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CASE STUDY ON STRUCTURAL REHABILITATION OF A DAMAGED WING OF A BUILDING, IN ORDER TO CHANGE DESTINATION

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Abstract: *This paper presents a case study made on an existing building, with reinforced concrete frames as structural resistance system and masonry walls, which have obtained an advanced state of degradation. The proposed consolidation solution leads for obtaining a seismic insurance degree that fits the requirements imposed by the P 100-2006 normative.*

Key words: *concrete, frame structure, masonry wall, seismic insurance degree.*

1. Introduction

The case study presented in this paper was made on a building of a hospital in conservation due to the advanced state of degradation acquired over the time , Figure 1 and to which is assigned a new function: as "Research Center'', Figure 2.

Fig.1. The building before rehabilitation

Fig.2. The building after rehabilitation

The case study investigated on the building was made in two steps:

- determining the level of earthquake insurance in accordance with the norms P100-92 and P100-2006
- determining the structural rehabilitation solution for the existing building in order to change the destination and the fulfilment

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of the requirements of earthquake insurance according to P100-2006 normative.

In this paper, the authors aim is to present the second phase of the investigation work.

1.1. Elements of general description

The structure type is reinforced concrete frames (calculated only for gravitational loads) with brick masonry walls used for partitioning. The building has 1500 m2 in section and has a height Basement (partially) + Semi-basement + Ground floor + (2-3) Floors +Attic. It consists of three parts - bodies A, B1 and B2 separated by settlement joints (and seismic joints). The building was built between 1938-1940 and is now damaged and vandalized. [1]

1.2. The characteristics of the area

The seismic zone including the building complex is characterized the coefficient $a_g = 0.24$ [m/s^2] , and corner period Tc = 1.6 sec. according to the map 3.1 of P100-1/2006 normative. [2][3].

The climate zone for snow loading values corresponding to the characteristics of the load of snow on the ground, s0.k is 200 daN/m^2, [5], and the climate zone for wind loading values, is corresponding to a characteristic referenced pressure of the wind, averaged over 10 minutes at 10m height, qref, is 0.5 kPa, [6]

1.3. The calculation characteristics of the building

Specific load on the floor:

-carrying (normal), usually 200 daN/m^2

-the weight of the structural elements is automatically considered in the calculation (by the calculation program used) [8]

The maximum number is five levels above ground for wings B, and four for wing A, maximum height of the roof of the building is 18 m. The importance class is I (construction of vital importance) according to P100, tab. 5.1 [2]. According to STAS 10100/0-‘75 the importance class is II (special class of importance). The category of constructions according HG 766/1997 is B.

1.4. The structural and material characteristics of the wing “B1” of the existing building

From structural point of view they could find 77 concrete pillars in the intersections of the texture axes, each linked to at least one beam of reinforced concrete from the others columns and form together a single frame bunk. [1]

The concrete marks (in columns), established instrumentally and utilised in calculations is C 12/15 (B200}.

Aspects regarding the state of concrete in structural elements is showed in Figures 3,4. The elasticity module taken in calculations is 240000 daN/cm^2 (corresponding concrete mark). (fig. 3)

Fig.3. An existing pillar , at the basement of the building.

The steel utilised for reinforcement structural elements is OB37 and the percentage of longitudinal reinforcement pillars reinforced is 0,9-1% (8Ø20}.[1]

Fig.4. An existing pillar damaged

Fig.6. A deteriorated frame of reinforced concrete

2. The structural consolidation of the building investigated

2.1. The description of the state of degradation of the existing building

The visual inspection of buildings has showed the existence of multiple degradations due to seismic movements and vandalism in recent years. Figures 5,6.

The multiple degradations are embodied in cracks on the mains directions of the building to brick walls, peeling plaster on the walls from the contact areas with concrete frames and peeling walls of the mesh formed by the frame (fig. 5). But it wasn't seen cracks in reinforced concrete frames (fig. 4, fig. 6), which means that energy dissipation was made by degrading the masonry, which means that the concrete reserves of strength are not consumed.

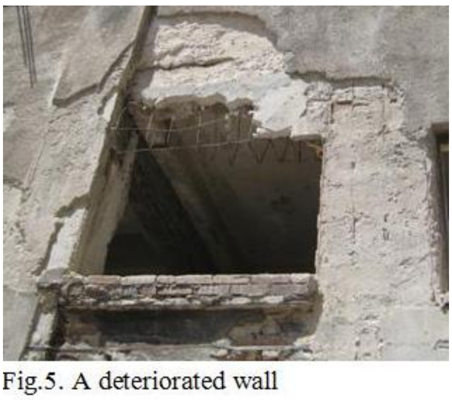

Fig.5. A deteriorated wall

All the other degradations are due to lack of maintenance and vandalism. In the basement of the building there are also infiltrations.

2.2. The analytical method E2a for assessing the level of protection from seismic action

This method was pursued for determining the nominal level of assurance to seismic actions, R, according to the head 11.4 of P100 normative seismic changed in 1996.

The value of R is given by the ratio of the conventional seismic load bearing capacity capable (S_{cap}) the construction and conventional seismic load level on site (seismic base shear force) corresponding to the current state building (S_{nec}).

The calculation method was applied on the current model of structure, studying the wing B1 of the building.

It was used the structural analysis program AXIS, and applying the loads determined at point 1.3, properly (according to technical rules now available for loads), Figure 7.

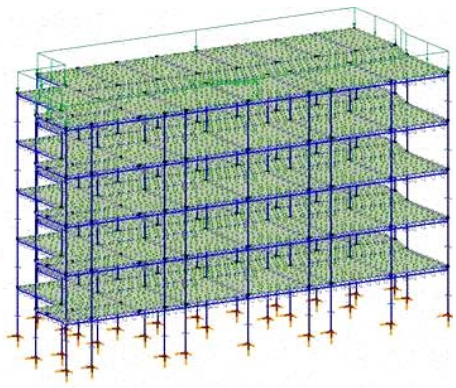

Fig.7. The load form of the structure in the structural analysis program AXIS

It was also respected the existing gauges of the structural elements.

The study was global, but considering especially the pillars highly loaded, appreciated to be in the critical area, and the results obtained are given in Table 1.

The results of the study, made on the wing B1 of the building Table 1

Periods of vibration in N-S direction [sec]	0,33
Periods of vibration in E-W direction [sec]	0,29
Periods of vibration general torsion mode [sec]	0,29
The relative displacements of the level for the N-S direction [%]	4,55
The relative displacements of the level for the E-W direction [%]	3,64
S_{cap} value [daN]	41358,1
S_{nec} value [daN]	75196,55
The degree of assurance at seismic actions	0,55
fulfillment degree of insurance against seismic actions	NO

- Periods of vibration of the building for vibration mode I are 0.33 sec in the N-S direction, 0.38 sec. E-W direction and 0.29 sec. general torsion model.
- The relative displacements of the level are 4,55 % for the N-S direction and 3,64% on the E-W direction, closer to the actual behavior of the structure as seen on the ground, Figure 8.

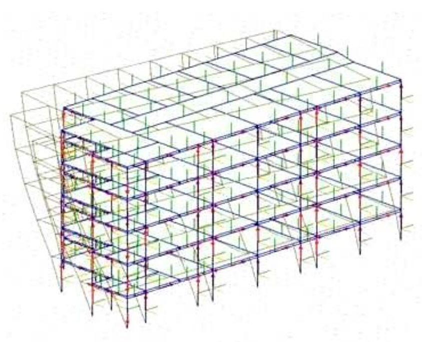

Fig.8. The lateral displacements of the building, acording to the structural analysis program AXIS

- The S_{ca}p value in this situation (defined as the ultimate performance of reinforced concrete columns) is 1.79 times smaller than Snec, which leads to a degree of nominal seismic assurance of R = 0.55 (in the conditions that it was operated with seismic loads increased by 1.75 times (the coefficient of importance to public health units). [1]

According to the head 11.4 of P100 normative seismic changed in 2006, the minimal seismic assurance degree need so that the existing structure withstand the loads imposed by the new regulations in use, is R_{min}=0.7

All these facts shows that it's needed to achieve a structural reinforcement of the building. [7]

2.3. The description of the solution proposed for structural rehabilitation

According P100-1992 normative, completed in 2006, the analyzed building, at the end of the consolidation process it must be fulfil a degree to insurance against seismic actions at least 0.7, according the category to which this building belongs.[3]

Consolidation will be done by introducing instead of some existing brick walls of concrete walls, with their own new foundations (Fig. 9).

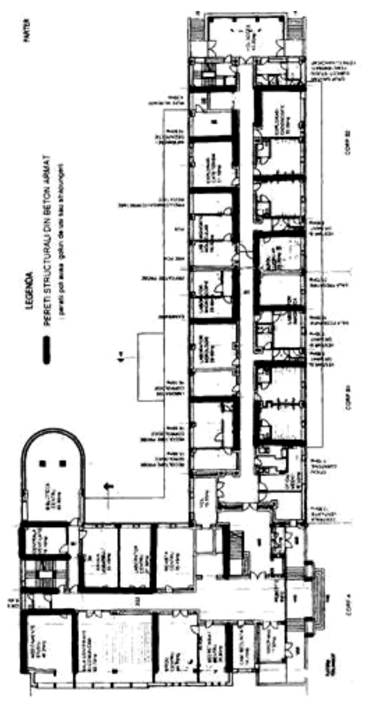

Fig.9. The displacements of the concrete walls that are used for consolidating the building

Concrete walls will have a thickness of 15 cm and will be made of concrete B300 (C18/22,5). Their route will be between the existing concrete columns.

The walls positioning, that will be the same with some of the existing masonry walls, will cause them to go through some concrete beams of the frame.

In order to establish the fulfillment of the degree of insurance against seismic actions, it was used the structural analysis program AXIS, as it was used in the first case (point 2.2), but taking into account that the structural system is changed, by introducing the reinforced concrete walls (Fig. 10).

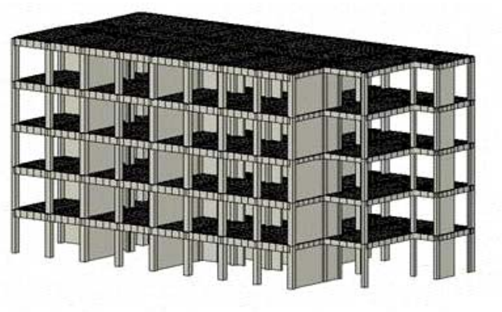

Fig10 The wing B1 after introducing the concrete walls that are used for consolidating the building

The loads are the ones presented at point 1.3 and at he the end oft the structural analysis, it has been obtained the following results:

- Periods of vibration of the building for vibration mode I are 0.20 sec in the N-S direction, 0.24 sec. E-W direction and 0.18 sec. general torsion mode I.
- The relative displacements of the level are 1 % for the N-S direction and 1,60 % on the E-W direction.
- The S_{cap} value in this situation (defined as the ultimate performance) is 75692,62 daN, which leads to a degree of nominal seismic assurance of R = 1 .

The results obtained are presented in Table 2.

The results obtained from the analysis for the wing B1 consolidated Table 2

Periods of vibration in N-S direction [sec]	0.20
Periods of vibration in E-W direction [sec]	0.24
Periods of vibration general torsion mode [sec]	0.18
The relative displacements of the level for the N-S direction [%o]	1.00
The relative displacements of the level for the E-W direction [%o]	1,60
Scap value [daN]	75692.62
Snec value [daN]	75196.55
The degree of assurance at seismic actions	1,00
fulfillment degree of insurance against seismic actions	YES

3. Conclusions

When this structure was designed in 1940 there was no legislation to regulate and enforce seismic calculation of the structures. The structural sizing was done based on meeting the future taking in good condition of the gravitational loads

Due to changes to the functionality of the studied building although it did face 3 major earthquakes and it's still be to fulfill certain conditions in order to preserve the old usage, it was necessary to be adopted an improved on the structural system, so that the loads generated by the new functions transmitted structure can be properly endured by the consolidated building.

All interventions provided were designed to improve the mechanical performance of the structure, increasing strength and stability of the whole building.

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