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The restoration of the foundation in the north side of the temple of Apollo Epikourios

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ABSTRACT: One of the main objectives of the ongoing restoration programme of the classical Greek temple of Apollo Epikourios is the repair and strengthening of its foundation. In this paper the restoration of the foundation in the north side of the temple (where the work has been completed) is presented. In that part of the monument, foundation failure was caused, mainly, from the existence of a clay layer, beneath the foundation top course (the euthynteria). Consequently, the restoration involved removing the clay material, and repositioning it at a later stage, after stabilizing it with lime and cement. Thus, a durable base was created for the resetting of the restored euthynteria that followed. The work included, also, the built of small, non-visible walls in the north-west corner, for retaining the subeuthynteria course. The restoration of the temple north foundation was carried out with respect to the ancient constructions, and did not alter significantly the original structural character of the monument.

1 INTRODUCTION

The temple of Apollo Epikourios at Bassai, in the mid-west Peloponnesus, is a Doric temple, constructed in the last quarter of the 5th century B.C. It has 6×15 columns in its perimeter and measures 16.14×39.84 [m] at the foundation top course. It is built, mainly, of the white-light gray local limestone.

The temple is one of the best preserved buildings of classical antiquity (Fig. 1). However, it presents many severe structural damages: foundation deformations, stone-blocks fractures in the steps, and significant tilts of the columns. Furthermore, its material has deteriorated extensively due to the extreme weathering conditions that prevail during winter time in the area (the temple's altitude is 1130 m a.s.l.). All those problems of the monument have diminished significantly its stability, and they endanger its safety, in case of a future earthquake.

Figure 1. The temple of Apollo Epikourios, before the beginning of the restoration work, from NW.

In 1987 the monument was covered with a temporary enclosed protective canopy. The canopy was erected to shield the monument from damage from the environment, for as long as required to materialize the restoration plans that were being formed.

The problems of the temple and the programme for its conservation and restoration were presented at the 1st International Meeting for the Conservation of the monument in 1995, where it was widely acknowledge the need for extensive intervention.

The restoration work began in 2001, and focused on the north side of the temple, the object of the first phase of the intervention. It consists in removing architraves and columns (in full height), dismantling the steps and the top course of the foundation (the euthynteria), strengthening the foundation, structurally restoring and conserving the stone-blocks, resetting the euthynteria and the steps, using new clamps made of titanium, and reinstating the columns and the architraves. Having already restored the foundation and repositioned the blocks of the euthynteria and the first two steps, the work is currently directed towards restoring and repositioning the third step (the stylobate) and reinstating the six north columns to the monument in vertical positions.

In this paper the studies and actions (experimental and numerical investigations, intervention practices) related to the restoration of the foundation in the north

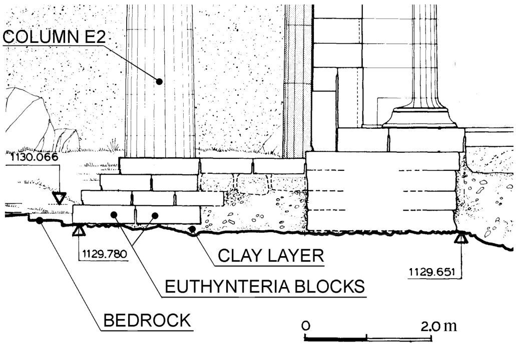

Figure 2. The foundation in the east side of the temple (cross section very close to the north side, Svolopoulos 1995).

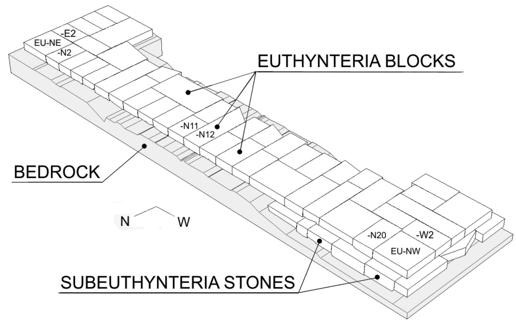

Figure 3. The euthynteria stone-blocks in the north side of the temple (isometric sketch).

Figure 4. The subeuthynteria stones in the north-west corner of the temple (down view).

side of the temple of Apollo Epikourios (where the work has been completed) are presented.

2 THE FOUNDATION IN THE NORTH SIDE OF THE TEMPLE

Apollo Epikourios temple is built facing north, on a natural slope that inclines gently to the west-southwest. The slope required the dressing down of bedrock in the east side of the building and in its west side the addition of an artificial fill and the construction of walls to retain the fill.

The temple foundation consists of two rectangular systems: the external, under the colonnade in the perimeter of the building, and the internal, under the walls of the cella (Fig. 2). Along most part of the north side of the temple (as along the east side) the bedrock is very close to the superstructure. Hence, the foundation in that area of the monument is formed solely by one layer of stone-blocks, the euthynteria. Between the euthynteria and the bedrock the ancient builders had placed a layer consisting of clay fill mixed with stone flakes, of varying thickness (from zero to few tens of centimeters). This layer seems to serve as a convenient way to give each euthynteria block a firm and continuous contact with the rough bedrock surface below (Fig. 2).

The bedrock at the north side of the monument drops about midway from the east, at which point a single subeuthynteria course begins (Fig. 3). This course progressively becomes thicker, as it proceeds to the north-west corner. A layer of clay separates also the euthynteria from the subeuthynteria stones, and the subeuthynteria from the rock.

The dismantling, for restoration purposes, of the north side of the monument allowed for the first time an extensive part of its foundation to be fully unveiled. Firstly, it allowed to uncover the euthynteria blocks (Fig. 3); then (and after the excavation of the clay layer) it was possible to reveal the subethynteria course in the northwest corner, five subfoundation stones scattered at the bedrock, a cavity in the bedrock with a group of few stones inside, and the bedrock upper surface at the rest of the excavated area.

The north euthynteria of the temple consists of rectangular shaped blocks in two rows, which were laid as headers (Fig. 3). Twenty-one blocks are in the façade row, with varying width and with common length and depth about 0.68 m and 0.28 m, respectively. A pair of double-lengthened blocks (EU-N16, EU-N19) appears in the west part. The corners terminated with nearly square shaped blocks measuring 1.15×1.12 [m]. The sizes of the back row blocks vary significantly; consequently, the vertical joints run in random patterns. Clamps connected the façade blocks only in the top face, close to the north edge.

The subeuhtynteria course in the temple's north side begins below the sixteenth from the east euthynteria façade block (EU-N16), (Fig. 3). It consists of irregular sized cut stones (Fig. 4), some of which (most probably) came from an earlier monumental building and

Figure 5. The stones inside the bedrock cavity and the reused, reshaped block in the north limit of the cavity (view from SE).

were reshaped for new positions. An oversized stone has been placed in the corner, obviously for stability reasons, measuring about 2.10 × 3.05 × 0.40 [m]. The top surfaces of these stones have been shaved down to form a continuous horizontal bedding for the euthynteria. No clamps secured the subethynteria stones.

The cavity found in the bedrock below euthynteria (Fig. 5) is roughly semi-spherical in shape, with depth reaching 85 cm and volume about 2.5 m^3. Its center is beneath the back face of the sixth from the east euthynteria façade block (Fig. 7). Inside the cavity a group of stones were found, placed one on top of the other, occupying the northern third of the cavity. The stones are of various sizes and irregular shapes. The rest volume cavity was filled with clay. Although the stones have settled, the highest altitude of the top stone is close to the altitude of the proximate bedrock, indicating the initial group elevation. It is obvious that the structural function of the stones is to form a subfoundation 'pillar' for transmitting the building loads to the rock. In the north limit of the cavity, parallel to transverse axe of the temple a reused block is laid, based partly on rock and partly on clay.

3 DIAGNOSIS OF DAMAGES IN THE NORTH SIDE OF THE TEMPLE

The failure of the foundation of Apollo Epikourios temple has been recognized as one of the most severe structural problems of the monument. This is because the foundation deformations are considered as the main factor that caused the damages of the building (Fig. 6). Furthermore, before the enclosure of the monument with the canopy, the deformation of its foundation was a phenomenon in progress.

In previous study (Papantopoulos 1995), it was suggested that in the east part of the temple foundation failure occurred, mainly, because some clay material was washed away from rainwater, evoking the above euthynteria blocks to settle. In the west part failure

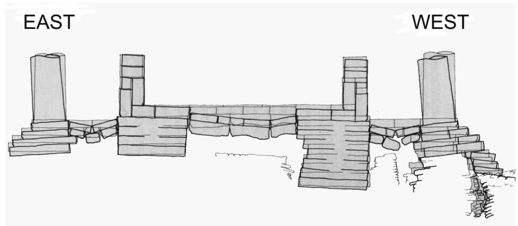

Figure 6. Sketch presenting, in exaggeration, the deformations in the foundation of the temple (Papantonopoulos 1995).

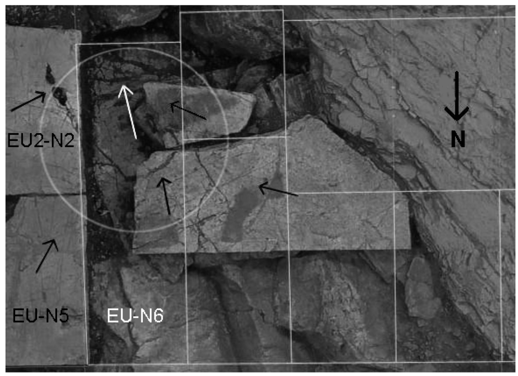

Figure 7. The top stone of the group inside the bedrock cavity, the proximate subfoundation reused block and the neighbouring euthynteria blocks (down view). The black arrows indicate the inclinations of the stone, the fragments of the reused block, and the blocks. The white arrow shows the direction of column N2 tilt. All arrows are pointing at the lower parts of the cavity.

was caused by the gradual slide of the artificial fill down the slopping rock, which dragged along the above foundation. Those assessments were based on measurements of settlements in different parts of the monument and observations about the foundation construction, which were made in trenches excavated in few selective positions around and inside the building.

As the restoration work progressed, the full uncover of the north foundation of the monument provided new data, which study further enforce the aforementioned assessments, confirming the necessity of the extensive intervention. The new data came from: (a) the documentation of the deformed positions of the euthynteria blocks; (b) the detail measurement of the clay layer thickness; (c) the discovery of the bedrock cavity and the group of stones inside; and (d) the documentation of the deformations of the subeuthynteria stones.

More specifically, the data showed that: (i) The foundation stone members based directly on bedrock or on thin clay layer presented limited settlements.

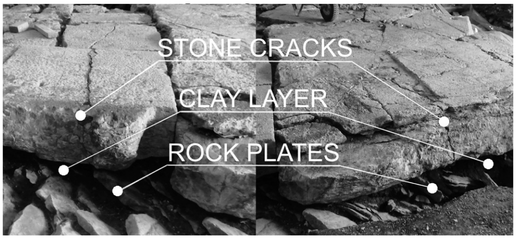

Figure 8. The large corner subeuthynteria stone (right) and its side stone to the east (left). View from north. It is obvious that the stones have settled, inclined toward the slope in the west, and that their cracks are at the contact points with the rock.

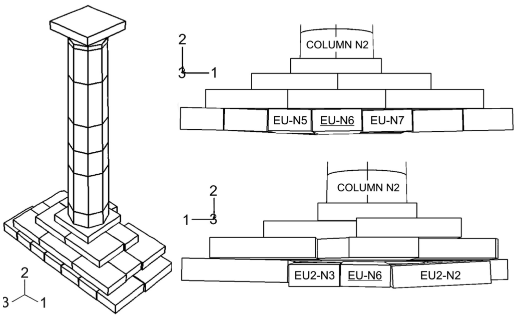

Figure 9. Left: The numerical model. Right: North (up) and south (down) views of the model lowermost part.

(ii) The stones based on thick clay have settled significantly, inclined in every case toward the side where the below clay layer was thicker. This was very clear in the euthynteria blocks placed above the bedrock cavity (Figs 7, 9 right). (iii) The blocks based partly on bedrock and partly on clay were fractured across the base condition differentiation line, with their fragments based on clay suffering the larger settlements. The latter was quite obvious in the reused block placed beside the group of subfoundation stones (Fig. 7), and in the north stones of the subeuthynteria course (Fig. 8).

Thus, the data strongly indicate that, during the centuries, a gradual reduction of the clay layer led to the settlements of the foundation stone members. The reasons for the clay layer diminishing were the washing away of material from rainwater (which started passing into the temple, after the collapse of the roof), and the creeping flow of clay toward lower parts of the bedrock, under the loads of the building and with the decisive cooperation of rainwater. The gradual clay escape was toward the lowermost parts of the cavity (Fig. 7), through the fissures and the discontinuities of the bedrock, and down the slope in the west side (Fig. 8).

It should be noted that, although small creeping settlements are certain to have take place in some parts of the bedrock during the monument's lifetime, they are evidences which denote that no significant local collapse in the bedrock has occurred. The evidences are the existence of the group of stones inside the cavity and the fact that the altitudes of the top surfaces of the subeuthynteria stones are close to the altitude of the top course of the western ancient retaining wall and to the altitude of the bedrock in the central part of the north side of the building.

Based on the above assumptions, the course of events that led to the damages of the temple in its north side can be described as follows: The north façade, as the whole building, remained intact for many centuries, until the collapse of its roof, which, probably, took place due to the biological decay of the wooden supporting elements (historical data report that the temple was whole with none noticeable deformation, six centuries after its construction!). The absence of cover allowed rainwater inside the building, onto the blocks of the steps. As a consequence, the rainwater chemical action caused material deterioration, diminishing the surfaces of the blocks, opening the gaps in their interfaces. This fact permitted rainwater to penetrate further, until, eventually, it was able to reach the clay layer beneath euthynteria. Then, rainwater started to wash away clay material and to make easier the creeping flow of clay toward lower parts of the bedrock, causing: (i) reduction of varying magnitude to the clay layer thickness; (ii) sunk of the subfounadtion stones; and (iii) slide of the subeuthynteria course. Those damaging for the temple foundation slow natural phenomena accelerated when pillagers, searching for the metal clamps, removed the intercolumnar slabs and broke the façade blocks of the steps.

The deformations in the supporting system of the euthynteria generated non-uniform settlements and irregular displacements of its blocks. (However, because almost all the blocks remain fully based on clay, they did not fracture). Naturally, the euthynteria subsidence led to simultaneous deformations in the blocks of the steps, which caused loss of full contact in the blocks interfaces and subsequent modification of the blocks loading condition from compression to tension. The latter alteration induced material failure in the weakness points of the blocks; therefore, further settlements occurred in the steps, causing columns inclinations and entablature deformation. The first cracks in the blocks of the steps led to rearrangement of their contacts and consequential creation of new point or line loadings, which caused new fractures and so on.

It is worth noticing that as long as the temple remained intact, earthquakes did not damage it significantly. Only after human intervention (the breakage of the blocks and the looting of the clamps by the

pillagers), strong earthquakes probably disintegrated further the building, by opening the blocks joints and their fragments gaps or/and by creating instantaneous or residual stresses concentrations that led to new blocks fractures.

4 NUMERICAL REPRODUCTION OF THE DAMAGES IN A PART OF THE TEMPLE

4.1 *The numerical model*

In order to further enforce the assessment that foundation failure is responsible for most of the damages in the north side of the temple of Apollo Epikourios, a numerical analysis was conducted with the aim to reproduce the damages in part of the monument, as a consequence of the euthynteria deformations. For that purpose, with the use of the software Abaqus, a 3-dimentional model was created, which included the second from the east column of the north side, and the blocks of the steps and of the euthynteria that are beneath the column (Fig. 9 left). In other words, in the analysis it was simulated the part of the temple which is over the cavity of the bedrock, without the entablature.

The model's geometry definition was based on actual measurements of the temple stone blocks. The model was formatted in such a way so that all the blocks (except those of the euthynteria) were simulated in the state and position that they were in the initial, undamaged condition of the temple; meaning as distinct members, in full contact, with no relative displacement, and in vertical or horizontal positions.

On the contrary, the euthynteria blocks were simulated inclined and displaced (Fig. 9 right), so as to represent the documented in-situ settled positions of the corresponding temple blocks. The aim was to include in the analysis the deformations of the temple foundation, for finding out what damages will appear in the superstructure, as a consequence of the deformed foundation. In order to succeed that, the euthynteria blocks were fully constrained, while the rest of the model was free to deform nonlinearly in any direction under its own weight.

Gravity loading was the only load applied to the model; it was ramped up over 0.3 sec, and then it was maintained constant. The dynamic analysis total time (1.5 sec) was sufficient for the full appearance of the damages in the model. For simplicity purposes, the model discretization took place using 8-nodes hexahedra elements that resulted to the cross sections of the column shaft to be polygonal, instead of circular with 20 flutes, as in reality.

The material behaviour of the blocks of the three steps was simulated using a non-linear model, suitable for quasi-brittle materials which elastic behaviour is isotropic and linear and its main failure mechanisms are cracking in tension and crushing in compression. The properties adopted in the analysis were based on experimental study about the temple limestone material (Papantonopoulos 1995) and are for the modulus of elasticity 80.1 GPa, for the Poisson's ratio 0.35, for the tensile strength 1.4 MPa and for the compressive strength 38.5 MPa. The material behaviour of the rest blocks was simulated using a linear model, with modulus of elasticity 80.1 GPa and Poisson's ratio 0.35.

The interactive behaviour of the model members normal to their interfaces was determined with the use of a 'hard' contact model that allows when two surfaces are in contact, any pressure to be transmitted between them and, when the surfaces separate, it reduces the contact pressure to zero. In the tangential direction of the interfaces, a classical friction model was used, with friction coefficient of 0.75 (value derived from tests, Papantonopoulos 1995).

4.2 *The uncertainties in the analysis*

It should be noted that the numerical analysis contains uncertainties related to the simplifying assumptions made in the simulating process, as well to the complex parameters that influence the dynamic behaviour of the temple. The main points that render the numerical predictions as a rough estimation of the behaviour of the simulated temple part are:

The limestone of the monument is anisotropic, due to the layers and the discontinuities of its structure; instead, in the analysis it was simulated as a isotropic, continuous material. The state of the temple when foundation failure occurred and cracks appeared in the blocks, is unknown. Hence, it is uncertain if the model should have included stone members from the entablature, for more accurate simulation of the dead loads that caused material failures. Furthermore, dynamic actions due to seismic events are not included in the analysis; although those actions may have partly contributed to the monument geometrical deformations or material failures. Finally, elements representatives of the metal clamps in the blocks of the first two steps were not included in the numerical model.

4.3 *Numerical results – conclusion*

The numerical analysis resulted, as it was expected, both significant displacements and rotations of all the model members and material failures in the blocks of the steps. The deformed model is presented in Figure 10. It is quite obvious that the steps have settled significantly, and that the column, carried along by the steps, has subsided and inclined toward SE, that is toward the position of the bedrock cavity in the monument (Fig. 7). Specifically, the analysis predicted maximum column deviation from the vertical position

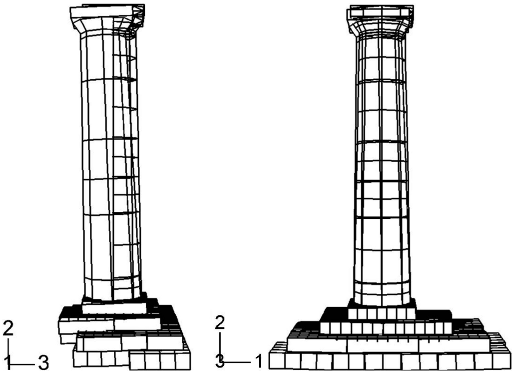

Figure 10. The deformed model, from east (left) and north (right). It is clear the intensive column inclination toward the position of the cavity in the bedrock.

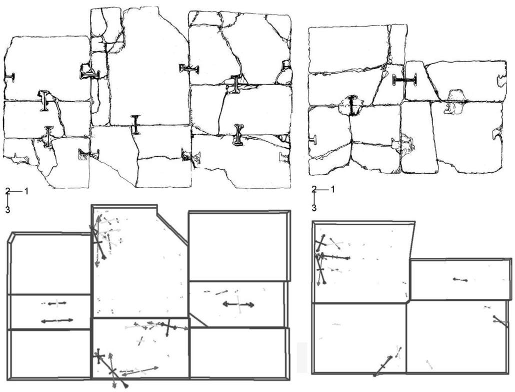

Figure 11. Up: The blocks fractures (as documented in-situ) in the first (left) and in the second (right) step. Down: the relative numerical results.

by 23.6 cm to the south and by 7.7 cm to the east. In-situ the column was measured tilting 26.5 cm to the south and 5.0 cm to the east.

The computed material failures in the blocks of the first two steps and the respective documented blocks fractures are shown in Figure 11. The comparison indicates that the majority of the blocks fractures were reproduced by the analysis at the same or nearby positions.

In conclusion, it can be formulated that the numerical simulation resulted damages for the monument part that is above the bedrock cavity (as a consequence of foundation failure) very similar to the ones observed in-situ. Thus, the analysis argues for the assessment that most of the temple damages were caused by foundation failure, and, by extension, for the necessity of the large-scale intervention.

5 THE BASIC MATERIAL USED IN THE RESTORATION OF THE FOUNDATION

5.1 *The reasons for the material selection*

As previously mentioned, the problems in the north foundation of the temple of Apollo Epikourios were caused, mainly, because rainwater gradually washed away material from the clay layer. Hence, one of the basic objectives of the foundation restoration was the replacement of clay with a more durable material, capable to arrest the damaging phenomenon of material loss in the layer beneath euthynteria. In order to attain that objective, it was decided to reuse the clay material, stabilized with lime and cement. The decision was based on the following reasons:

Through stabilization clay develops sufficient strength which assures durability against weathering actions, and, consequently, the safe transfer of the building loads to the bedrock. In parallel, stabilized clay is a material similar to the one placed by the ancient builders; thus its use in the restoration work ensures minimum repair, without altering significantly the original structural character of the temple foundation. Furthermore, stabilized clay does not develop very strong adhesive bond with rock, hence, its implementation is considered almost entirely reversible. Additional reasons which render stabilized clay as suitable material for the restoration work are the facts that it remains plastic for a few hours after its preparation (therefore, it facilitates the resetting of the blocks by allowing microadjustments in the blocks positions or/and in its top surface) and that it should be compacted for developing the highest possible strength (thus, its compaction secures that no voids are left in the rough bedrock surface).

5.2 *Basic material properties*

The exact composition of the stabilized material used in the restoration of the temple foundation was derived from an experimental study, carried out at the Laboratory of Road Construction of the National Technical University of Athens, in two stages (Kolias 2003, Papadopoulos & Karahalios 2003). The basic scope of the study was to investigate various components proportion of stabilized clay, concluding about the most suitable mixture for use in the restoration work. The criterion for the mixture selection was the development of compressive strength above 2.0 MPa, requirement which, according to the international practice of road construction, insures that the stabilized clay material will not suffer damages due to weathering actions.

The constituents proportion (by mass) of the selected mixture is: 37.6% clay (from the layer beneath euthynteria), 37.6 limestone sand and gravels (from crushing the stone flakes from the layer beneath euthynteria and stones from the surrounding area

of the monument), 3.0% lime, 7.5% cement, and 14.3% water. The basic experimental results about the mechanical properties of the stabilized clay mixture which, eventually, was used in the temple restoration work are the following: The material developed, at the age of 28 days, compressive strength 2.156 MPa (average value from testing 8 cylinder specimens, d/h = 7/14 [cm]) and, at the age of 63 days, 3.204 MPa (from tests on 3 cylinder specimens); its indirect tensile strength was also measured at the age of 28 and 63 days, and it was found 0.341 MPa and 0.651 MPa, respectively (the latter values were deduced from 'Brazilian tests' on 8 and 2 specimens).

5.3 *Test implementation*

Before the use of stabilized clay in the restoration work of the temple, its behaviour was tested under real loading conditions in a structure that simulated a small part of the building foundation. More specifically, a layer of stabilized clay, 20 cm thick, was constructed on the bedrock by the monument's east side. On the stabilized layer two stones were laid, within the first hour from the layer construction.

The stones were in shape and in size similar to the temple euthynteria blocks (Fig. 12 left). On top of the stones, large blocks were placed (Fig. 12 rigth) for further loading of the stabilized layer. The loading was applied for over a year, gradually increasing, achieving at its peak, 90 kPa compressive stress at the layer (value larger than the loading which the stabilized layer will bear in the restored state of the monument); during that time, periodic altitudes measurements were taken, which showed that the stabilized layer settled, about, 1 mm.

The diminutive layer settlement, in combination with observations made during the preparation of the stabilized material and the laying of the stones (such as they were no voids between the stones and the layer, Fig. 12 left), led to the overall conclusion that stabilized clay exhibited satisfactory behaviour in its test implementation and it can be used in the restoration work of the temple.

Figure 12. Left: The two stones placed on the stabilized clay layer. Rigth: Loads upon the stabilized layer.

6 THE RESTORATION OF THE FOUNDATION

6.1 *Consolidation of the subfoundation stones and the subeuthynteria course*

For the consolidation of the subfoundation stones found in the north side of Apollo Epikourios temple, the five scattered stones and the top stone of the group inside the cavity were removed and structurally restored; meaning the fragments of the stones were connected using threaded titanium bars and white cement paste, according to the technique developed in the restoration work of the Acropolis monuments (Zambas 1988, Vintzileou & Papadopoulos 2001). Then, the stones were conserved and repositioned. In the cases where the stones did not fully based on bedrock, the void between the stones and the rock was filled with stabilized clay. The stones were repositioned horizontally, with altitudes resulted from observations about the altitude variation of the proximate bedrock surfaces.

The consolidation of the group of stones inside the bedrock cavity was accomplished with the construction of a wall in the remaining empty cavity space. The wall was built with stones from the local area and stabilized clay as binding material.

For the consolidation of the subeuthynteria course in the north-west corner of the monument, trenches 1.0–1.5 m wide were excavated across the north and south limits of the course, both in its external and internal sides. It should be noted that for the excavation of the west external trench a part of the artificial fill, consisting of clay and stones of irregular shape and size, had to be disturbed; however, the trench width was kept the minimum necessary, and the removed stones were replaced in nearby positions. The trenches extended down to the bedrock, and underneath the course for a width of 0.50 m.

In the trenches, walls were built to support and retain the course (Fig. 13). The walls were built with some of the stones removed from the ancient structure,

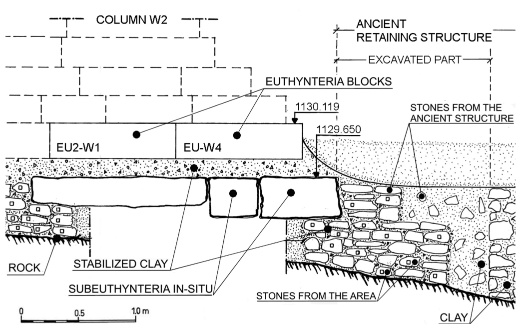

Figure 13. The consolidation of the subeuthynteria course. Cross section parallel to the transverse axe of the temple.

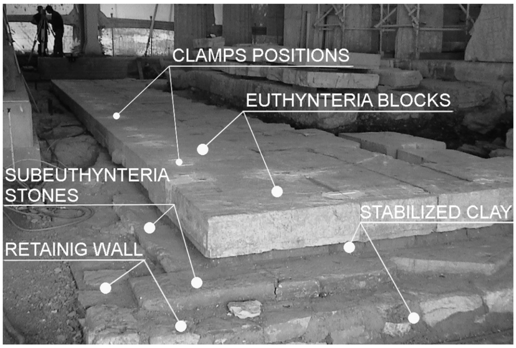

Figure 14. The restored foundation in the north side of the temple, from NW.

stones from the local area distinguished by indicative sign, and stabilized clay as binding material. The remained empty spaces of the trenches were filled with clay and the rest removed stones.

6.2 *Resetting of the euthynteria blocks*

The resetting of the euthynteria blocks in the north side of the monument followed the consolidation of the subfoundation stones and the subeuthynteria course and took place simultaneously with the construction of the stabilized clay layer, which was interjected between the blocks and the bedrock. All the blocks were structurally restored and conserved before they were repositioned.

First repositioned block was the eleventh from east of the façade row (EU-N11). This block is based almost entirely on bedrock and it is from the euthynteria part which presented the minimum deformations. Thus, the position and the altitude of the block before the intervention were considered as the least deviated from the initial ones; therefore, block EU-N11 was selected as the key stone of the resetting. After block EU-N11 the resetting continued towards the two ends of the north side, simultaneously. All the blocks were repositioned in horizontal positions, with top face altitude 1130.119 m (value equal to the altitude of block EU-N11).

A brief description of the blocks resetting procedure is presented below: Initially, the block is placed on wooden wedges in its four corners, fact which allows microadjustments of the block position; then, after the approximate finding of the block resetting position a load is placed temporary on top of the block, for securing its position. Afterwards, stabilized clay is inserted in the gap between the block bottom face and the bedrock, and it is compacted. Finally, the last corrections of the block position are made, using topographical instruments for the position checking. The next day the wedges and the load are removed and the resetting continues to the adjacent block. Care is taken so that the joints of the stabilized layer are not in the same plane with the vertical joints of the blocks.

For the restoration of the foundation in the north side of the temple 45 euthynteria blocks were restored and repositioned (Fig. 14). The restoration of the temple north foundation was completed with the reconnection of the euthynteria façade blocks using new titanium clamps. The new clamps are designed to improve the monument seismic behaviour, without inducing blocks fractures (Papadopoulos 2007).

7 CONCLUSIONS

Although Apollo Epikourios temple is one of the best preserved buildings of classical antiquity, it faces many worrying structural problems, one of which is foundation failure. In the north side of the temple foundation deformations were caused, mainly, from the existence of a clay layer beneath the foundation top course (the euthynteria). New data, revealed in the course of the dismantling (for restoration purposes) of the temple north side and subsequent damages diagnosis further enforced the aforementioned assessment, confirming the necessity of the large-scale intervention. Consequently, the restoration of the monument foundation involved removing the clay material and repositioning it at a later stage, after stabilizing it with lime and cement. Thus, a strong and durable base was created for the resetting of the structurally restored and conserved euthynteria that followed. The exact composition of the stabilized material was derived from an experimental investigation and, prior to its implementation on the monument, its behaviour was checked under real loading conditions, in a structure that simulated a small part of the foundation. The restoration work in the north foundation of the temple included, also, consolidation of the subfoundation stones and the subeuthynteria course in the north-west corner, which was carried out with the construction of supporting and retaining walls, using stabilized clay and stones from the local area.

The restoration of the temple north foundation was carried out with respect to the ancient constructions, and did not alter significantly the original structural character of the monument. In order to attain the latter objective, the restoration study was undertaken from an approach based on the one hand, on an attempt to understand the monument's structural behaviour and its repair needs, and on the other hand, on numerical and experimental analyses. Furthermore, although the study and its consequent intervention practices were aiming at the restoration of a small part of the temple foundation, they can also be applied when the intervention expands to the remaining parts of the monument.

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