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# Aspects regarding the extension and consolidation of a house located on a sloping plot of land

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**Abstract.** When the land available for a construction is in slope, with a high degree, there can be a series of problems related to geotechnical data and execution difficulties, considering the foundations and the structure itself. The grade of difficulty is considerably increased when an extension or attic is intended to be design and build. The paper is presenting some considerations to this problem, taken into account a study case – extension of an existing structure for a family house.

## 1. Introduction

There is a continuous expansion of the urbanization in Romanian cities. The lack of buildable plots is partially solved by extensions of the existing buildings, which provides benefits in terms of solving the needs for housing, while preserving the urban habitat for the local population.

This paper is presenting some considerations upon the extension of the existing house build on a sloped plot. There is presented a study case for an extension with an attic for an existing construction located in Săcele city (Braşov county), on a ground with slope ~ 35 degrees (figure 1, 2). Through the design theme, the owner wants to transform a family house into a two apartments house. It is also desired that the ground floor does not change its current functions or dimensions. The project respected this design theme, so that the same wall partitioning was kept on the ground floor, the extension area having more of an access role to the attic.

The conditions of the building location, in a landscape specific to mountains areas, are generally challenging in terms of structural solutions [1].

Considering the study case, in order to accomplish a functional building extension with an attic, several infrastructure problems have been encountered: foundations with insufficient depth and width, the nature of foundation soil, problems in rainwater drainage, natural slope of the land and problems related to existing structure: lack of columns confinement for the load-bearing brick walls, the lack of the perimetral belt at the level of the reinforced concrete slab above the ground floor.

The article presents solutions for identified problems in the existing construction and for details for the extension and attic. There is also taken into account the increasing of the energy efficiency of the house, in the end comparing the existing and the designed situation [2].

## 2. Description of design and execution difficulties

According to the design theme, the owner wants to build an extension and an attic for an existing house. The existing height regime is ground floor and will become a ground floor with an attic, increasing the total height of the construction. As presented in figures 1 and 2, there are two retaining reinforced



concrete walls: one located in the area of the house and one in the back of it (which is approximately at the level of the ground floor of the existing house) [3]. Also, in figures 3 and 4 there are presented the facades of the existing building.



Figure 1. Left side facade, first support wall.



Figure 2. The second support wall.



Figure 3. Existing main facade.

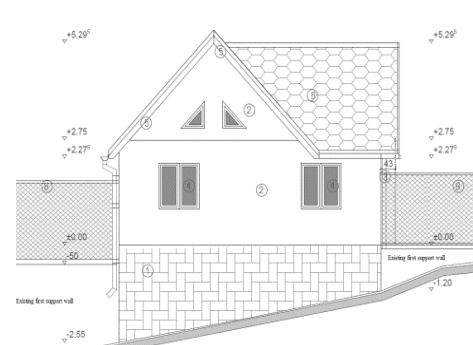


Figure 4. Existing left facade.



Figure 5. Proposed main facade.



Figure 6. Proposed left facade.



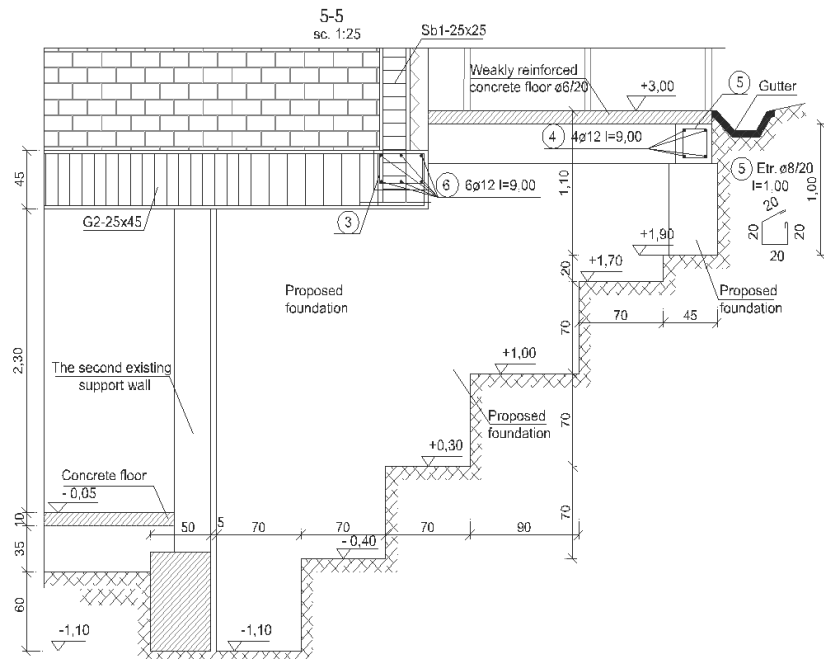


Figure 8. Detail 5 of the foundation.

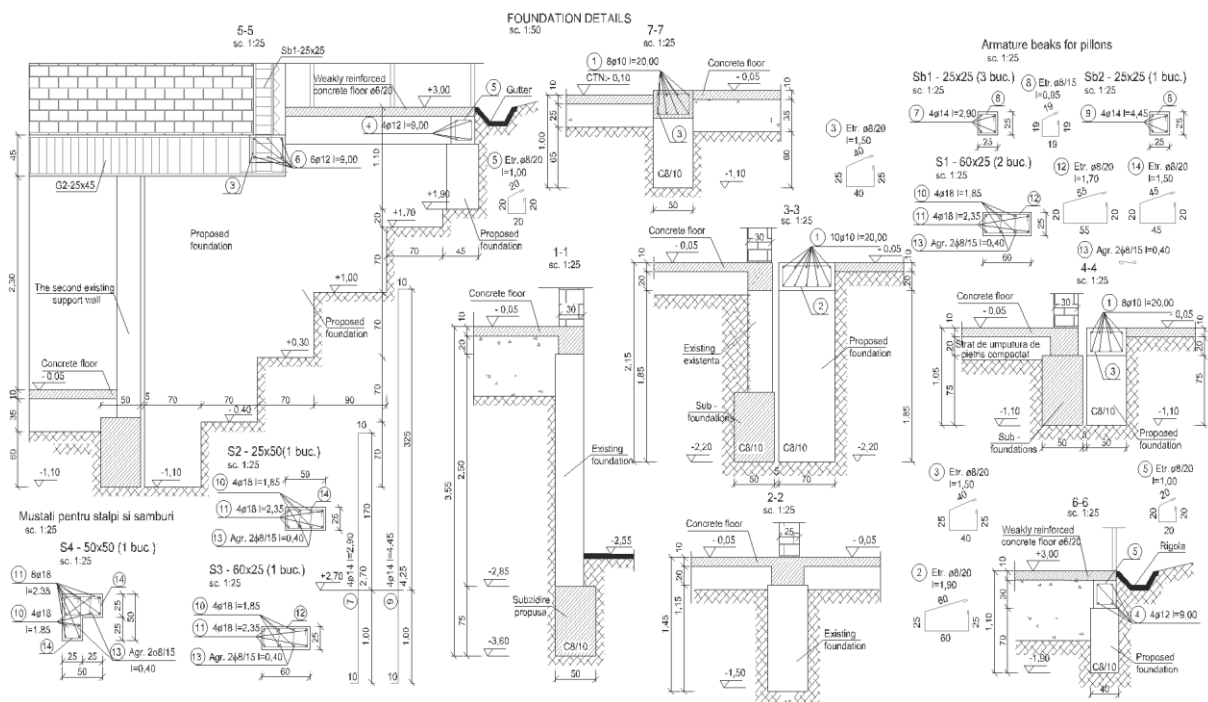


Figure 9. Foundation details.

The seismic gap at the level of the roof was made by doubling the wooden support elements. This mode of execution also allows independent movement at the roof level. Fortunately, in axis C, between axes 2 and 6, the architect provided a skylight who changes the slope of the roof. The roof tiles are made of steel sheet. Under these conditions, the steel sheet will be cut at the slope change, and the bottom sheet can move under the protection of the sheet above.

A reinforced concrete belt was designed under all the external walls and under a part of the structural walls of the attic in order to withstand the seismic loads – ensuring a rigid slab. The columns provided in the attic, over the existing building area, are also embedded in this belt.

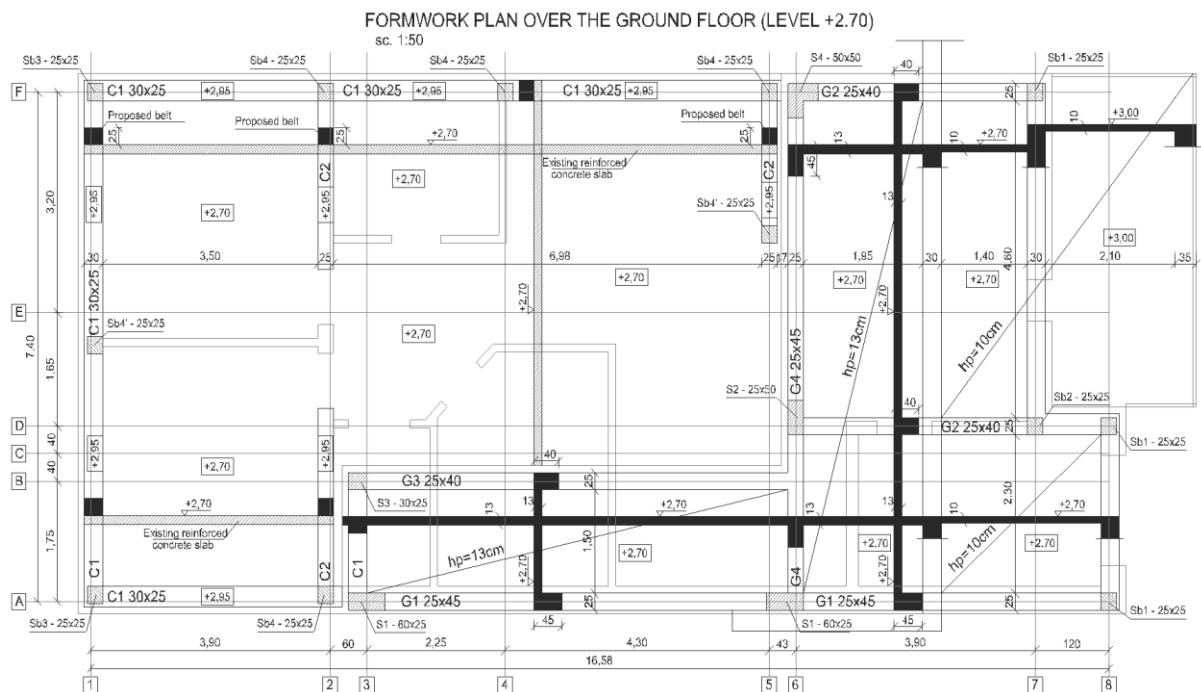


Figure 10. Formwork plan over the ground floor (level +2.70).

Considering the execution, the pouring of the concrete was a challenge due to the fact that the road access nearby the construction had to be blocked. To enter in the yard of the house you have to make a sharp turn, impossible for a big vehicle. Thus it was needed to pour the concrete into gutters, supported on the formwork, to the edge of the terrace and the extension area, directly from the road area. Due to the traffic conditions, pouring of the new foundations, half of the sub-foundations and the belt over the attic was erected in a single stage. In the second stage it was erected the other half of the sub-foundations, the pillars supporting the extension and the pillars over the old construction. In the third stage, the floor of the extension was made. In the last stage, the pillars from the attic in the extension area and the belts and beams under the roof were made [7].

### 3. Results and Discussion

The first investigated problem [9] was the one related to the presence of a small damage at the level of the existing construction foundation. In addition to the access road to the property there is a water channel protected with precast concrete elements. This channel collects excess water from a swamp area (ponds, ravines, meanders, etc.) located upstream of the construction site. Due to this channel as well as the presence of a rainwater collection pipe on the property, this pipe being embedded in the first retaining wall, a slight degradation of the foundation of the existing building was identified. For this reason, a consolidation was recommended to stabilize the land in the area together with the necessary works for the attic and the extension. The owner considered these additional works too expensive. Due to the fact that the degradations in the foundations are minor without the appearance of dislocations or rupture of the foundation continuity, the consolidation of the land will be done at a later stage when measures will be taken to consolidate the entire access road [7, 10].

The second investigated problem was related to the seismic gap. Based on the geotechnical study, as well as the laboratory tests performed on the existing construction, the following were found: areas of the continuous foundation is embedded above the frost depth [4, 11], or do not have a sufficient width,

lack of reinforced concrete pillars for masonry confinement, both interior and exterior structural walls are made of vaults with natural aggregates, lack of waterproofing, wrong location of drains. In order not to affect the resistance structure of the initial construction, the decision was made that the extension be completely disconnected from the existing structure. In this way, a seismic gap of 5 cm at the level of the foundation and of 10 cm at the level of the structure was provided, a gap that will separate the entire structure into two building structures [6]. The width of the seismic gap was calculated so that from the most unfavorable combination of lateral displacements, including those resulting from the general torsion, the two bodies do not touch each other. The approximation of the calculated maximum displacements was 7.32 cm, so below the dimension of the gap provided in the superstructure [7]. The seismic gap is provided on the entire height of the two constructions. At the level of the frame, on the area between axis 2 to 6, it was necessary to double the frame support elements. At the level of the attic, the architect provided a skylight necessary both for a good natural lighting and for increasing the useful interior surface. Following discussions with the architect, the skylight was made in the form of changing the main slope of the roof and on the entire area of internal longitudinal overlap of the two bodies, i.e. on axis B, C between axis 2 and 6. The change point of the slope was chosen between the axis B and C, which facilitates the sliding of the roofing surfaces one below the other [12].

Between the existing construction and the second retaining wall there is a passage corridor, between the courtyard in front of the house and the land behind the house, which the owner wanted to keep. For this reason the second retaining wall had to be kept in its original form. The extension was necessary, to support, on the continuous foundations located behind the retaining wall. In order not to introduce additional forces from pushing the ground due to the loads from the extension, the foundation for the extension was made in minimum steps of length, the starting quota of the foundation coinciding with that of the retaining wall. Above the passage corridor, the floor above the ground floor of the extension was provided, thus forming a kind of passage tunnel. Normally the ends of the tunnel should have been blocked with the passage of the continuous foundation. The solution of this problem consisted in the support of the main beams G2-25x45, G2-25x45 on the left on the pillars S1-60x25, S2-25x50 respectively S4-50x50, and on the right directly on the simple foundation block, the beams being connected to the foundation belt from the beginning (figure 8) [13].

The wooden structural elements of the frame over the initial construction, show some damage, respectively most of them have smaller dimensions than the structural elements of the future frame, it was proposed that this wood should not be reused. It was also proposed that the structure of the frame for the entire attic be made of ferrocement. According to economic calculations, this solution would have been cheaper. The beneficiary opted for the classic solution with wooden elements [3].

Besides the structural consolidation on the initial building, a thermal rehabilitation was proposed to increase the energy performance. For the final energy performance of the entire building, the technical characteristics of the building and installations, the location of the building in relation to external climatic factors, sun exposure, the influence of neighboring buildings, own energy production sources and the internal climate of the building were taken into account. It was proposed to mount on the roof several solar panels for the production of electricity and heat. They were also provided for thermal insulation with 15 cm thick polystyrene and the installation of triple-layered double-glazed windows [14 - 16].

#### 4. Conclusions

The design of the extension and attic for the construction analyzed in this paper, raised significant series of difficulties in terms of consolidating existing foundations, joining the new extension area, founding on an area with high slope, difficult access of construction works due to the narrow area and on the slope.

There are presented several details regarding a possible structural solution for extension of an existing house taken into account the seismic gaps and the foundation issues, considering the different foundation levels.

Currently, construction work is almost complete. The owner was asked to make a periodically current inspection (at intervals of one year) for the entire building, both to verify the behavior over time of the consolidations made to the existent construction and at the new part of the extension. If it is proved that the executed works will not show damages, the adopted solutions can be used for other similar constructions.

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