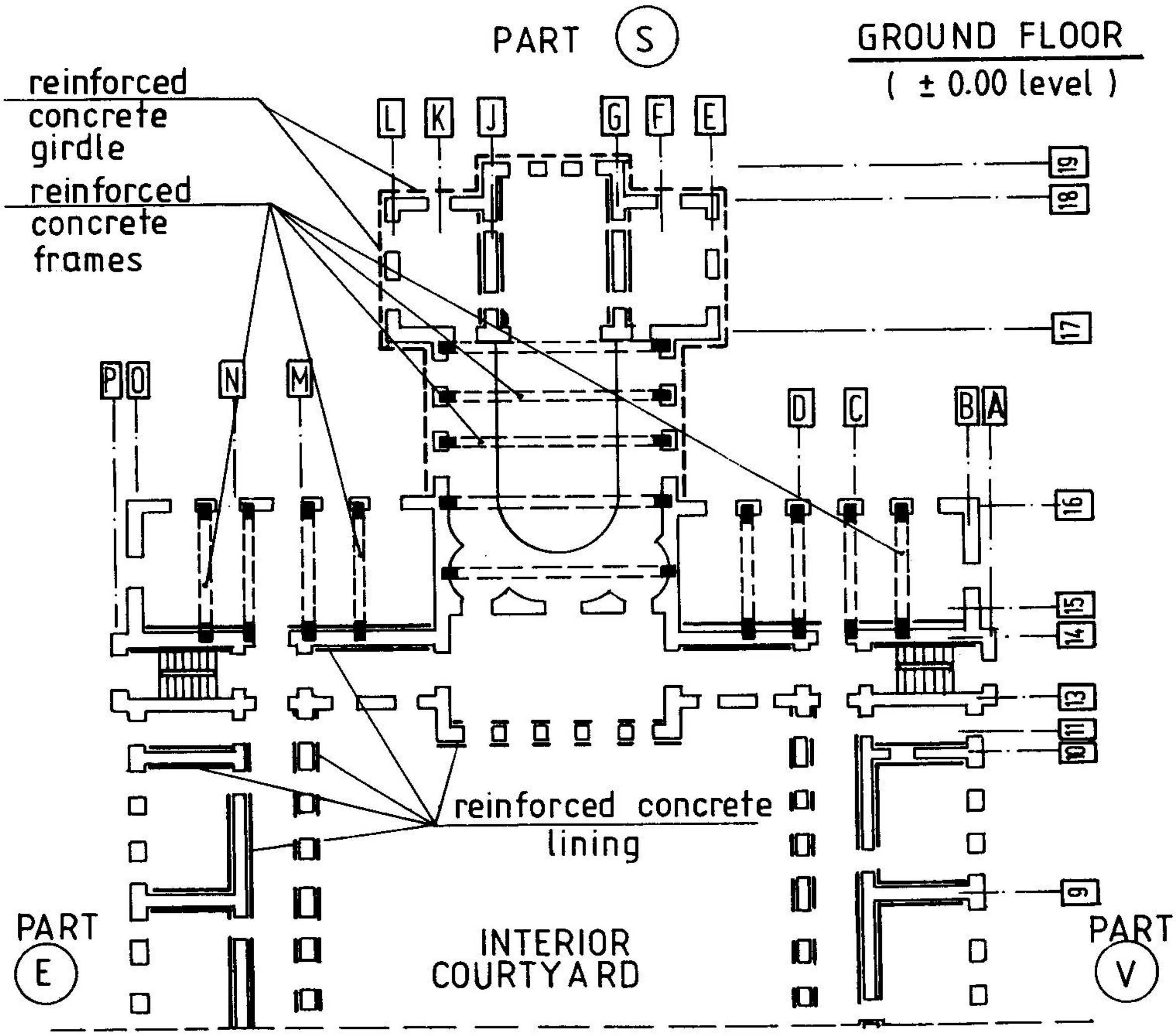

Fig. 4 The consolidation of the South wing of the building

- the repairing of the damaged staircases with partial masonry restorings, steel bars and girdles;

- the local repairing of the interior and exterior walls between windows and doors by lining with reinforcement nets and high resistance shotcrete;

- the making of some reinforced concrete girdles on the exterior of the amphitheatre, at the level of the floor situated above the basement, at the superior part of the windows railing and at the level of the floor above the amphitheatre. These girdles will be linked to the columns of the new frames by piercing the exterior walls.

- the consolidation of the exterior and interior corners of the North wing by lining the whole height of the building with reinforced concrete and by linking these corners with horizontal steel bars (tie rod) included in the exterior reinforced concrete girdles at the floors levels.

It can be concluded that the repairing and the consolidation based on a design that will take into consideration the above mentioned suggestions can contribute to the restoration of the structure rigidity and bearing capacity at least up to the level they were before the earthquake action.

REFERENCES

1. TOLOGEA S., Problems Regarding the Constructions Pathology and Therapy, Technical Publishing House, Bucharest, Romania, 1976.
2. ***, The Expert-appraisement of the Building of the Faculty of Agronomy from Craiova, "Service Constructions" Association, Timisoara, Romania, 1990.
3. ***, Normative Regarding the Composition and the Calculus of the Masonry Structures - P2/85, I.C.C.P.D.C., Bucharest, Romania, 1985.
4. ***, Normative for Antiseismic Design of the Constructions - P100/92, I.C.C.P.D.C., Bucharest, Romania, 1992.
5. IANCA S. I., Solutions for the Repair and the Consolidation of the Building of the Faculty of Agronomy from Craiova, Proceedings of the International Symposium "Ancient Building Restore - Handbooks and New Technologies", University of Naples, Italy, 1993.