

# Technical and Economical Management of the Reconstruction of the Bearing Structure of an Existing Arcade in the City Centre of Thessaloniki

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## Abstract

This paper deals with the economical and technical management of the construction of the bearing structure of the arcade Hirsch. Initially, the technical description of the work is presented which is of particular interest because in this project geotechnical engineering issues, buildings' underpinning issues, conservation aspects and issues of strengthening of the bearing structure constructed by reinforced concrete and adding of floors constructed by a mixed metal body, were combined, which made the project unique. Then the estimate of quantities of work is presented and on this basis the budget of the project is calculated. The schedule of the project comes after as it was originally estimated and as it was finally formed after significant delays due primarily to the discovery of archaeological finds in the Tsimiski part during the embedment of the piles of Berliner Wall. As a result, works on the part of Tsimiski were ceased for six months. The archaeological discoveries apart from the delays they caused had as a result significant changes in the static and dynamic analysis of the project. In addition, an estimate of the machinery used is quoted. Finally, there is a presentation of the project from an architectural standpoint.

## Key words:

Hirsch, technical, management, bearing, structure

## 1. Introduction

The Hirsch arcade was named in honor of the Baron Hirsch and his humanitarian action. The arcade consists of one of Thessaloniki's flagship buildings. It takes up the area between Tsimiski and Mitropoleos streets adjacent to Aristotelous square and Komninos street. The area, spanning a total 2,470 square meters, belongs to the Israeli community of Thessaloniki. Three buildings comprise the current complex: a. a four-story building with a basement on Tsimiski street, b. a single-story building with a basement on Mitropoleos street, and c. the in between building with a basement in the midsection of Tsimiski and Mitropoleos streets. The Hirsch arcade was constructed in different consecutive phases. Initially, during the Interwar years, a series of ground-floor department stores facing Tsimiski Street was constructed, and during the period of 1947-1953 the remaining floors of the arcade were erected. The section on Mitropoleos street was constructed between 1963-1968. In 1969, after a sequence of small-scale reconstructions taking place on the ground-floor department stores, the function of the arcade linking Tsimiski and Mitropoleos streets commenced (Rigopoulos, Tahiaou and Wohnstudio 2010).

The arcade building has been contracted to NOTOS.COM limited for further development and utilization. The concession is set to last 25 years after the completion of all construction activity (Penelis, 2010).

The Hellenic Ministry of Culture and Sports oversaw the restoration of the façade on Tsimiski Street, as well as the arcade itself. Additionally, it was demanded that the shell, up to and including the ground floor's ceiling remained architecturally intact, which resulted in the ground reinforcement employing grouting techniques instead of piles, due to limited space. Moreover, it was demanded that the basement floor maintained a uniform level, which led to the dredging\* of the basement and the demolition of the foundation of the Tsimiski segment (Penelis, 2010).

## **2. Technical description of works**

### **2.1 Structural propping of the Tsimiski street façade**

The demolition process of the bearing structure will be preceded by the structural shoring of the preservable façade on Tsimiski street. To this end, special metallic scaffolding will be constructed and shall be founded on jetpiles which shall be constructed on the pavement of Tsimiski street (one per each pillar of the scaffolding) (Penelis, 2008).

### **2.2 Demolitions on the four-story building**

The demolition will be preceded by the propping of slabs and beams of the floors to be demolished, starting from the fourth floor's roof (Level +18.18). It should be noted that the shoring will take place on every floor. The demolition of the roofs takes place gradually, with the removal of two spans per step (Penelis, 2008).

### **2.3 Demolition of the basement ceiling**

The demolition will be preceded by the shoring of slabs and beams of the floors to be demolished, according to the implementation plans. The main beams, excluding those which obstruct the ramp's descent, shall remain intact until the completion of the foundation work and the strengthening of the columns using conventional jackets. The two side spans of the four-story building shall be excluded. In those spans, new walls (stairs and lifts core) shall be erected, while the basement's and ground floor's roofs will be demolished. The sections where the erection of lift and stair cores is planned, will be excluded from the zones general demolition. During the demolition of the basement ceiling's slab, the columns' extreme height renders them fragile. For this reason the columns shall be reinforced with peripheral support and connecting metal phrases which will function as connecting beams (Penelis, 2008).

### **2.4 Propping of the ground-floor roof of the four-story building on Tsimiski Street**

Given that the subsistent free height of the basement in the section of the project at hand is limited, the demolition of the foundation in its entirety is in order, so as to construct in its place but lower (-5,07) the new apron slab, 1.00m thick. As a result, we shall suspend the remaining ground-floor roof of the four-story building (level +7,80) on a temporary metallic scaffolding, according to the design and the calculations that accompany it. The pillars of the scaffolding shall be founded upon double jetpiles which will be constructed at the basement floor. The jetpiles will be erected from the level of -1,60 and their free length up until level -5,07 will be encased in pile cap – wall. This is followed by the demolition of the dividing walls of the basement, between the four-story and the single-story building. The two side spans of the building (four-story section), where new lift and stair cores are to be erected, are excluded from the demolition. Instead general demolition of the ground floor and basement roofs is planned (Penelis, 2008).

## 2.5 Groutings

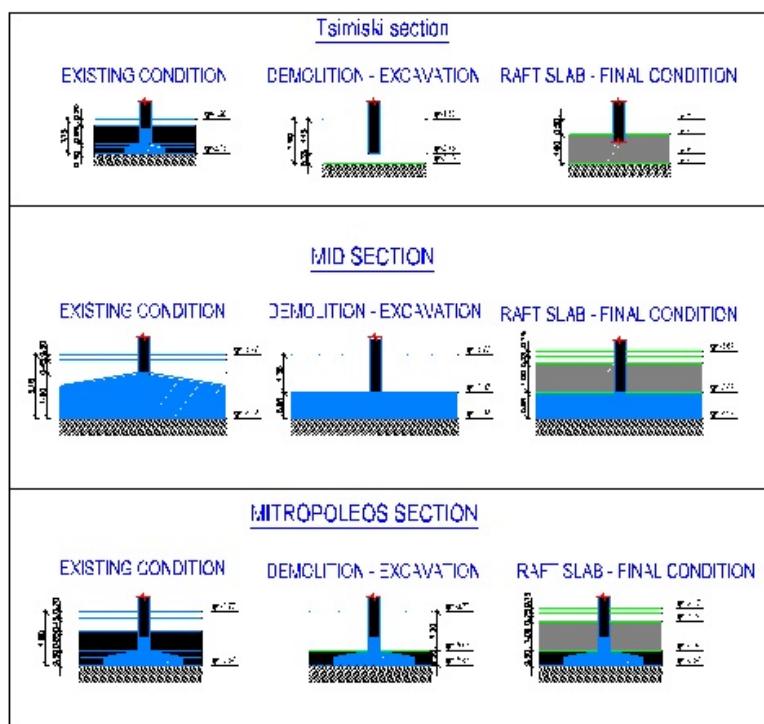
Prior to the reconstruction work in the Hirsch arcade, a geotechnical research and study was conducted, from which it was inferred that the soil did not possess the requisite bearing capacity and for this reason it was decided to reinforce the ground with grouting. (Penelis, 2008).

A pilot program of groutings was organized, which was implemented in the region of the central arcade, at such a point so that it would enable access to the required equipment. The purpose of this pilot program was to determine with precision: the grid of the dredging, the depth of the dredging, the synthesis and the pressure of the grout. After the completion of trial groutings, it was decided to carry out 1200 groutings with controlled grout pressure, so that the elevation of neighboring buildings would be avoided and the bearing capacity of the in-between loose soil would be improved (Penelis, 2008).

Initial evaluations suggested that the sedimentation would be at about 4cm. Finally, the sedimentation today as measured is at about 3mm, something which further confirms the success of the operation (Penelis, 2008).

## 2.6 Modifications on the foundations

The new foundation was based on the improvement of the current soil (specifically the layer from -6.0 until -14.5), with the use of low-pressure grid groutings. The predetermined choice was to be a raft slab of 100cm thickness, which would be constructed at a constant level for the entirety of the basement. The foundation level is -5.07 (Fig 1). For the construction of the raft slab, excavations and demolitions in the various segments of the current foundation are required (Penelis, 2008).



**Figure 1: Modification of the foundation**

The current foundation is divided into 3 segments: a) the Mitropoleos segment, which includes the part of the building from the Mitropoleos façade up to the joint, and has strip foundations in two directions, b)

the midsection, which spans from the joint up to the Tsimiski section, and consists of isolated pads, and c) the Tsimiski section which occupies the remaining part of the foundation, and consists of strip foundations in two directions (Penelis, 2008).

In the raised section of the basement of the four-story building, the dredging of the foundation shall take place, so that the final free height of the basement in that section increases and so that there is a constant level for the entirety of the basement (Penelis, 2008).

## **2.7 Construction of Berliner wall and perimeter walls**

Due to the position of the new construction, which lies in contact with neighboring buildings, it was demanded that a perimeter wall be constructed, as well as a Berliner type wall for the foundation of the preserved façade with jet-piles (Penelis, 2008).

## **2.8 Strengthening of the current bearing structure with reinforced concrete**

The level of the basement's roof is in its entirety a new construction of reinforced concrete. New columns are planned as well as the strengthening of the old ones using conventional jackets and new beams. It is important to take note during the centering of the façade's new columns, and leave enough distance from the current façade so that the new metallic columns HEB600 of the superstructure do not collide with the horizontal UPN200, on which the façade will be anchored. These UPN200 will be utilized for the final connection of the old façade onto the new metal bearing structure (Penelis, 2008).

The level of the ground floor's roof on the section of Tsimiski Street is to be preserved onto the final building as well. The strengthening of the current columns, beams and slabs is also planned, and so is the placement of conventional jackets onto aforementioned columns, beams and slabs (specifically for the slabs, 5cm conventional jackets on the top layer of the slab). Since having a grid is a necessity, we shall select the columns that need to be strengthened with conventional jackets, so that the new and existing columns are in order (Penelis, 2008).

In the remaining section of the building, the increase of the roof's total height to the new level of +8.00 is planned, excluding the sections where the two current open spaces (which are to be reinforced and preserved). The foreseen construction process is the erection of columns (conventional jackets and new ones) up until the new level, and the construction of new beams without the construction of slabs. The construction of slabs as composite is foreseen to take place after the erection of the rest of the new composite slabs of the roofs and the demolition of the current basement. After the completed erection of the rest of the roofs, the demolition of the current roof of the ground floor (central and Mitropoleos sections) is planned, as well as that of the columns which have not been reinforced in this section (Penelis, 2008).

## **2.9 Construction of composite slab of the roofs**

The new stories of the building are planned to be constructed with composite frames, namely metallic columns and composite slabs. The seating of the columns on the reinforced concrete will be carried out with chemical anchors for the Tsimiski section, and with anchors encased in the new reinforced concrete for the rest of the sections (Penelis, 2008).

The roof's level of the first floor consists of composite columns HEB600, encased in reinforced concrete 50x82cm. The main beams are HEB400, the HEA 180 purlins and the composite slab of the floor, which consists of Konti type sheet metal and reinforced concrete. The roofs' levels between the second and the fifth floors consist of metallic columns HEB600, main beams HEB400, purlins HEA180 and Konti-type sheet metal and reinforced concrete composite floors (Penelis, 2008, Penelis 2009)

The Mitropoleos façade which protrudes onto a cantilever is supported by a truss (parallel to Mitropoleos) on every floor and upon one transverse truss (perpendicular to Mitropoleos) which protrudes from the lift and stair core (Penelis, 2008).

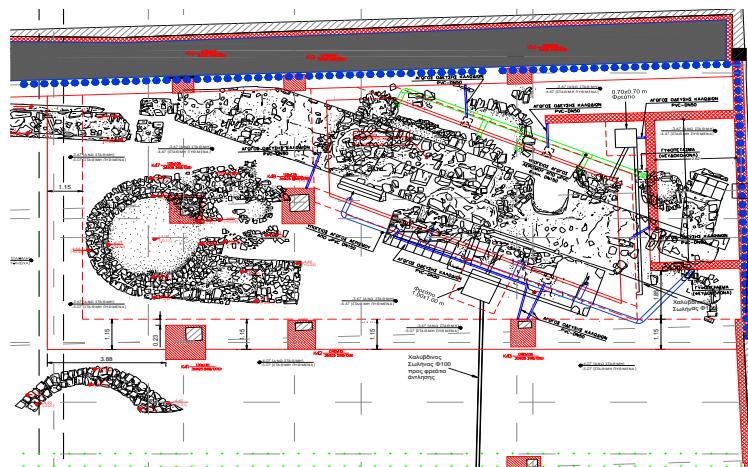
## 2.10 New Mezzanine

After the erection of the entirety of the bearing structure, the demolition of the current roof of the first floor in the sections previously mentioned, and the completion of the spans of the new ground floor roof, the construction of a new composite mezzanine is planned. The mezzanine consists of main beams HEB400 (except for a few HEB500 exceptions), secondary beams HEA180, Konti KSH98 type sheet metal (1mm). The level of the mezzanine consists of HEB400 main beams, which are anchored onto the reinforced concrete columns and HEA180 purlins. Given the uneven levels on the mezzanine, and the need to anchor metallic beams onto the new or reinforced concrete columns, it is necessary and crucial that the anchorings for the mezzanine be placed during the casting of the bearing structure (Penelis, 2008).

## 3. Modification in the Tsimiski Section due to archaeological findings

During the construction process, part out of two archaeologically significant walls of the city were revealed, made of large stone slates (of 2,47m total width), as well as pipelines and wells from the end of the 2<sup>nd</sup> century A.D. up until the Ottoman period. It was decided to preserve the wall in the basement of the building and, according to usual tactics, to showcase it inside a sealed space with a glass roof (Rigopoulous , Tahiaou and Wohnstudio 2010).

The discovery of archaeological findings lead to a necessary modification of the static study of the work. These modifications regard the Tsimiski section in its foundation, the basement and the ground floor. Regarding the foundation, the modification of the general raft slab was demanded with a reduction of the thickness from 100cm to 80cm in the section between the axes (arcade ax – 10 & M2-01). Additionally, a new hole was created (dimensions were 4,00x9,00m) in order to showcase the wall. Finally, the demolition of column K49 was demanded (Fig. 2) (Penelis 2009)



**Figure 2: Archaeological findings and modification in Tsimiski section**

In the roof of the basement column K49 was deleted and the strengthening of the beam was demanded. Column K49 was deleted and the roof of the ground floor was constructed as “planted” (Penelis 2009).

Moreover, on the ground floor a strong beam was constructed along the axis of yy', of 80x110m dimensions, so that with columns K43 and K54 it creates a frame along which the metallic column K49 is "planted" (Penelis 2009).

#### 4. Budget

The work's budget was calculated on the basis of estimations of quantities of materials required, using the price catalogs invoiced at 2007. Below you can note the budget as it was estimated in this paper, as well as the budget as it was composed during the design of the project. The resulting differences are due to lack of experience and the omission of estimating certain processes from the author of the current paper.

**Table 1: Budget of the project**

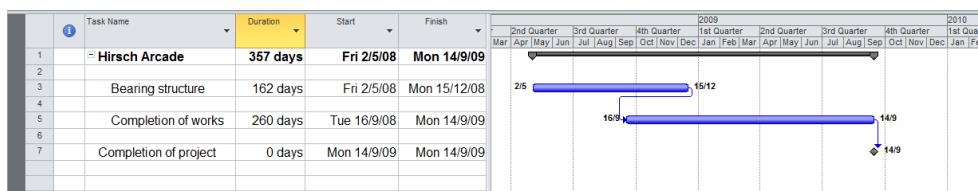
Budget (current paper)	9.234.612,72€
Real budget on the basis of the study	9.236.165,81€

#### 5. Construction schedule

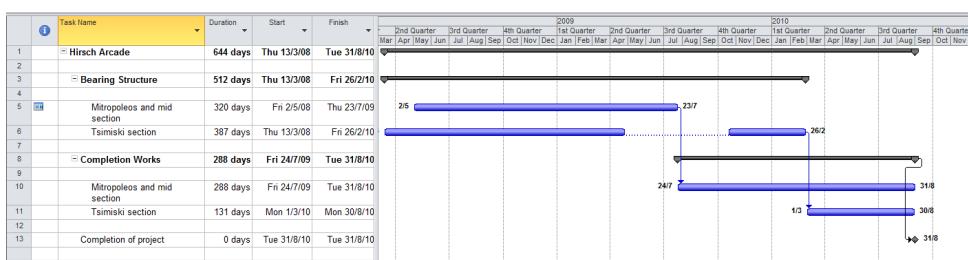
The contract of the project for the reconstruction of the Hirsch arcade was signed in July 2007 and according to the initial provision, operations for the construction of the frame of the arcade ought to be completed by December 2008, while the completion of all remaining operations would conclude approximately ten months later (Fig 3).

The reconstruction of the Hirsch arcade was thrown entirely off of the original timeline, resulting in the completion of the bearing structure in February 2010 instead of December 2008, as was originally planned (Fig 4).

There were three main factors that lead to the large deviation in the final duration of the project from that which was initially estimated: a) delay due to archaeological in the Tsimiski section, b) delays during grouting, c) delays during dredging processes in the basement and the structural shoring.



**Figure 3: Construction schedule as it was initially planned**



**Figure 4: Final duration of the project**

## **6. Architectural study**

The architectural demands regarding the Tsimiski street façade were based on two basic principles: the façade to be in continuity with the rest of the buildings adjacent to the building and contemporary methods and materials to be used. For the façade on Mitropoleos street, due to the surface of the building having large height, a slight slope was selected, in the belief that the increasing slope of the building along its vertical axis would give the illusion that the building was “breathing” (Photos 1,2) (Wohnstudio, 2010)

## **7. Conclusions**

From the design of the project it was decided that the façade on Tsimiski Street would be preserved. This was accomplished with the construction of special metallic scaffolding which was founded on jet-piles. This scaffolding demanded unique construction for which particular calculations and design were needed so that it would withstand the required load, but at the same time it ought to enable pedestrian traffic on the sidewalk of Tsimiski Street. Additionally, one of the demands of the work’s design was the dredging of the basement on the Tsimiski section. Lowering the final level of the basement floor by 2,50m, namely under the foundation of the building, created the need to underpin the building. Additionally, it was maintained and strengthened while demolishing the roof basement’s slab. Finally, the demolition of the strip foundation in combination with the demolition of the basement roof’s slab resulted in the creation of large free height and by extension the creation of a malleable construction. This also resulted in the coating of the columns with perimeter support and triangular metallic frames which functioned as connecting beams that prevented them from breaking due to their large height.

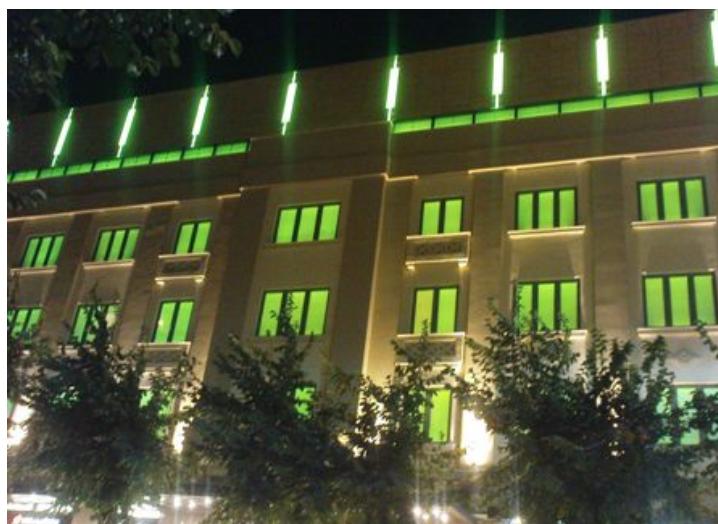
Aside from the difficulties that had been predicted during the design, there were others that came up during the construction of the project. The archaeological findings that were uncovered at the Tsimiski section lead to large delays in the completion of the work but also in the modification of the static study of the project. In addition, the construction of the lift and stair cores from reinforced concrete demanded more time than the assembly of the metallic elements which comprise the bearing structure. Finally, significant difficulties arose in the transport of the material, and primarily those needed to assemble metallic elements, due to traffic. All the above had as result significant delays to the completion of the project.

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**Photo 1: Mitropoleos façade**



**Photo 2: Tsimiski façade**

## **9. Acknowledgement**

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## **10. Note of the author**

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Architectural design: Woonstudio (A. Dimitrakopoulou, A. Sarantis, K. Maganiotis)

Static design: Penelis Consulting Engineers S.A G Penelis, Gr. Penelis, K. Paschalidis, Chr. Drakopoulos, E. Polymerou, N. Patsas)

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1<sup>st</sup> phase contractor: J&P, ETETH (L. Lagakos, A. Daimonakos)

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