STEEL CANOPY OF THE GYMNASIUM STOAS AT ANCIENT MESSENE

Themistoklis Bilis, Maria Magnisali
PhD candidates, School of Architecture,
National Technical University of Athens,
e-mail: themisbilis@yahoo.gr,magnisali@yahoo.gr

Olympia Panagouli, Euripidis Mistakidis
Laboratory of Structural Analysis and Design,
Department of Civil Engineering, University of Thessaly, Volos, Greece
e-mail: olpanag@uth.gr, emistaki@uth.gr

Panagiotis Tokmakidis,
Rural and Surveying Engineer, PhD Candidate AUTh,
e-mail: ptokmaki@gmail.com

Aris Theodorou
Civil Engineer, MSc
SDENG, Steel and Structural Detail Engineers, 55 Makrinitsas str., Volos, Greece
e-mail: aris@sdeng.gr

T. Kouimtzoglou
Architect, PhD candidate School of Architecture NTUA
3DDesign
e-mail: kouim@yahoo.com

1 ABSRACT

Ancient Messene constitutes an impressive example of Hellenistic city in Greece. Its Gymnasium consists of the stadium and long stoas that run all along its three sides while at the fourth side a monumental honorary building is constructed. The colonnades of the stoas have been recently restored.

The partial reconstruction of the roof at the NE corner of the building aims to recreate the initial architectural form of the stoas. The roofed space will be an ideal place for the exhibition of the stone antiquities that have been found in the area. For this reason, a steelcanopy is designed with reference to the ancient model of the wooden roof so that the ancient building remains without aesthetic charge from new elements especially from the outside. The new structure will leave the monument completely unaffected.

2 INTRODUCTION

Ancient Messene constitutes an impressive example of Hellenistic city in Greece. It has been recently excavated by professor P. Themelis and restored as most of its material has been revealedfallen and abandoned at the flow of the stream.Its Gymnasium (Fig. 1) consists of the stadium and long stoas that run all along its three sides while at the fourth side a monumental honorary building is constructed. It is situated at the south of the agora in a natural formation of slopes that create the appropriate background for the construction of its large stadium.

The aim of this paper is to present the study of a canopy that partially covers the NE corner of the Gymnasium's stoas. Their colonnades have been recently restored using mainly the ancient architectural members. The canopy is set at a length of 31.00m for the Eastern Stoa and almost 12.00m for the northern one and covers an area of almost 400m^2. The roofed space that will be created will be an ideal place for the exhibition of the stone antiquities that have been found in the area.

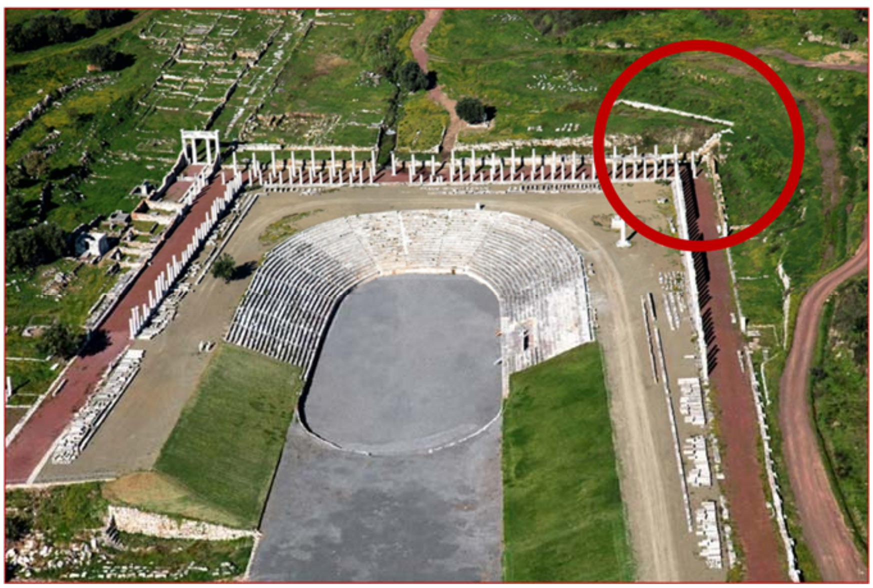

Fig.1. Messene. Gymnasium. Aerial view (Xenikakis).

3 GENERAL DESCRIPTION

The shed is designed with reference to the ancient model of the wooden roof. The loads from the roof end up on the ground with columns placed alongside the ancient bearing components (colonnade and back wall) so that the new structure will leave the monument completely unaffected. With this arrangement of new columns, the ancient building remains without aesthetic charge from new elements especially from the outside (Figs 2 and 3). This design takes also care for the back walls of stoas. This is achieved by the arrangement of back columns behind the monument in the ancient ditch and the suspension of the restoration of back walls by the shed. In that way, the archaeological relic remains untouched from the metal canopy and also the walls are restored in a modern way so as to create the dark background for the admiration of the well lighten by the sun colonnades.The design of the roof offers also great flexibility for future interventions, such as anastilosis of other architectural members, conservation of the stone entablature or the back walls, etc.In the visible parts of the shelter there are no elements that would remind modern constructions. The dimensions of the new columns are decided to be thinner than those of the ancient material so as to be hidden behind them. The concept is to remain invisible to the visitor, when strolling around the stadium. The back wall is recreated by plasterboards so as to hide the columns of the back and complete the inner space of the stoas.

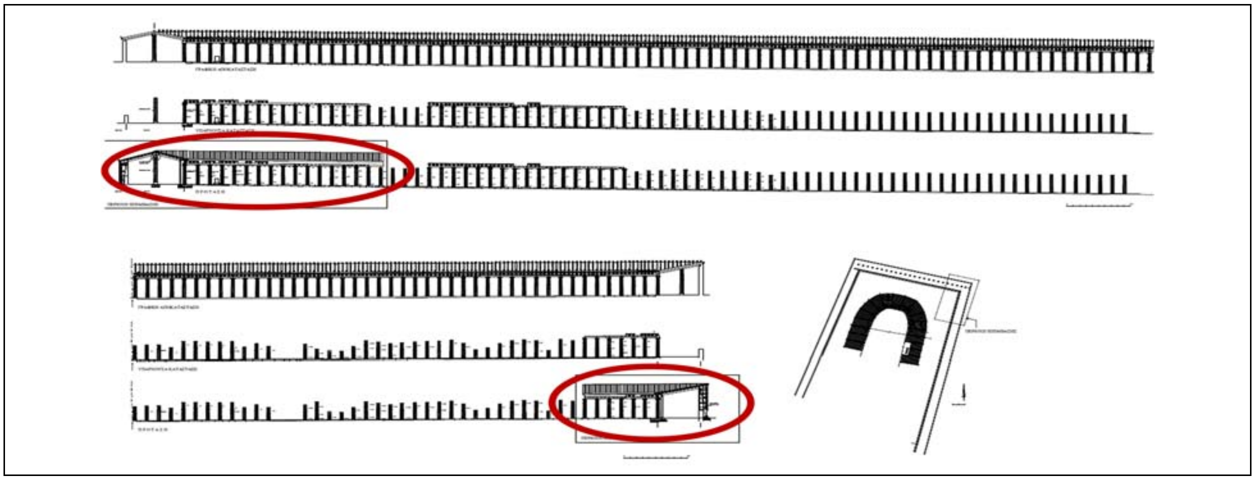

Fig.2. Graphic restoration/Recent situation after partial restoration/Proposed shelter.

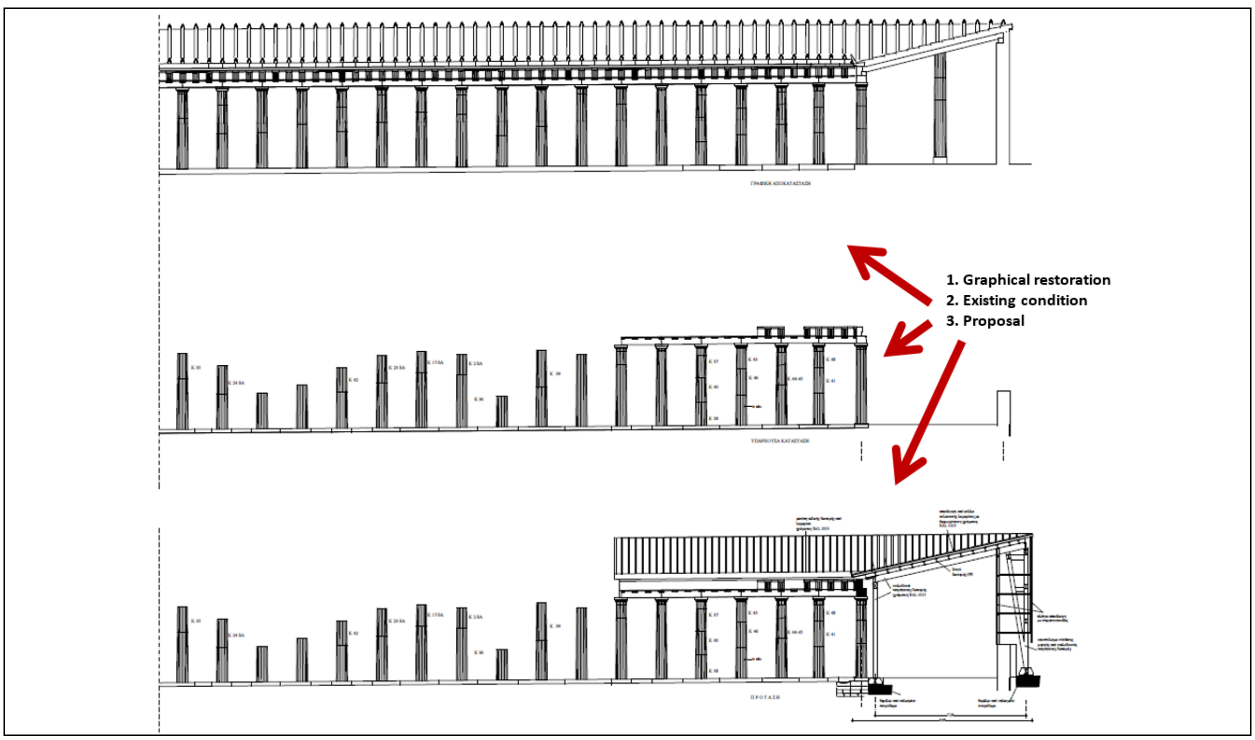

Fig.3. Eastern stoa at the NE corner of stoas of Gymnasium

Fig.4. Messene. A photorealistic view of the inside of the monument, after the intervention, where it can be noticed that the delicate steel structure fits well with the restored ancient members, recreating the initial architectural form

Fig.5. Messene. A photorealistic external view of the monument, after the intervention, where the steel columns and members are completely hidden behind the ancient columns and lintels

4. 3D SCANNING OF THE MONUMENT

Prior to the design of the steel structure, a 3D topographical scanning of the monument took place. The instrument used for the 3D scanning, was a Faro “Focus 3D Multisensor” laser scanner. The accuracy of the device is |2|mm at 10 to 25m distance from the 3D scanner. In order to capture in 3D the wider area of the stoa, 28 scan positions were selected and equal scans were performed. For the registration of the 28 scans, spherical targets were deployed at the area. The registration process took place using the Faro Scene software.First, the spherical targets were automatically identified for each scan. Then, using the target based registration process, the software automatically indicated the matching spherical targets between adjacent scans and finally the scans were registered together to form a unified point-cloud, product of the 28 scans combined. The resulted accuracy of this process was 3mm to 6mm (best and worst RMS among all scans). Then, ICP algorithm was used for cloud to cloud registration of the scans, using as initial guess the target based registration results. The resulted accuracy of this process was 1.9mm to 4.1mm which is satisfactory for the scope of this survey. The next step from the registration process, was the colorization process, where the colors from the integrated camera of the instrument were applied on the final, unified point-cloud. Finally, the unified point-cloud was exported to .POD file format and also to .PTX in order to continue working on third party software. The PTX files were used in Polyworks processing suite to create a textured 3D mesh of the stoa. The .POD files were imported to Bentley Point-Tools application to create ortho-images of facades, sections and floorplans with scale information embedded into them. Therefore, the architect’s team could easily import those ortho-images into CAD and draw as build plans of the stoa.

4. THE STRUCTURAL SYSTEM OF THE CANOPY

The plan view of the structure consists of two orthogonal segments, connected to create the form of the letter Γ. Due to functional requirements, it was selected not to arrange an expansion joint and the two orthogonal segments of the structure were connected monolithically, something that resulted to increased forces at the connection area, for all the considered load cases.The structure consists of planar frames that are interconnected by bracings in order to become spatially stable (Fig. 6a).Thefront columns and beams of these frames, that are visible, have rectangular hollow sections in order to resemble geometrically the timber sections used in the ancient structure.Theback columns are actually trusses, consisting of HEB200 chords, connected by SHS80x4 bracings and are not visible to the public, as they are covered by plasterboards. The front columns are connected by trusses that are completely hidden behind the stone lintels of the monument (Fig. 6b). The back columns are connected by standard X bracings, arranged at certain positions.The roof consists of standard IPE120 purlins, on top of which the final architectural cover of the structure is fastened.

The bottom ends of the columns are hinged. They are supported on concrete footings, having the form of narrow strips, which run along the front and back boundaries of the monument. The decision to arrange hinged columns, resulting actually to reduced overall stiffness and to increased structural steel weight, was mainly dictated by the limited dimensions of the footings, which were not able to undertake overturning moments.

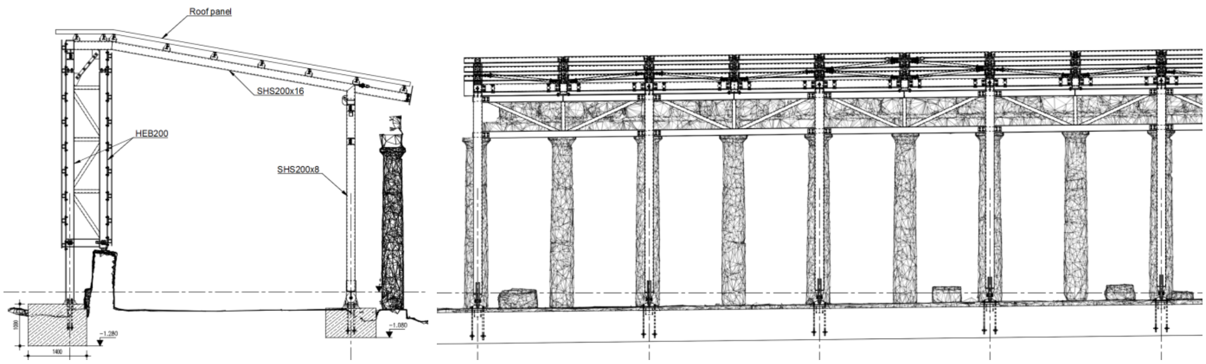

Fig.6. a)Typical plane frame and b) part of the elevation at the front columns axis.

The structure was designed against combined wind and snow loads. Special attention was given to the wind loading, due to the special form of the canopy which is partially open. The aerodynamic coefficients were calculated for 4 different wind directions, following the rules of Eurocode 1-part 1-4 [1] for open monopitch canopies, which resulted to 20 different wind load cases. The snow loading was calculated using Eurocode 3-part 1-3 [2]. In order to cover the normative requirements, a total of 61 combinations of wind and snow loads were taken into account. The seismic design was done according to the provisions of the Greek seismic code [3]. The structural steel members were designed using Eurocode 3 [4].
The analysis model was setup using the software suite of CUBUS Ltd (STATIK-5, FAGUS-5, STAHL-5,on the basis of the ortho-images that resulted from the 3D monument scanning. In the sequel, the structural members were inserted in the TEKLA modelling software. In the same model, the digital information that resulted from the 3D monument scanning was used as a reference. The detailing of the steel members followedand the final steel model was checked for possible clashes with the monument, taking into account the expected displacements under the various actions (Figs 7,8).

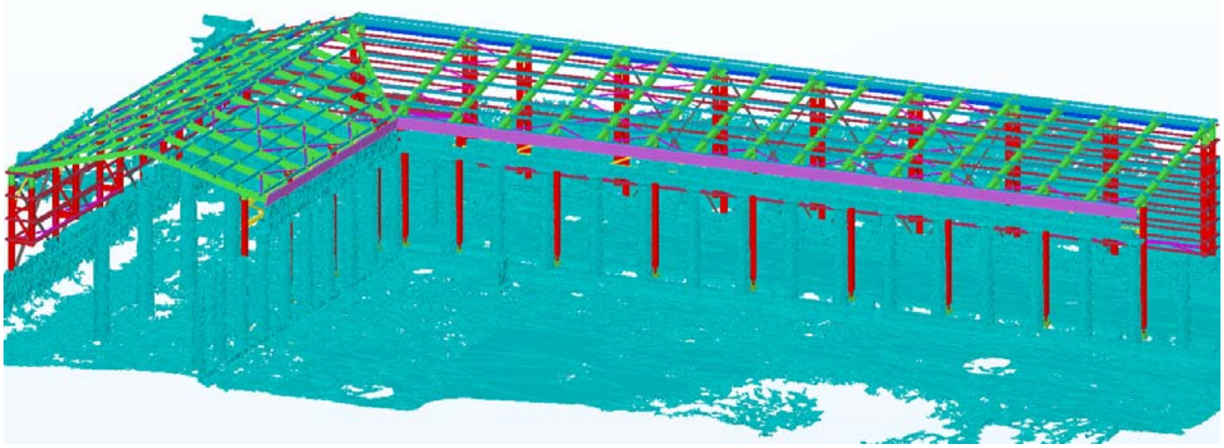

Fig.7. An overview of the steel structure having as reference the digital model of the monument.

The structural design was complemented by an appropriate erection methodology. The dimensions of the structural steel components were small enough to fit in small trucks that would easily reach the location of the structure. Within the archeological site the circulation of small cranes is only possible and for this reason the maximum weights of the steel components were in advance calculated so as they can be handled with the appropriate equipment.

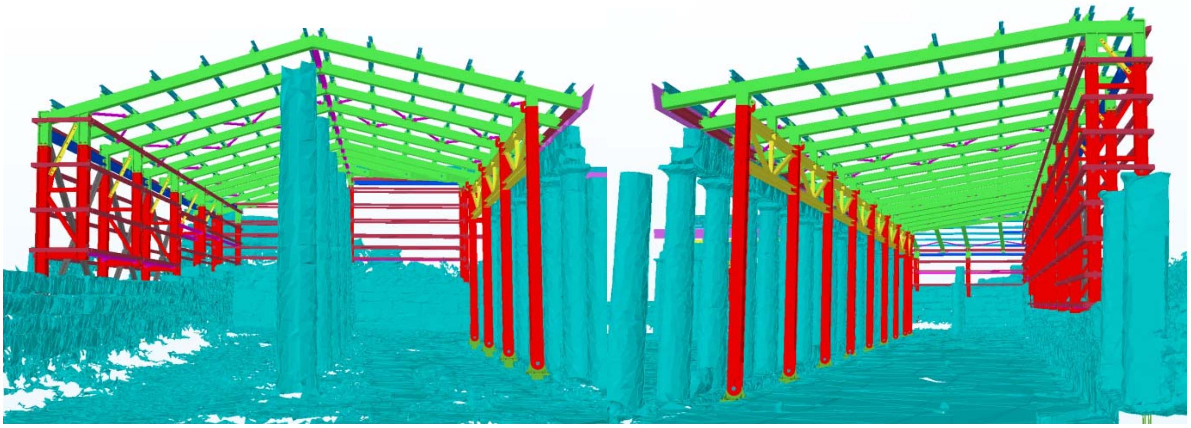

Fig.8. Side views of the steel structure together with the digital model of the monument.

For the site connection of the steel members bolted connections were used, with the exception of the front column – main beam connection for which site welding was used, to avoid the adverse architectural impact of a bolted connection. However, special precaution was taken so that the structure would be already stable prior to the execution of the site welding (Fig. 9).

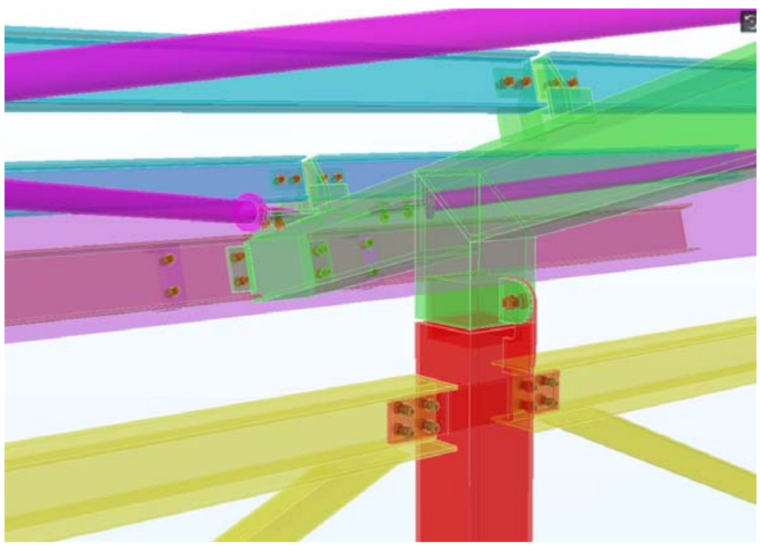

Fig.9. Detail of the front column-main beam connection.

5. REFERENCES

[1] EN1991-1-4, Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions, European Committee for Standardization, 2005.

[2] EN1991-1-3, Eurocode 1 - Actions on structures - Part 1-3: General actions -Snow loads, European Committee for Standardization, 2003.

[3] EAK2000, Greek Code for Seismic Resistant Structures,Organization for Earthquake Resistant Planning and Protection, Ministry for Environment Planning and Public Works 2000.

[4] EN1993-1-1, Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings, European Committee for Standardization, 2005.

ΜΕΤΑΛΛΙΚΟΣΤΕΓΑΣΤΡΟΣΤΟΓΥΜΝΑΣΙΟΣΤΟΑΣΤΗΣΑΡΧΑΙΑΣΜΕΣΣΗΝΗΣ

ΘεμιστοκλήςΜπιλλής, ΜαρίαΜαγνήσαλη
Αρχιτέκτονες, Υποψήφιοι διδάκτορες, Σχολή Αρχιτεκτόνων Μηχανικών ΕΜΠ
e-mail: themisbilis@yahoo.gr,magnisali@yahoo.gr

ΟλυμπίαΠαναγούλη, ΕυριπίδηςΜυστακίδης
ΕργαστήριοΑνάλυσης και Σχεδιασμού Κατασκευών,
Τμήμα Πολιτικών Μηχανικών, Πανεπιστήμιο Θεσσαλίας, Βόλος
e-mail: olpanag@uth.gr, emistaki@uth.gr

ΠαναγιώτηςΤοκμακίδης
ΤοπογράφοςΜηχανικός, ΥποψήφιοςΔιδάκτωρΑΠΘ
e-mail: ptokmaki@gmail.com

ΆρηςΘεοδώρου
Πολιτικός Μηχανικός, MSc
SDENG, Steel and Structural Detail Engineers, Μακρυνίτσης 55, Βόλος
e-mail: aris@sdeng.gr

ΤίμοςΚουιμτζόγλου
Αρχιτέκτων, Υποψήφιος Διδάκτωρ, ΣχολήΑρχικτεκτόνων ΜηχανικώνΕΜΠ
3D Design
e-mail: kouim@yahoo.com

ΠΕΡΙΛΗΨΗ

Το Γυμνάσιο της αρχαίας Μεσσήνης αποτελεί ένα σπουδαίο μνημειακό σύνολο της ελληνιστικής εποχής, στον ελληνικό χώρο. Το Γυμνάσιο, αποτελείται από το στάδιο και τις στοές που το πλαισιώνουν από την δυτική, τη βόρεια και την ανατολική πλευρά. Οι κιονοστοιχίες των στοών έχουν μερικώς αναστηλωθεί με χρήση κυρίως αρχαίων αρχιτεκτονικών μελών που βρέθηκαν στην ευρύτερη περιοχή του Γυμνασίου.
Η μερική στέγαση των αναστηλωμένων στοών στο ΒΑ άκρο του Γυμνασίου έχει στόχο να αναπαράγει τη βίωση της αρχική εικόνας των στοών με την κατασκευή ενός σκιασμένου χώρου, χρήσιμου και πολυλειτουργικού για τις ανάγκες των επισκεπτών. Ο στεγασμένος ημιυπαίθριος χώρος, που θα δημιουργηθεί, θα αποτελέσει ιδανικό τόπο για την έκθεση λίθινων αρχαιοτήτων που βρέθηκαν εκεί. Συγχρόνως στον χώρο αυτόν θα μπορούν να σταθούν οι επισκέπτες του αρχαιολογικού χώρου προκειμένου να παραμείνουν για να ενημερωθούν, να εμβαθύνουν αλλά και να απολαύσουν το σύνολο του Γυμνασίου, προστατευμένοι από τις σκληρές καιρικές συνθήκες της υπαίθρου. Με την προτεινόμενη διάταξη των υποστυλωμάτων η αισθητική επιβάρυνση του μνημείου ελαχιστοποιείται ενώ προσφέρει μεγάλο βαθμό ευελιξίας αφού επιτρέπει πιθανές μελλοντικές επεμβάσεις.