

The Role of the Three-dimensional Virtual Model in the “Replica” Project of Architectural Elements: the Case of the Athenian Academy by Th. Hansen

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INTRODUCTION

This study emerged from the general research programme of Bari Polytechnic’s ICAR Department, “The Reform of Mediterranean Architecture and Landscape.” It is a continuation of work carried out for a research doctorate, aimed at the identification of the essential characteristics of *plastico muraria* architecture. This study forms part of the stone architecture curriculum, and deals with (in reference to the scale of the building) issues related to technical and technological renovation of the planning and construction of stone systems in continuity with the historic legacy of forms, through digital planning systems and the use of numerically controlled machines for production.

Choice of topic

The subject of the thesis is Athenian neo-classical architecture, investigated in the context of the problems arising from the design and the exact execution of cut stone architectural elements. This research topic aims at the projected renewal of *plastico-murari* systems, in continuity with the Mediterranean architectural tradition, and intends to examine the character of cut stone organic architecture. The definition of the (classical) model in this case defines the intrinsic nature of classical cut stone architecture (reference models), that summarises its constructive and formal principles, establishing an indispensable connection between the conceptual phase of the work and its planning and execution, thereby guaranteeing the technical-formal unity of the architectonic organism in production.

This condition imposes upon the project and its execution the explanation of the geometrical process, defining the forms of the elements that make up its construction so as to understand the originating processes and to render them repeatable. The exact reconstruction of the geometries of the stone elements that the buildings are made of, whether targeted at the production of ex-novo elements for construction, or, if intended for the replication of elements for restoration through the serial production of the stone elements, ideally requires the recovery of the process that originated them. This can be achieved by retracing the salient moments from the conceptual phase to that of the construction of the form, both in its flat and three-dimensional nature.

To that end, during the analysis and theoretical definition phase a critical reading was carried out on

appropriately chosen classical models (the buildings on the Acropolis of Athens) and Athenian neo-classical models (the buildings of the Athenian Trilogy – library, university, academy (**fig. 1**)) that derived directly from the first, for their technical reproducibility, starting from the knowledge of the intrinsic geometries of the elements and the techniques of connection and assembly. In the planning phase, work was carried out with the use of solid and superficial modelling software (*Cad, Rhinoceros*), which allowed for the understanding of the exact forms of the buildings, through their virtual construction, so as to render them capable of being copied.

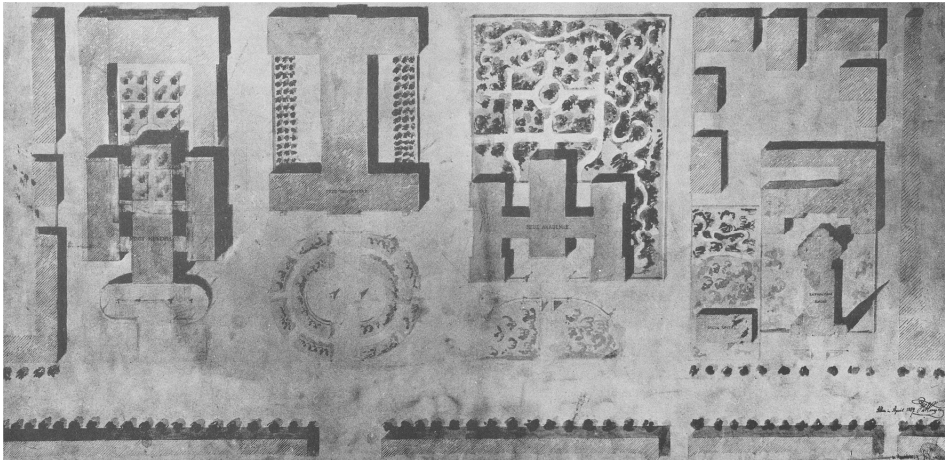


Figure 1. The buildings of the Athenian Trilogy (library, university, academy)(Φίλιππος Ιωαννου, *Ηακαδμια Αθηνων Και Τοκτιριο Τησ*, Athens 1995).

Subject and structure of the study

This study assumes the theoretical hypotheses of the topic of architectural replication already explained in studies carried out for the Research Doctorate Programme and in the ICAR Department (Polytechnic of Bari). Following on from this work this paper investigates classical construction, taken as a model for the highest expression of the perfect synthesis of form and technique, closely connected in the productive context. Therefore, the case studies are considered to be useful for gaining an understanding of how it is possible to establish continuity in the traditional “plastico-muraria” architectural production of the region, that is, of buildings in cut stone, both through overcoming the differences in reproductive systems and through the identification and study of the forms of the elements that, transmigrating temporally and spatially, conserve their essence within the trabeated system, formally and technically.

The starting point for the thesis was classical Greek architecture, regarded as paradigmatic, in reference to two fundamental topics:

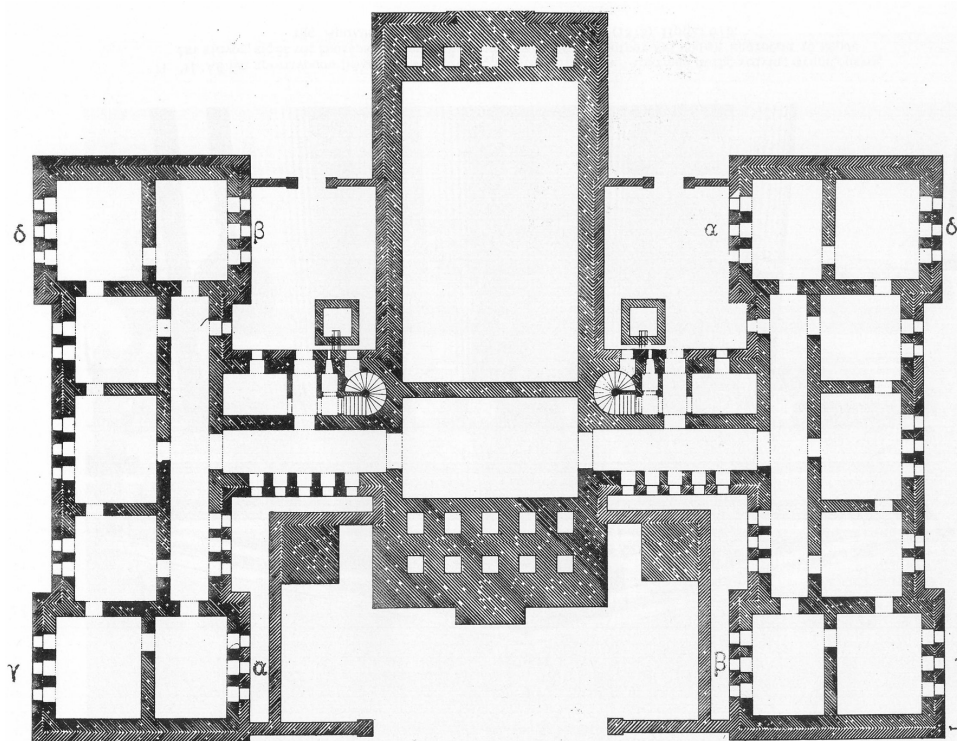
- The reproducibility of the elements of cut stone architecture in relationship to the recovery of the expressive and technical essence of the original models up to their re-design and exact execution (through the recovery of the original project)
- Spatial/temporal transmigration of the forms and techniques used in the practice of “stone work sites” and inferred from the classical tradition, assumed as the point of departure in the development of the modern debate on planning elements

Next came the choice of analysing the synthesis of the architectural elements of classical origin and their syntax through synoptic tables. This is necessary not only for a triple reading of the elements of the ancient buildings (linguistic, tectonic, synthetic), but also to discuss their reinterpreted model in a context that is geographically identical to that of the first elements, but temporally different, namely, the 1800s, when the recovery of the classical model and, in some cases, the replication of some of its elements, came about according to a different reproductive logic. This analysis is made through a comparison, again by means of synoptic tables that allow for understanding, through the three keys to interpretation, “which forms transmigrate and how,” that is, according to which variations of their original character.

Area of study

The choice of Attica in Greece as the area of study was motivated by the following two factors:

- Classical Greece represents the cradle of the *plastico-muraria* building tradition, or of the cut stone architecture of the areas located on the Mediterranean basin. Specifically, the classical Greek temple, a perfect machine in which all the elements share in defining the unity of the architectonic organism, became the basic model for understanding the reasoning that relates form to constructive practice.
- Athens is the city where two significant testimonies to the architectonic production inherited from tradition coexist and are part of our constructive patrimony:
 - The *classical models*, the buildings of the Acropolis, undisputed references (for their precision of execution and for their intrinsic technical-formal coherence) from the period of the nineteenth century excavation campaigns when the theoretical disputes on the validity of the archaeological model in architecture developed;
 - The *neo-classical buildings*, which not only recover the figurative and synthetic motifs of the first, but which thoroughly grasped the constructive reasoning and the exactness necessary for the planning and realisation of the elements, at times creating variants of the elements of classical syntax.



72. Ἀντιστοιχία τῶν μικρῶν ἀετωμάτων τῆς Ἀκαδημίας: α = εἰκ. 68, β = εἰκ. 70, γ = εἰκ. 71, δ = εἰκ. 69.

Figure 2 The Athens Academy (Φίλιππος Ἰωαννῶν, *Ἡακαδῆμια Ἀθηνῶν Καὶ Τοκτιριο Τησ*, Athens 1995).

The last part of the research is developed in relation to the problems of applying solid three-dimensional modelling in the restoration of the building. Here the stress is placed rather on the construction of the models, starting from theoretical contributions, such as the treatises that first employed the redesigning of order. A virtual dismantling of the building was carried out, even in its geometries and inner connections, and it was then recreated in its entirety. The main point of reference of these meditations, nonetheless, remains the research carried out in the Department of Architectonic Planning on the “Architectonic Reform of the Mediterranean City and Landscape” and, in particular, they are part of the topics covered by the “Stone Architecture” curriculum.

The theoretical area is that of critical reflection on the updating of design methods relating to the stereotomic paradigm, which contains both the geometrical complexity of the design models, and the executive exactness in production and the preparatory procedures of the construction site.

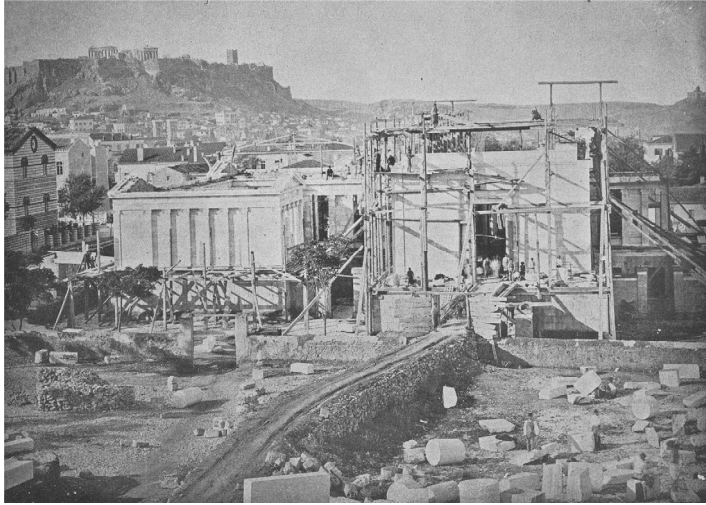


Figure 3 The Athens Academy under construction (Φίλιππος Ιωαννου, *Ηακαδμία Αθηνων Και Τοκτιριο Τησ*, Athens 1995).

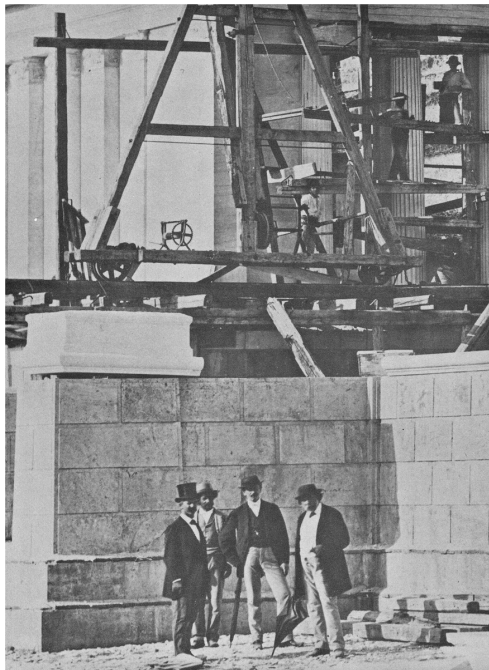


Figure 4. The Athens Academy under construction (Φίλιππος Ιωαννου, *Ηακαδμία Αθηνων Και Τοκτιριο Τησ*, Athens 1995).

Research methodology

This study adopted a dual methodology. On the one hand, using the methods of the classical interpretation of architecture, and the theories that informed it; on the other hand, the description of the case studies through the three-dimensional elaboration of the elements of the buildings studied - the current digital design techniques that have become a critical support in the current review of the language of modern stone architecture.

The “replica” project for recuperating the forms of nineteenth century stone architecture of the Mediterranean region

Talking about “shapes replica” in the classical repertory by way of the neo-classical architecture of Hans Christian Hansen (1803-83) and Theophil Hansen (1813-91), in Athens, means to understand the methodological approach that these two Danish architects applied in their surveys of ancient buildings, to absorb their models and transferring rules and principles (technical, formal and compositional) to the design and building of the nineteenth century fabric of the so-called “Athenian Trilogy”.

The close link between artistic and archaeological production, that connotes the whole period starting with the publication of J. Stuart & N. Revett’s, *Antiquities of Athens* (1789), till the construction of the neo-classical Athenian buildings is, indeed, emblematic of the relationship between the "cognitive methodology" of ancient monuments and the criterion adopted in the brand new planning of these buildings, whose “technical and formal apparel” was a clear attempt of a *careful* reinterpretation of classicism.

The acquisition and knowledge of the ancient model – a synthesis of geometrical and proportional rules subtending historic buildings – testify to the influence that archaeology has exercised on the architecture through punctual graphical survey renderings that have allowed the architects to understand the compositional principles and rules, and to analyse technical solutions adopted in new building construction.

The critical reading of ancient edifices carried out in the 1800s by the architect-archaeologists during the excavation campaigns in Athens, can be interpreted like the first phase of repossession, in many cases aware of the logical process that links the “moment of conception”, and therefore of the original developing of the project, to the construction phase of the architectural organism. Thus the search for the ancient becomes, for the architect, a starting point from whence he moves to set out brand new figures or to invent brand new typologies. The archaeological antiquity which gradually identified itself with the foundation of the ancient architecture, and the “classical model” - that the architect- archaeologist, P. Leroy, considered in architecture an “abstract model” - a whole set of principles to be reproduced - remained unquestionably the main reference that will influence all the architectural production at the time.

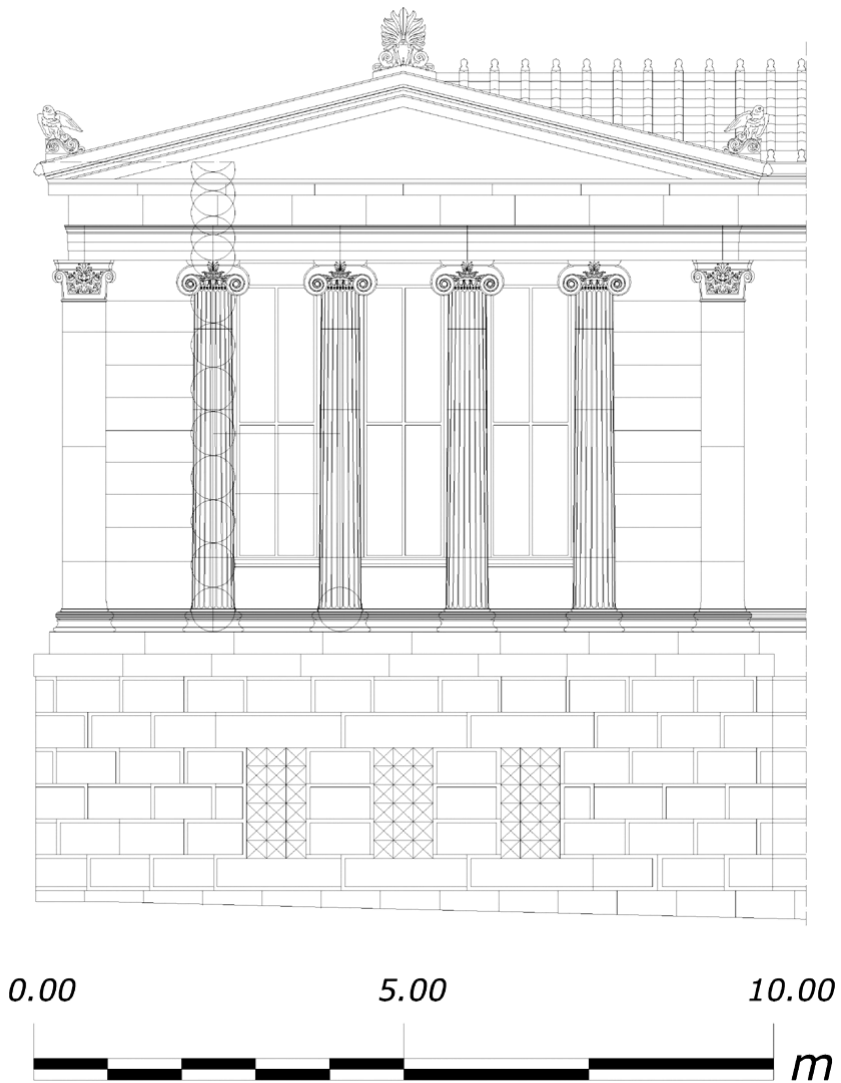


Figure 5. Geometries and proportions in the elements of the Athens Academy.

An analysis of the survey work carried out by Hans Christian Hansen on the monuments of the Acropolis, Athens, especially on the Athena Nikè Temple, clearly shows how, and how much, the careful acquisition of all information related to the building, from every single element to the whole, are material to the understanding of the close link between “classical models” and the neo classical buildings in Athens derived from them.

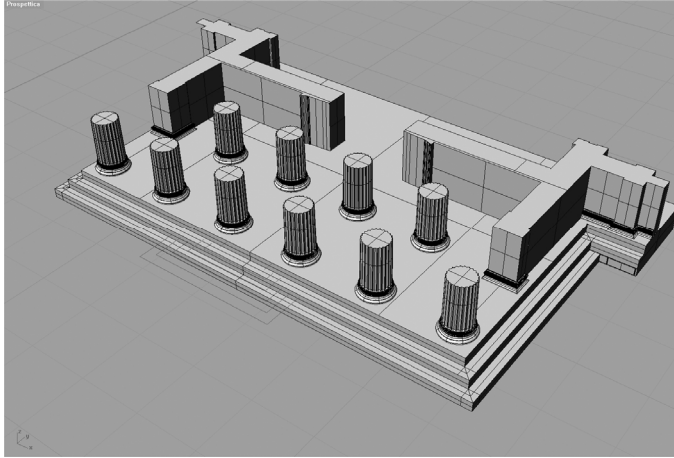


Figure 6. 3-D reconstruction of the main portico of the Athens Academy

Through dimensional and proportional information (of the building elements/components) collected during their surveys, these architects developed a reverse process. They tried to recover the original constructional idea of the analysed work through the understanding of the model, and therefore they created a *replica* process that worked for developing original projects, but remained absolutely faithful in contents (geometries, proportions, shapes, and techniques) to the classical model. The Hansen brothers tried to resolve the discrepancies of the reproduction procedures found in some elements of the classical buildings, skilfully reproduced in their projects, while also searching for the ancient tools used for carving stone (such as the miller etc.), sometimes reproducing and integrating such with those produced by the new technological knowledge.

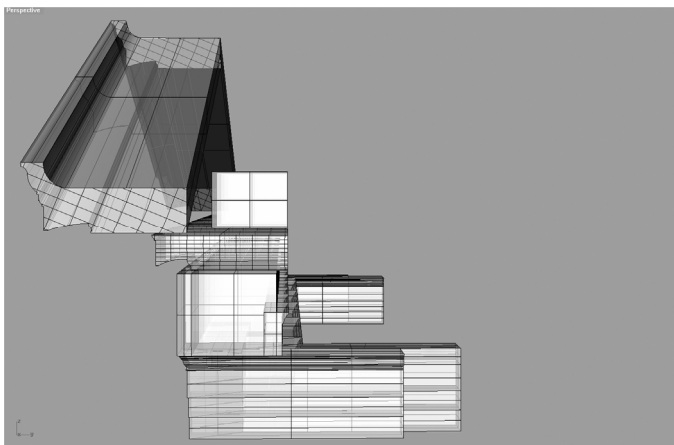


Figure 7. 3-D reconstruction of the roof of the main portico, Athens Academy.

Formal and technical reference models: analogies, differences and continuities

Although the neo-classical Athenian buildings represent the end of a long classical tradition in European architecture, they also show “how much and how” it is possible to transmit a formal, technical and cultural model that could guarantee continuity both in constructional procedure and the use of “original local materials”, as well as in the expressive, linguistic and formal features, that distinguish buildings belonging to the same cultural area, such as existed in the Mediterranean. The recognisable features of ancient buildings in neo-classical edifices, is therefore recovered through the applied *model*, and for the buildings designed in Athens by the Danish architects, the reference models were the buildings of the ancient Acropolis, such as the Athena Nikè Temple, the Erechtheion and the Propylaea.

Neo-classical buildings seem to be so complying with the classical model mainly thanks to the “archaeological” education of the architects who designed them, especially Hans Ch. Hansen – who cooperated with Shaubert and Ross on the first restoration works of the Acropolis. He was entrusted with a restoration project of the Athena Nikè Temple and the drawing of building components during the survey was a fundamental step in the acquisition of the original model. Hans Ch. Hansen had the chance to study the geometrical construction of every single block of stone in the temple and he tried to understand the intrinsic proportional relationships of the building components. Finally he tried to put them correctly inside the building framework where they had a static function contributing, through their expressive features, to the formal unity of the whole architectonic system. Following this methodological research approach to ancient buildings, the architects who worked on the restoration of the Acropolis, through their analysis of the ancient constructional systems, knew very well the technique applied in the building of classical buildings. The architects’ job was made easier by some ancient buildings having been partially “dismantled”, sometimes by the Turks, who had used the stone blocks to build the town walls around the Acropolis, sometimes due to the degradation of those buildings.

The direct knowledge of the original models, and the training of specialist workers – to which Hans Ch. Hansen himself contributed by creating an Athenian school for craftsmen, who were first employed on the restoration and then in the building site of the neo-classical structures – are the reasons that allow a triple comparison between the reference models (classical) and the derived ones (neoclassical), at a compositive, formal-linguistic and tectonic-constructive level.

The case studies for this paper are the buildings of the neo-classical “Athenian Trilogy”, that is, those architectural projects built in Athens between 1839 and 1892 after the designs of two Danish architects, also brothers, Hans Christian Hansen and Theophil Hansen, in collaboration with Ernst Ziller. The three buildings analysed are: the University, the Library, and particularly the neoclassical Academy. The analysis developed in this research is mainly directed to the listing of

the general *expressive and technical features* of original models and to *compare* them with the neo-classical buildings (especially the Academy).

The role of the three-dimensional virtual model (Idea/Project/Building) in reprocessing the original project

The solutions adopted in the elaboration of the three-dimensional models for some elements of the main case study, the neo-classical Athenian Academy, show the opportunities offered by informatics systems both in the 2-D drawings and in the technical reproduction of architectonic models of the wall area.

The current use of information software in the building domain have, indeed, substantially changed architectural design, both in terms of the conceptual possibilities and in the way three-dimensional space is managed. Even though it is integrated in traditional means of surveying antiquities, in drawing and, eventually, in stone block model reproduction and digital modelling, soft wares allow a global synthetic vision of the built item (in this specific case we deal with architectural projects).

Current modelling soft wares, that allow a three-dimensional management of the Cartesian space, apply different logics moving from solid modelling to surface modelling (*nurbs* modelling, *mesh* modelling, parametric software and parametric-variational).

Through these means the geometrical description of complex forms of the architectonic organism is possible. The virtual model seems to be the most updated means for building reality comprehension and the device that allows its description, abstracting from it geometrical generating forms. The abstraction does not simply grant the recovery of the form, but it also finds out *modifiable and transmissible* features of the object under investigation. In the specific case of this research project, the *Cad* has allowed the transfer the information collected during the building survey of the Academy to the abstract *virtual model*, as all its geometrical elements are clearly known and have allowed the understanding of the complexity of the whole architectonic organism.

The analytical reading of the neo-classical Athenian Academy, the object of this research, proceeded according to a schedule that worked from the bottom to the top of the building. It established for every single element the problems involved in its three-dimensional development, starting from the site survey, the first step consisted in the critical drawing of the profiles of some elements two-dimensionally and comparing them with historical surveys of the Acropolis buildings, that constituted for the Danish architects the *geometrical model* reference regarding a series of elements, *replicated* or sometimes *reinterpreted* in their neo-classical buildings.

This first step of generating abstract geometrical models allowed important conclusions to be made about the geometrical process that identifies each moulding of the order and thus allowing us, in the following step, to rebuild three-dimensionally the element generated from that profile.

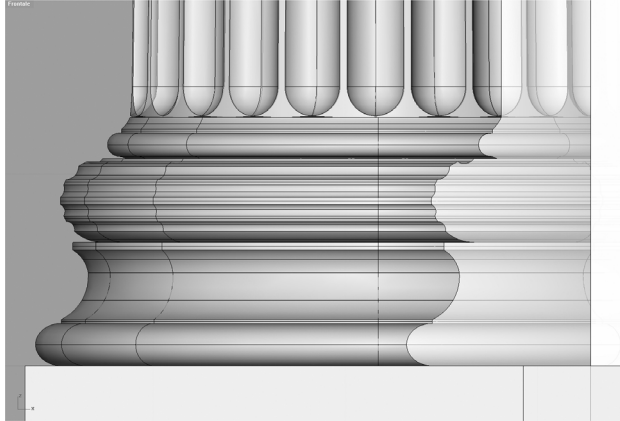


Figure 8.3-D reconstruction of the column base of the Academy portico.

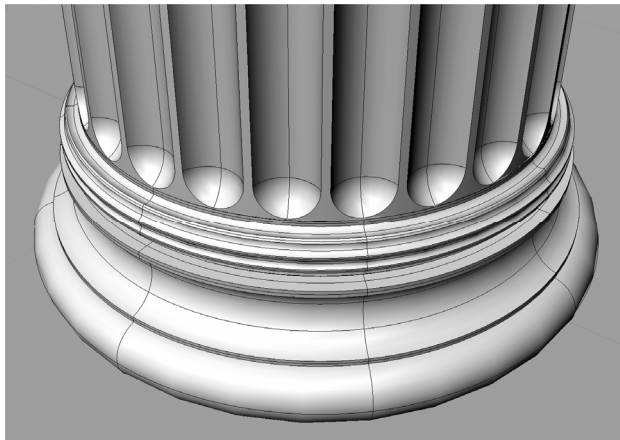


Figure 9. 3D reconstruction of the column base of Academy 's portico.

The reconstruction of the object itself happens through two fundamental processes: space measure and restitution. The three-dimensional solid modelling process, that virtually follows a stone-cutter (one of the classical world) – who progressed by removing material from the stone block and defining its parts and inner proportions geometrically -, proceed through Boolean operations (mutual subtraction of two solids, addition of another one and intersection of two solids).

In the case of the accurate study of the Ionic order, the capital construction with its exact profiles and mouldings, the sequence is obtained through the superficial modelling. The volutes of the capitals are realized through the construction of concave and convex surfaces where two sections

are known, "the first of departure and the second of arrival" (the generatrices) and the curves where sections move on (the directrices). This kind of 3-D analysis and synthesis, carried out in the three-dimensional reconstructing phase for the Academy (by the means of solid and surfacing modelling software), represents, indeed, a good support base in the building knowledge should any replica of the structure, such as the carved stone elements, be needed in the future when any part of the buildings are damaged and needs to be restored.



Figure 10. 3-D reconstruction of anthemion on Ionic capital. Athens Academy.

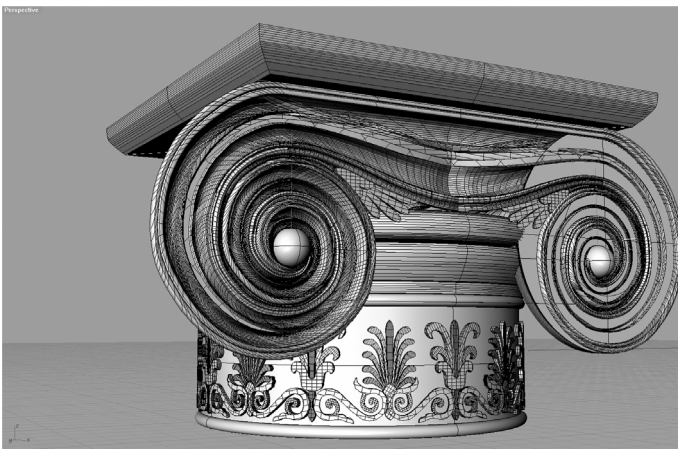


Figure 11. 3-D reconstruction of an Ionic capital. Athens Academy.



Figure 12. 3-D reconstruction of Ionic capital. Athens Academy.



Figure 13. 3-D reconstruction of Ionic capital. Athens Academy.

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