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ASSESSMENT AND EVALUATION OF A SINGLE STOREY EXITING STRUCTURE AND THE POSSIBILITIES TO EXTEND AT TWO STOREYS

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Abstract: *This paper describes the technical solutions used for the structural strengthening of an existing reinforced concrete framed construction. Tests have been carried out on the existing construction to obtain the results required for an assessment in accordance with the current regulations and to evaluate the possibility of adding one floor. The test results led to the following necessary works: strengthening of existing reinforced concrete pillars, execution of reinforced concrete belts on the existing foundations, execution of a reinforced concrete slab over the existing ground floor, so that the exploitation under safety conditions to be assured.*

Key words: *structural rehabilitation, existing buildings, seismic energy dissipation*

1. Introduction

The existing building was designed and built before 2005, at that time the horizontal load calculation regulations were different from those currently in use [1,2].

1.1. Description of existing structure

- Number of existing storeys – 1, ground storey;
- Horizontal polygon shape; dimensions: 28.25m x 15.73m;
- Regular superstructure with maximum height of 2.95 m;
- Frames - monolithic reinforced concrete;
- Isolated reinforced concrete foundations;
- IIIrd class of importance and exposure to earthquake;
- Number of bays: 7;
- Cross sections: Beams 30x50 cm;
  Central columns: 40x50 cm;
  Marginal columns: 40x50 cm;

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- Reinforcement:	Current floor beams	top	4 Φ 20;
		bottom	4 Φ 20;
	Central columns	ground floor	4 Φ 14 + 8 Φ 12;
	Marginal columns	ground floor	4 Φ 14 + 8 Φ 12;

- Concrete: Columns: C 20/25;
  Beams: C 30/37;
- Steel: PC 52.

1.2. Evaluation of existing building state

Cracks in reinforced concrete beams;
Settlement of concrete in the structural elements.

Fig. 1. *Actual state of the existing structure*

1.3 Proposals to extend the existing structure

- Number of floors: ground storey + first storey
- Horizontal polygon shape; dimensions: 28,25m x 15,73m;
- Regular superstructure with maximum height of 2.95 m;
- Frames - monolithic reinforced concrete;
- Isolated reinforced concrete foundations;
- Monolithic reinforced concrete slab as the ground floor
- Roof type – terrace + insulations and proofing;
- Plasters and paintings as wall finishes.

2. The Qualitative Assessment of The Existing Structure and Classification to Seismic Risk Classes

2.1. The R_1 degree – function of structural composition for seismic actions (Code P100-3/2008)

The qualitative assessment of the resistance structure by calculation of the "The R_1 degree –

function of structural composition for seismic actions" establishes the extent to which the rules of general compliance of structures and of detailing the non-structural and structural elements are observed. The value of the degree R_1 is 75 points out of 100 and is associated with seismic risk class III [2, 3, 7].

2.2. The R_2 degree – function of structural damage (Code P100-3/2008)

The qualitative assessment of the resistance structure by determining the "The R_2 degree – function of structural damage" shows whether the integrity of the materials from which the structure was made of has been affected during the construction service time. The value of the degree R_2 is 79 points out of 100 and is associated with seismic risk class III.

2.3. The R_3 degree – function of structural resistance capacity, given by 2[nd] level methodology (Code P100-3/2008)

The values of R_3 degree for each of the structural elements are calculated.

On the basis of these values the possible fragile failure structural elements are found out, especially of the structural elements in the same situation, the ratio between the resistance of the vertical and horizontal elements and the probabilistic structural mechanism of seismic energy dissipation is estimated.

This information is essential for classifying a building into a seismic risk class.

R_3 degree for beams at the ground storey Table 1

Before strengthening		M_{Ed} [kNm]	M_{Rd} [kNm]	R_3	Necessary strengthening
Central beam - 25x55 cm	Ground storey	14	162	11.571	NO
		10	162	16.2	NO
Edge beam - 25x55 cm	Ground storey	14	162	11.571	NO
		10	162	16.2	NO

R_3 degree for columns at the ground storey Table 2

Before strengthening		M_{Ed} [kNm]	M_{Rd} [kNm]	R_3	Necessary strengthening
Central column - 40x50cm	Ground storey	12	124	10.333	NO
Edge column - 40x50 cm	Ground storey	12	124	10.333	NO

According to the values given above, the existing building is classified as seismic risk class IV, corresponding to buildings where the expected seismic response is similar to those buildings designed on the basis of present regulations.

3. Design of the Extended Structure

3.1. Design of the strengthening solution

For the existing construction the proposed solutions are:
- increasing the section of the existing columns from the ground storey by 7.5 cm on all sides, so results the section: 55x65 cm;
- casting of a slab over the ground floor (20 cm);

For the extension, 2nd storey, the proposed solutions are:
- Columns of 35x35 cm;
- Longitudinal beams of 25x30 cm;
- Transversal beams of 25x40 cm;
- Slab of 15 cm thickness.

3.2. Stiffness at horizontal forces

According to the provisions of Annex E of P100-1/2013, verification of inter-storey drift is performed at two limit states, the service limit state (SLS) and the ultimate limit state (SLU). The structural elements to be verified have the dimensions given by pre-design.

3.3. Vibration period of the strengthened structure

For T_C = 0,7s there were chosen 12 own modes of vibration. The amount of masses involved exceeded 90% of the total mass of the structure.

Vibration period and modal participation factors Table 3

Vibration mode	Period	Translati on - X	Translati on - Y	Transla tion - Z	Transla tion - SX	Transla tion - SY	Transla tion - SZ
1	0.3491	87.298	0.0002	0	87.2983	0.0002	0
2	0.3397	0.0003	83.0034	0	87.2986	83.0036	0
3	0.2964	0.3331	0	0	87.6317	83.0036	0
4	0.1362	12.354	0	0	99.9862	83.0036	0
5	0.1233	0	16.9932	0	99.9862	99.9969	0
6	0.1121	0.0136	0	0	99.9998	99.9969	0
7	0.0388	0	0.0003	0	99.9998	99.9971	0
8	0.0370	0	0.0027	0	99.9998	99.9999	0
9	0.0245	0	0	0	99.9998	99.9999	0
10	0.0232	0	0	0	99.9998	99.9999	0
11	0.0218	0	0	0	99.9998	99.9999	0
12	0.0212	0	0	0	99.9998	99.9999	0

3.4. Verification at the service limit state SLS

Verification at the service limit state aims to maintain the main function of the building after earthquakes, which may occur several times in the life of the building, by controlling the damages of the non-structural elements and of the inner installations of the building. By satisfying this condition, the costs and the time necessary for repairs to settle the construction into the pre-earthquake situation are limited.

Inter-storey drift at SLS Table 4

Storey	Direction	d_{re}	d_r SLS	d_{ra} SLS
Storey 1	Transversal	0.00032	0.001073	0.005
Ground storey		0.00028	0.000935	
Storey 1	Longitudinal	0.00033	0.001127	0.005
Ground storey		0.00022	0.000746	

3.5. Verification at the ultimate limit state SLU

Verifying lateral deformations at the ultimate limit state is primarily intended to prevent the collapse of non-structural elements. This verification is required for concrete structures (but not for wall structures or coupled frame-wall structures), for steel structures and composite steel-concrete structures.

Inter-storey drift at SLU Table 5

Storey	Direction	d_{re}	d_r SLS	d_{ra} SLU
Storey 1	Transversal	0.00053	0.005883	0.005
Ground storey		0.00046	0.005154	
Storey 1	Longitudinal	0.00055	0.006163	0,005
Ground storey		0.00053	0.005883	

3.6. Calculation of the proposed structure

Structure calculation at horizontal and vertical actions was performed using the ETABS software. The superstructure calculation model is a frame restrained at the base into foundations, due to the more rigid infrastructure.

The reinforced concrete slab presents high stiffness and strength to horizontal action (seismic action) in its plan and can be considered non-deformable in this plan.

The structural elements of the superstructure, columns and beams were modelled using linear type finite elements.

The calculation of the efforts presented is done at the seismic combination of loads.

Design bending moments for beams are given directly by the envelope diagram of all the possible combinations of loads.

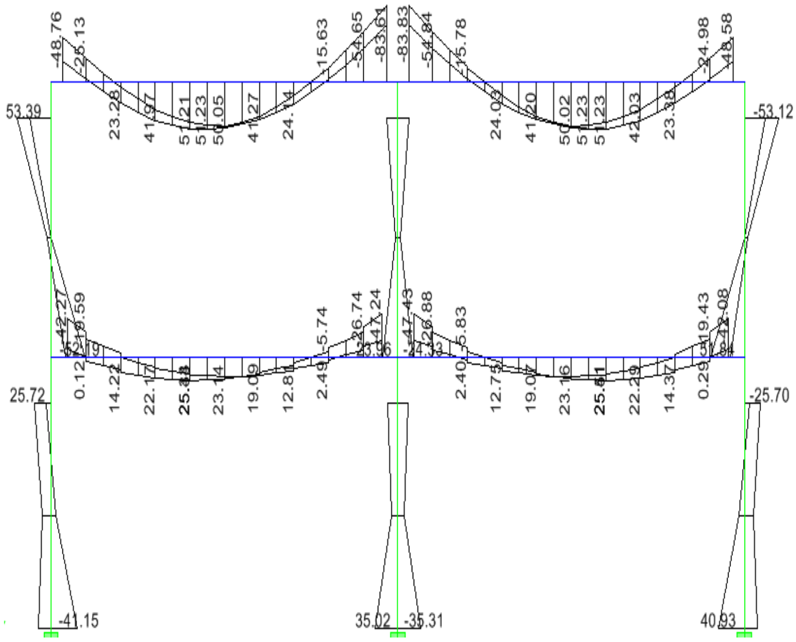

Fig. 2. *Bending moments values for transversal frame*

4. Conclusions

After the construction of 1^{st} storey and the application of the strenghtening solutions for ground storey columns, the structure is classified as seismic risk class IV.

The plastification mechanism of the structure remains similar to that of the un-strengthened structure.

The construction ensures all the requirements for the safe service.

References

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