

Stereotomy: modern stone architecture and its historical legacy

Giuseppe Fallacara

Marco Stigliano



© Giuseppe Fallacara, Marco Stigliano, 2012
gfallacara@hotmail.com
ma.stigliano@gmail.com

© Richard Etlin for introduction, 2012

Stereotomy: modern stone architecture and its historical legacy

Traduzione dall'italiano
Eileen Mulligan

Composizione tipografica in
Fedra Sans, Fedra Serif, Fedra Display
© Peter Bifak, 2001-2006

I diritti di traduzione, di memorizzazione elettronica, di riproduzione e di adattamento
anche parziale, con qualsiasi mezzo, sono riservati per tutti i Paesi.
Non è consentito fare fotocopie senza il permesso scritto dell'Editore.

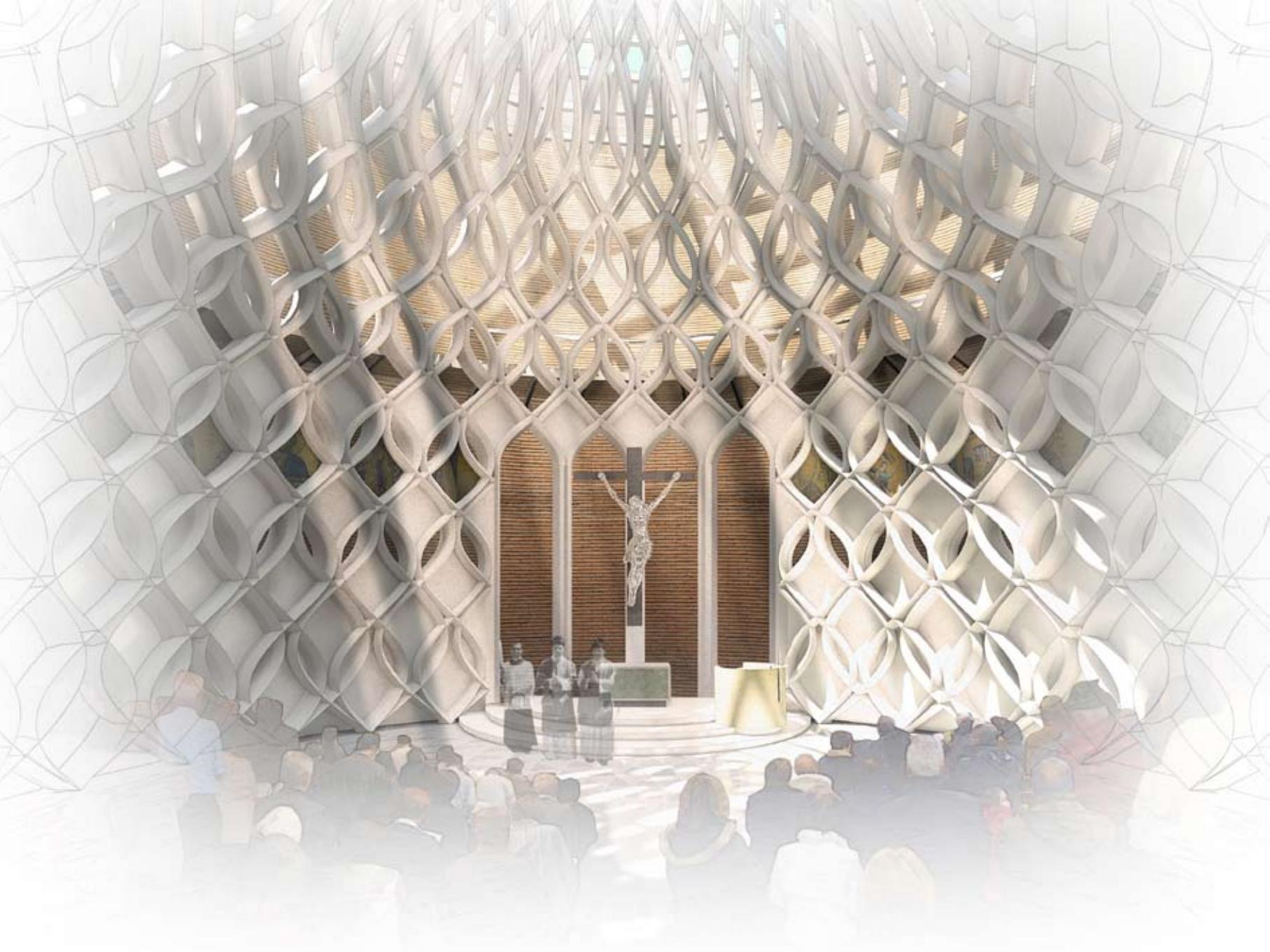
ISBN 978-88-95612-??-

1^a edizione, settembre 2012

[cover]
Banka Kombëtare e Shqipërisë, già Banca Nazionale d'Albania (M. Stigliano 2006)

Table of Contents

Foreword		
The Return of the Ghosts	Giuseppe Fallacara	6
Preface		
his title	Name	10
Introduction		
Stereotomy: The Paradox of an Acrobatic Architecture	Richard Etlin	18
Chapter 1		
Sixty Years of Stereotomy: 1951-2011	Giuseppe Fallacara	40
Catalog 1		
Sixteen Prototypes of Modern Stereotomy	Giuseppe Fallacara	70
Chapter 2		
Towards a Sustainable Design Project	Marco Stigliano	186
Catalog 2		
Sustainable Stone Architecture	Marco Stigliano	206
Credits		290



Project for Santi Cosma e
Damiano Church in Rome,
Claudio D'Amato, 2012

This book is dedicated

The Return of the Ghosts

This book is the outcome of research conducted since 2002 by the ICAR Department of the Faculty of Architecture at the Bari Polytechnic under the direction of Professor Claudio D'Amato Guerrieri, to whom this book is dedicated. After ten years of research into stereotomy and its technical-morphological developments, I felt that it was finally time to bring the work to a close and to present it to a wider audience. Maurizio Brocato – a great friend with whom I share a passion for the trilogy: technique, invention, and construction – provided me with this occasion by proposing an ENPC volume as the right editorial milieu for a project based on structural morphology applied to the discipline of stereotomy, which was codified first in France.

I would like to thank Maurizio for giving me this opportunity and Alain Ehrlacher for having supported this project and for having believed in the work presented here.

This book has been developed in collaboration with my colleague Marco Stigliano, for whom I served as dissertation advisor for his Thesis for graduation on the architecture of Saverio Dioguardi, completed ten years ago. Analyzing stereotomy, Marco focused on the cylindrical corner trumpet vault (*trompe*) in the INCIS building in Via Cognetti, Bari (Fig. 2). This unique construction, dating from 1922-23, was built by Dioguardi in brick with stucco covering and recalls those buildings he had perhaps seen elsewhere, almost certainly in Paris, that had attracted him for their marvelous resolution of corner supports that in France were achieved through stone stereotomy.

Dioguardi's gaze, directed back in time to a stylistic and morphological continuity between France and Italy, is also a gaze into something

deeper and more ancient that links these two nations: their particular use of limestone in architecture. These are two construction cultures that, since time immemorial, have investigated the aesthetic potential intrinsic to the techniques of building with limestone, which by its very nature is both strong and, at the same time, easy to model. Puglia is a landscape of stone, not a precious or decorative stone, but rather a stone at once solid and eloquent, perfect for building, and useful in any type of structural experimentation.

Cesare Brandi describes the Apulian landscape in the following terms:

[...] Ma c'erano, i fantasmi, c'erano apertamente, senza sotterfugio: e di giorno e di notte. Fantasmi solidi, sparsi ovunque, inestirpabili, per quanti se ne raduni. Sono le pietre. Le pietre che la terra pugliese ha in sé come i fantasmi del proprio passato, di una storia ignota e preumana. Con un aratro fatto a spillo, un uncino tuttalpiù, il contadino pugliese solca quell'ossario che è la sua terra, di quelle ossa, che, a volerle togliere tutte, sarebbe come pretendere d'esaurire la sabbia lungo il lido del mare: si fa una buca e quella risorge dal fondo, con l'acqua. Il contadino alza grandi mucchi: poi sceglie, distribuisce, compone a mosaico muri meravigliosi, cementati senza calce, le parieti; edifica trulli, pagliare. Dovunque si vada, in Puglia, si vedono pietre che si aggregano, si cercano, si compongono, come se invece che pietre fossero calamite. Ma perché sono fantasmi. Sono fantasmi, gli unici veri, che vogliono rivivere nell'epoca del cemento armato la loro prima vita di una storia agli albori, quando tutto era da inventare, e, per un'invenzione sola, non bastavano i millenni a esaurirla. E noi stessi, di quante invenzioni preistoriche non ci serviamo ancora?



12

How many of these prehistoric inventions can still inspire contemporary architecture? This is the primary question our work tries to address, by offering answers in terms of design and experimentation.

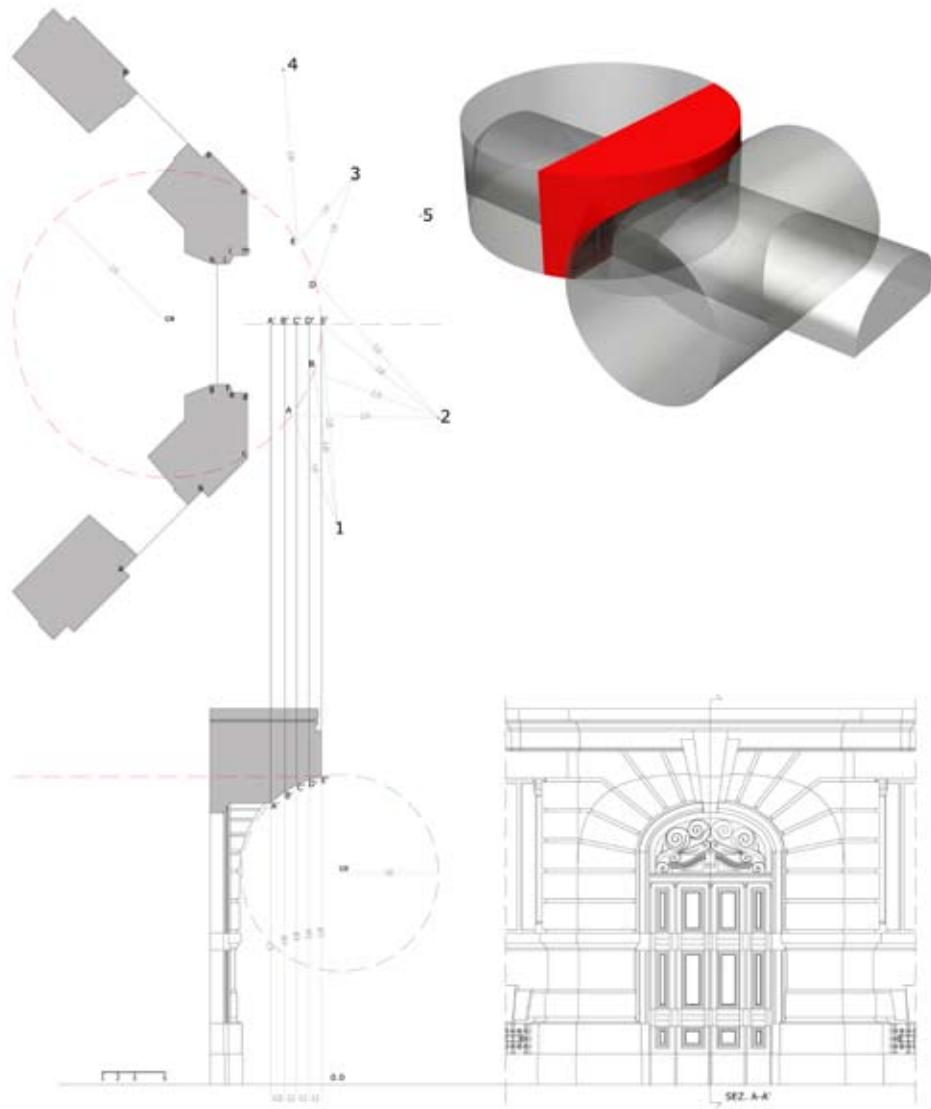
The age of stone architecture is timeless and has prehistoric roots; it reaches beyond all trends and tendencies; it avoids that sense of transience that marks most contemporary architecture; and, at the same time, it inspires our most varied reflections and experiments, whether of constructive elements or small architectonic works. This book seeks to give a logical and chronological order to those reflections. Through our contribution to the development of stone architecture, we wish to emphasize that there is much still to be investigated and invented with stone, whereby we mean the enthusiastic rediscovery of those techniques and processes that time has forgotten but that hold, nonetheless, promise for the future. This book begins with a Preface by Maurizio Brocato, followed by a brief historical Introduction by Richard Etlin, which sets the stage for the contemporary material presented in the following two chapters and their accompanying Catalogs. Richard Etlin is an architectural historian who collaborated with me and Luc Tamboréto to publish *Plaited Stereotomy: Stone Vaults for the Modern World* (Rome: Aracne, 2008). In his introductory essay presented here in this new book, Etlin provides a poetic synthesis of the history of stereotomy, in a way that introduces stereotomy both to the historian and to the working architect, while defining clearly the precursors of *l'art du trait géométrique*, the paradigmatic models that by virtue of their exemplary nature are to be considered lodestars of this art form.

Then, In Chapter 1 and its accompanying Catalog, I try to define the state of the art in stereotomy research since the 1950s and I describe, with the help of illustrations, a possible and visionary future for stone architecture, viewed through the tangible evidence of a series of experiments that are described from the point of view of both their ideational and their technical realities. In Chapter 2, along with its Catalog, Marco Stigliano "comes down to earth" with an overview of research, ideas, and experiments of small-scale architecture, conceived to show the potential of stone architecture regarding the eco-sustainability of the materials in relation to the principles of construction used in these works.

With this said, we hope our readers will emerge from reading this book with their sensibilities heightened and their curiosity stimulated, keen to consider stones, as Brandi suggests, "as ghosts who want to return to live again in this age of concrete", and it is to these ghosts that we wish a speedy return.

¹ C. Brandi, *Pellegrino di Puglia*, Roma-Bari, Laterza, 1979.

02. INCIS Building in Bari,
Saverio Dioguardi, 1922-23



Stereotomy: The Paradox of an Acrobatic Architecture

When toward the end of the seventeenth century Charles Perrault joined the debate about the achievements of contemporary culture in comparison with those of classical antiquity, — the so-called quarrel between the ancients and the moderns, — he knew that reference to the modern tradition in stone vaulting called stereotomy (literally meaning “the cutting of solids”) would demonstrate the superiority of the contemporary age. Perrault, though, used the more customary terms, *la coupe des pierres* (literally meaning “the cutting of stones”) and *le trait* (a term for the shape of the vault, including the arrangement of its stones, or alternately the drawing that shows both features, Fig. 1):¹ “There is perhaps nothing more ingenious in all the arts or in mathematics than *le trait* and *la coupe des pierres*, from which issues these astonishing trumpet vaults where one sees a building support itself by the strength of its shape and by the cut of the stones (Fig. 2); these low-slung vaults, most of them totally flat (Fig. 3); these flights of stairs that, without any pillar to support them (Fig. 4),² turn in the air along the walls that enclose them, and attach to landings that are equally suspended in air, without any other support than the walls and the ingenious cut of their stones”.³ Stereotomy, as Perrault explained, was based on a paradox: it uses “the weight of the stone against itself by making it hover in space through the very weight that should make it fall down”.⁴ Even more, there is nothing visually static about stereotomy. In effect, stereotomy is an architecture that appears not only to defy the laws of gravity; its forms also suggest a lithic manner of gymnastics, as if the vaults themselves are moving through space in the manner of an acrobat.

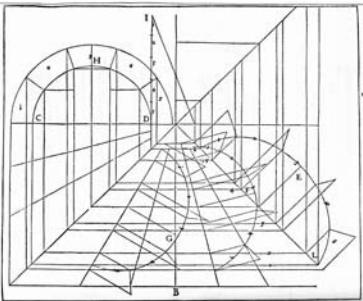
The modern stereotomy that Perrault so admired issued from what might be termed the aesthetic of enchantment of late Gothic architecture, so appropriately labeled by historians as Flamboyant. Whether in the late fifteenth-century Hôtel de Cluny (Fig. 5) where the severies appear to dissolve into flowing lines of delicate flames that flicker across the surface behind the ribs, the c. 1528 chapel in Noyon Cathedral (Fig. 6) where the ribs themselves appear to separate from the severies to flow through space, or Vienna Cathedral where Anton Pilgram’s organ loft of 1513 (Fig. 7) appears to dissolve into a tangle of intersecting and flowing curves, the sensation of active movement is coupled with the apparent abolition of gravity. The wooden sculpted figures of tumbling acrobats (Fig. 8) carved onto the façade of the late Gothic House of the Acrobats on the cathedral square in Blois is emblematic of this aesthetic, which one later finds mirrored, for example, in this graceful, asymmetrical trumpet vault in the Abbey of Notre-Dame des Ardilliers (c. 1650s) in Saumur (Fig. 9). These acrobats reappear in current-day stereotomy as decorative relief figures in DecoWall 2011 designed as a Pelasgic wall that doubles as an art work for the blind in a thermal bath in Varosiglet Park, Budapest, undertaken by students of the Politecnico of Bari under the direction of their professor, the pioneering architect of contemporary stereotomy Giuseppe Fallacara.⁵ From the vantage point of statics, the late Gothic penchant for pendant vaults (Fig. 10) prepared the mind for the use of trumpet vaults suspended in space. It is not accidental that the widely acknowledged father of “erudite” stereotomy,⁶ Philibert Delorme, the first to publish and comment upon the drawings used



Philibert Delorme,
Saint-Nizier, Lyon, mid-16th
century, entrance porch.
(Photo: R. A. Etlin)

1. Philibert Delorme, drawing (*le trait*) for a square *vis de Saint-Gilles*. From *Le premier Tome de l'architecture*, 1567, fol. 127v.

2. Philibert Delorme, Hôtel Bullioud, Lyon, 1536. (Photo: R. A. Etlin)



to prepare stereotomic vaults, included the pendant vault in his two treatises on architecture and reveled in the prospect of enlarging the "hanging keystone" to "four or six feet or more".⁷ Although a hanging keystone would appear to endanger the stability of a vault, paradoxically, as Delorme explains, it stabilizes it against what he termed the tendency of the ogival vault to rise upward,⁸ a phenomenon also commented upon by Brunelleschi and by Rodrigo Gil de Hontañón.⁹ Similarly, the trumpet vault that reaches out from the corner of a building to suspend in space a heavy cylindrical stone room paradoxically needs this weight to afford it stability, placing the voussoirs into the same type of compression that an arch requires. Thus, the mechanics of the pendant vault, like the mechanics of the trumpet vault, involve weighting that is counter-intuitive to the psychological sense of stability.

Yet, as Delorme explains, the design of a trumpet vault requires "extremely subtle" skill, "very difficult to put into practice" so that the vault does not fall down.¹⁰ In the eighteenth century, the architect Pierre Patte explained that stereotomy relied on "the way that weight is directed against the wall".¹¹ More recently, Randy Swanson has stressed the role of attending to the center of gravity as the essential strategy of stereotomic vaulting: "interlocking prisms whose centers of gravity that would fall behind the edge of the stone beneath it, thereby permitting each stone to be put in place without the workman's fear that it would fall from the vault".¹²

Perrault may have been accurate in pointing out that the ancient Romans did not engage in the acrobatic architecture of modern stereotomy.¹³

3. Monastery of Notre-Dame de la Couture, Le Mans, 1720-39. (Photo: R. A. Etlin)

4. Château d'Anet, stair hall by Claude Desgots, c. 1680-1712. (Photo: R. A. Etlin)



Yet, the fan-shaped vertical trumpet vault, which was to become the emblem of modern stereotomy, can be found in Roman building, notably in the monumental fountain façade of the Nymphaeum in Jerash (Fig. 11), where the uplifting and radiating lines of its form certainly contributed to the festive atmosphere created by water cascading down as it issued out of seven lions' heads into basins on the sidewalk from which it overflowed into drains of the underground sewer system.¹⁴ Stereotomic penetrations between intersecting vaults, which Auguste Choisy thought were generally avoided by the ancient Romans, except for rare instances in Roman Gaul, were probably more common than he imagined.¹⁵ One notable example can be found in the Roman Theater in Amman (Fig. 12). Contemporary scholarship has focused on the Near East as the birthplace of stereotomy in the Roman and early Christian era.¹⁶ Yet, the existence of a stereotomic mausoleum in Cassino know as the Tomb of Ummidia Quadratilla, commonly dated to the late first-early second century AD (Figs. 13-14),¹⁷ suggests to us how much ancient Roman architecture of this type in Italy must be lost and how little we know about the historical genealogy of stereotomy. This tomb gives further context to the skillful joining of the monolithic sequences of steps at the seam between each successive drum of Trajan's Column (dedicated 113 AD), where the very space of the interior, as well as the contiguous steps of the helix stair, have been carved out of massive, solid blocks of marble. The underside of the monolithic curving set of steps in each block gracefully meets the next as it spirals upward (Fig. 15).¹⁸

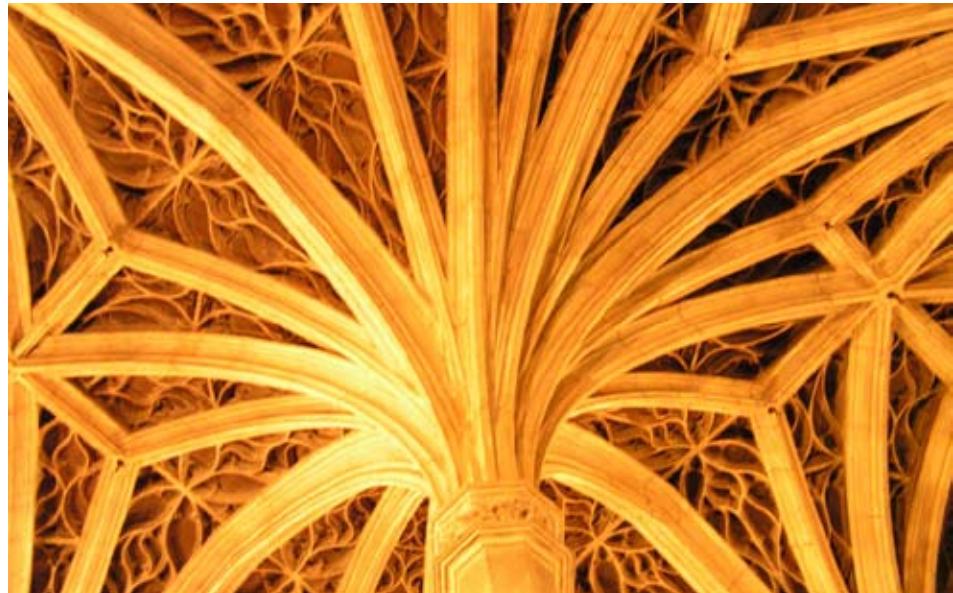
And finally, Seneca had employed the image of the arch as a metaphor for society in words that

5. Hôtel de Cluny, Paris,
chapel vaults, late 15th
century. (Photo: R. A. Etlin)

6. Notre-Dame de Noyon,
Chapelle de l'Assomption, c.
1528. (Photo: R. A. Etlin)

7. Anton Pilgram, organ loft,
St. Stephen's Cathedral,
Vienna, 1513. (Photo: R. A.
Etlin)

8. House of the Acrobats,
Blois. (Photo: R. A. Etlin)





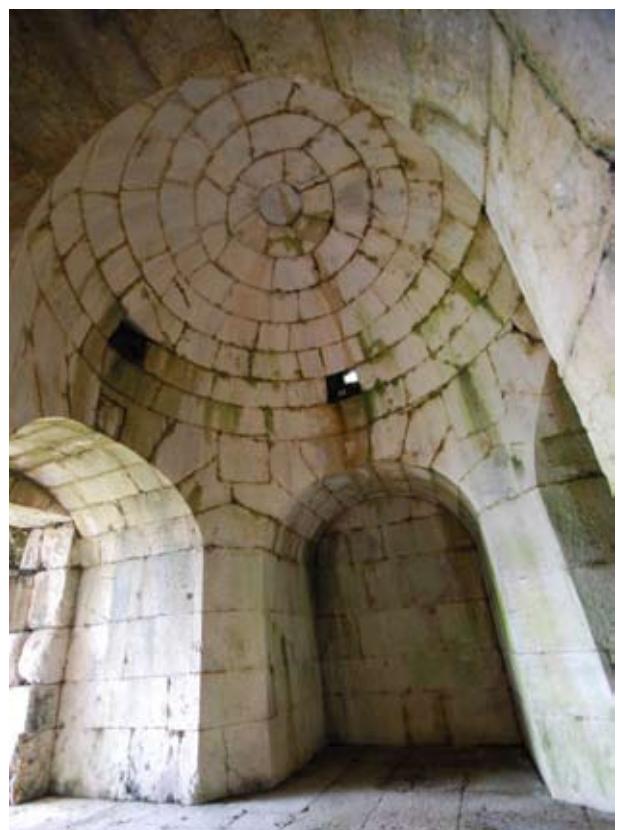
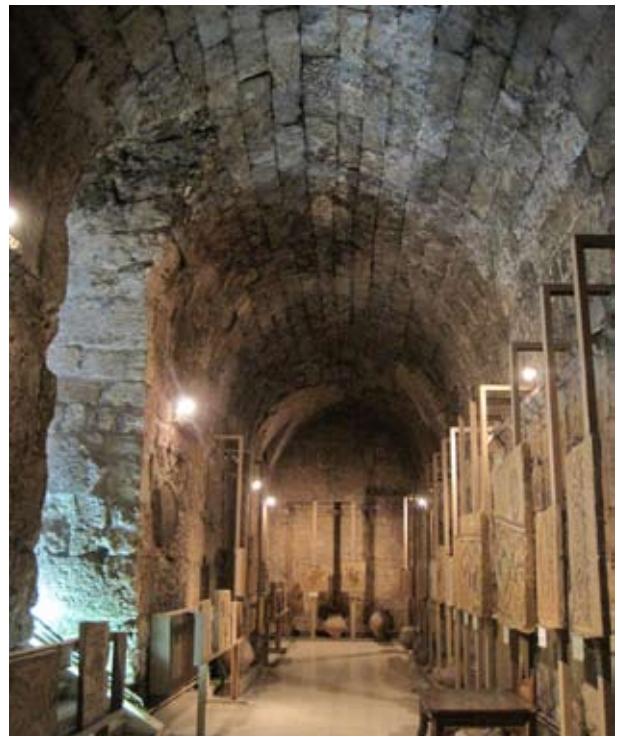
9. Abbey of Notre-Dame des Ardilliers, Saumur, c. 1650s.
(Photo: R. A. Etlin)

10. Saint-Ouen, Rouen,
Porche des Marmousets.
(Photo: R. A. Etlin)

anticipate Leonardo's own description of this structural form,¹⁹ as well as Charles Perrault's adaptation of the conceit to define the achievements of stereotomy. "Human society", wrote Seneca, "is like an arch made of stones: the arch would fall down, if the stones did not support one another, and it is held up by the very fact that they do".²⁰ Modern stereotomy, then, has adapted Roman structural forms and thought, transforming them into an enchanted, acrobatic architecture through the creative application of the sensibility of a late Gothic aesthetic.²¹ Perhaps no example of architecture demonstrates this heritage better than the organ loft in Nantes Cathedral, carried by a shallow pendant vault with a trumpet vault attached to either side (Fig. 16).²² Dating from 1620, this organ loft, which forms a ceremonial interior baldachin over the western entrance, demonstrates not only a sensitivity to the Flamboyant aesthetic of the original cathedral design, which was begun in 1434, but also an understanding of the harmonious nature of trumpet vaults with pendant vaults as elements of a late Gothic aesthetic.²³ Thanks largely to the scholarship of Arturo Zaragozá Catalán, we can say that the father of modern stereotomy was Francesc Baldomar, Valencian architect of the Royal Chapel (1433–63), Santo Domingo Convent (Fig. 17), where the shallow star vault offers alternative readings of a suspended cloth tent, an abstraction of the royal crown, and the fluttering wings of the local bat, an animal that was associated with the royal and civic seal (Fig. 18).²⁴ Baldomar's skew window in the last bay of Valencia Cathedral, itself a stereotomic tour de force (Fig. 19), suggests the profile of a bat in flight. Certainly the best known stereotomic vault is Jules Hardouin-Mansart's 1673 design for

the entrance vestibule of the city hall of Arles (Fig. 20), executed in conjunction with the local painter-architect Jacques Peytret.²⁵ It is a compound double vault braced by perimeter walls – including the full dead weight and load of the bounding facades – reinforced with coupled columns, assisted by massive *tas de charge* and hidden shear walls, as well as by an assemblage of peripheral *arrière-voussures* and *lunettes* that contribute to its aesthetic effect.²⁶ Measuring approximately sixteen meters to each side with a clear span and a shallow rise of only 2.4 meters, this vault appears to hover in space, its flowing lines suggesting the same manner of movement as the flames in the Hôtel de Cluny, albeit with a classical repose characteristic of the famously difficult stereotomic form of the twisting, spiraling, and rampant barrel vault of the Romanesque *vis de Saint-Gilles* in the eponymous church to which Hardouin-Mansart's vault appears to allude (Fig. 21).²⁷ If, as is likely, Hardouin-Mansart intended that his vault would take its place within the pantheon of French masterpieces of stereotomy in which the *vis de Saint-Gilles* occupied a place of honor, he was successful. In 1898, Charvet reported that both monuments were an obligatory visit "at the same time" for the *compagnons tailleurs de pierres* during the *tour de France* that constituted an essential part of their education as stonemasons.²⁸

The new city hall, whose ground-floor plan and facades were designed by Hardouin-Mansart, was built adjacent to the medieval *palais consulaire*, both buildings occupying a site within the domain of the ancient Roman forum.²⁹ Proud of its architectural heritage, the municipal government obliged Hardouin-Mansart to incorporate the Renaissance municipal clock tower (1558)





into the new design, although its irregular form and lack of alignment with the building presented significant visual problems.³⁰ Note that the municipal Renaissance clock tower at the city hall was crowned with a pavilion (Fig. 22) that recalls the medieval tower over Saint-Honorat (Fig. 23),³¹ which in turn is reminiscent of Arles's Roman amphitheater (Fig. 24).³² During the Middle Ages, this arena had been converted into a fortified encampment with four tall towers and a church, the interior occupied with concentric rings of houses, including dwellings within the vaulted bays of the perimeter, thereby making the amphitheater into an effective image of the community.³³ Located in the legendary Gallo-Roman cemetery, the Alyscamps, Saint-Honorat, with its tower capped with the miniature image of this ancient arena, offered a parallel between the city of the dead and the city of the living that it served. Thus, there was ample precedent for making direct allusions to Arles's architectural heritage in the design of the new city hall.

We know that Hardouin-Mansart was sensitive to this artistic and cultural heritage. As the Chevalier de Romieu noted when describing the facades that Peytret had drawn under Hardouin-Mansart's guidance: "the ornaments that reign outside represent everything that relates to the importance of this city in antiquity".³⁴ This heritage included the shallow arches of the Roman cryptoporticus under the forum featuring massive ashlar blocks with smooth surfaces and tight joints (Fig. 25), as well as the stereotomy in Saint-Honorat: its Romanesque octagonal cupola carried on trumpet vaults (Fig. 26), as well as the two Renaissance funerary chapels in that church, whose cloister vaults open to the sky with crowning lanterns that provide

symbolic forms appropriate for honoring the dead: the hexagonal Chapelle de Notre-Dame de Grâce (Fig. 27)³⁵ and the square Chapelle de Castellane (Fig. 28)³⁶ whose lantern is covered by a nearly flat vault (Fig. 29).³⁷

With the design of his vault, Hardouin-Mansart was probably paying homage to the Romanesque stereotomic vaulting just outside of Arles at the Abbey of Montmajour, with its annular barrel vault (Fig. 30) characterized by flowing lines similar to his new vault for the city hall. Hardouin-Mansart would return more literally to the form of the annular barrel vault of Montmajour in his design of the Orangerie at Versailles (1684-86).³⁸ Montmajour also featured a free-standing Chapelle de la Sainte-Croix (Fig. 31), equally impressive with the flowing lines of its half hemispherical domes (*cul-de-four*) that shoulder, like acrobats, the tall central cloister vault (Fig. 32), the entire ensemble an effective image of the Crucifixion and Resurrection.³⁹ In effect, the twin lobes of Hardouin-Mansart's large vault and the opposing lobe of the small vault (Fig. 20) appear as flattened and expanded versions of the stone patterns of the domes in the chapel.⁴⁰ Both the Chapelle de la Sainte-Croix at Montmajour and the Alyscamps enjoyed the prestige of association through legend with the burial of Charlemagne's knights killed when battling the Saracens.⁴¹

The Arles vault has been famous for its daring construction since the time of its completion. In 1726, for example, the Chevalier de Romieu recorded, "Upon entering the city hall one finds a large vestibule, whose daring vault with little convexity, being almost flat, can be counted among the first-rate works of architecture".⁴² And it has retained this status, essentially as the preeminent example of French stereotomic

11. Nymphaeum, Jerash, 191 AD. (Photo: courtesy L. D. Bratton)

12. Roman Theater, Amman, 2nd century AD. (Photo: courtesy L. D. Bratton)

13-14. "Tomb of Ummidia Quadratilla," Cassino, late 1st-early 2nd century AD. (Photo: courtesy M. J. Waters)

15. Trajan's Column, Rome, 113 AD. (Photo: courtesy M. J. Waters)

16. Cathedral of Saint-Pierre,
Nantes, organ loft, 1620.
(Photo: R. A. Etlin)



17. Francesc Baldomar, Royal Chapel, Santo Domingo Convent, Valencia, 1433-63.
(Photo: R.A. Etlin)

18. Royal and civic seal on iron gate, Serrano City Gate, Valencia. (Photo: R. A. Etlin)

19. Francesc Baldomar, Cathedral, Valencia, skewwindow, c. 1461.
(Photo: R. A. Etlin)



vaulting, to this day.⁴³ The twenty-seven-year-old Hardouin-Mansart had learnt his stereotomy under the guidance of his great-uncle François Mansart, in whose office he had worked from the age of fifteen until the latter's death five years later and whose surname he appended to his own family name of Hardouin. Contemporaries noted young Hardouin-Mansart's skill in cutting stone and remarked on his rise within the métier to the leadership rank of *piquer*.⁴⁴ Thus, it would be appropriate to nod in the direction of his mentor – known as "the god of Architecture"⁴⁵ – with a rapid glance at the stunning ensemble of cascading vaults open to each other and suspended in space (Figs. 33-34), along with their stereotomic stair (Fig. 35), in the Mansart wing in the Château of Blois (1635). Philibert Delorme wanted to astonish viewers with his vaults, emphasizing, for example, not only the magic of "suspending in air" a weighty, domed stone *cabinet* for Henri II at the Château d'Anet (Fig. 36) but also drawing attention to the dramatic and unexpected distortions that he was able to achieve with the form of the trumpet vault.⁴⁶ Delorme proudly directed the viewer's attention to the undulating molding at the line of penetration between the trumpet vault and the *cabinet* that was so "foreshortened, stretched, and rampant", which emphasized the "strange form" of the vault with "such a strange warping".⁴⁷ Had the supporting corner walls of the pre-existing building into which the trumpet vault thrusts been stronger, explains Delorme, he would not have made a circular *cabinet* measuring 10-12 feet in diameter but rather an oval 20-24 feet across. Viewers would have been "so much more astounded...to see so great a projection" over the void.

This would have furnished "the strangest and most difficult [architecture] that I could have imagined".⁴⁸

Stereotomy, then, required the combination of extraordinary imagination and technical mastery. In 1792, Simonin, writing in an era when trumpet vaults had fallen into discredit as contrary to good taste because they daringly seemed to confound the laws of gravity by suspending a great weight overhead that threatened to come crashing down,⁴⁹ nonetheless commented on Delorme's "paternal fondness" for this "undulating trumpet vault", while noting: "This trumpet vault was still considered a marvel during the previous century".⁵⁰

Visual effect was not the only impetus behind Delorme's stereotomy, for this architect was fully committed to providing the most commodious and salubrious dwelling possible. Three hundred years later Viollet-le-Duc would quote extensively from Delorme's ethical profession of the architect's responsibility to human welfare, which Delorme explained was so much more important than making the ornamental forms derived from the classical orders that defined the contemporary competence of the Renaissance architect:⁵¹

Most people whose profession is to build spend most of their time studying the ornamental subject of columns, measures, and facades rather than those fine rules of nature that concern the comfort, function, and benefits of a building for the dwellers. It is better, I believe, for the architect to concentrate on the latter rather than on decoration and beauty, or on the embellishment of a dwelling, which only satisfies the eye without contributing to the health and life of its people.⁵²

Viollet then comments:

"What better could one say?"⁵³

20. Jules Hardouin-Mansart,
with Jacques Peytret, City
Hall, Arles, vaulted entrance
vestibule, 1673-74. (Photo: R.
A. Etlin)

21. Saint-Gilles du Gard, *vis
de Saint-Gilles* stair. (Photo:
courtesy N. Mitrocsak)







Even in the domain of functionality, Delorme applied his creativity by using stereotomy. In the main entrance pavilion to the Château d'Anet (Fig. 37), Delorme eschewed a formal symmetry of windows in favor of a diagonal, corner arrangement that would provide more even and fuller illumination to a room. He facilitated the spread of natural light into the space with a flat vault over each of the two tall windows and combined this with partial groin vaults extending from the opposing diagonal corners (Figs. 38-39).⁵⁴ The form is inventive and visually captivating, especially since a flat vault is a visual oxymoron. One wonders why the stones do not simply fall down (Fig. 40). The addition of the partial groin vaults not only makes a more complex aesthetic composition, it also assures the stability of the vault, since a purely flat vault is subject to immediate collapse if the supporting walls do not maintain the requisite compression.⁵⁵ Hardouin-Mansart's contemporary, the mathematician Philippe de La Hire, who taught stereotomy and statics at the Académie Royale d'Architecture, commenced his manuscript *Traité de la coupe des pierres* [1687-90] with the observation that masons explained *la coupe des pierres* as the "science" that involves "joining [stones] together in the appropriate order such that they form a mass that can be considered a single stone".⁵⁶ Perhaps the most spectacular example of this technique can be found in the stair fully suspended in space without leaning at all against a wall in the Monastery of Notre-Dame de la Couture in Le Mans (1720-39), whose stereotomy Robin Evans brought to the attention of the current age (Fig. 41).⁵⁷ Antonio Becchi, who quotes this affirmation by La Hire in his classic study of stereotomy, associates this

22. City Hall, Arles, clock tower, 1558. (Photo: R. A. Etlin)

23. Saint-Honorat, Alyscamps, Arles, tower, 12th century. (Photo: R. A. Etlin)

24. Amphitheater, Arles, late 1st century AD. (Photo: R. A. Etlin)

25. Cryptoporticus, Forum, Arles, late 1st century BC. (Photo: R. A. Etlin)



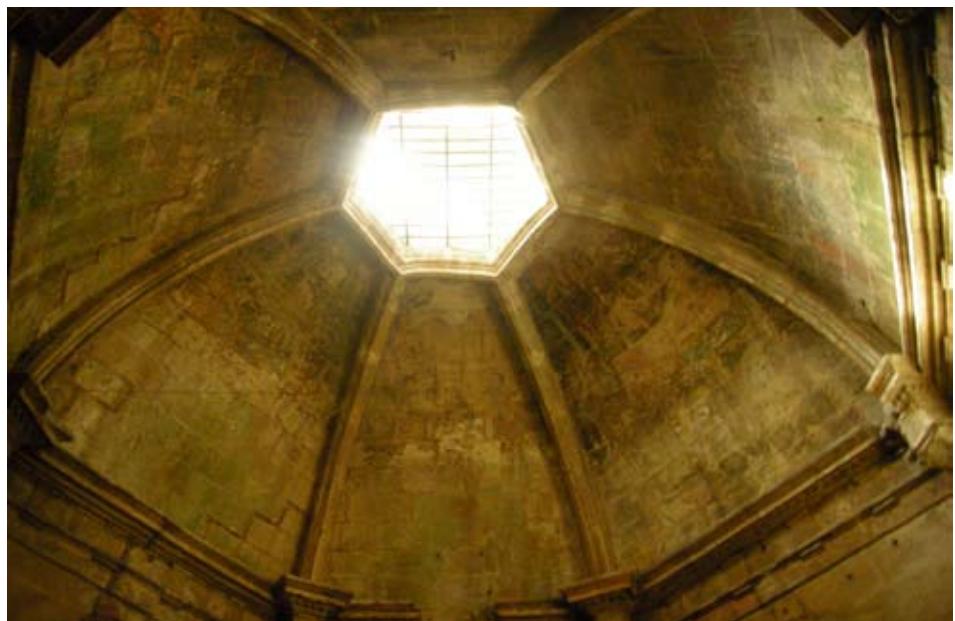
statement with La Hire's interest in interlocking forms, a procedure that a certain Jean Errard had proposed in the design for vaults published in 1584.⁵⁸

In the restricted world of stereotomy today, where the construction of stone stereotomical vaults represents an exception to customary building practice, Giuseppe Fallacara has adapted the proposals for flat vaults composed of interlocking stones from the late seventeenth century by Joseph Abeille and Sebastien Truchet, by making them into barrel vaults, even applying a skewed geometry to the latter to enhance the visual dynamism, while adding the structural benefits of a skewed grid. Fallacara's ceremonial portals use the principle of tessellation, whereby the repetition of an identical element fills the surface and provides the means for one stone to support the other through an interlocking profile.

"Some years before Raphael's birth", explains Christiane Joost-Gaugier, "Duke Federico de Montefeltro elevated the rank of architecture from a manual art to one of the seven liberal arts. The *virtù* of architecture, he stressed to Luciano Laurana, his architect, was in the fact that its foundations were in arithmetic and geometry, among the seven liberal arts those most honored by his court".⁵⁹ The subject of Errard's treatise of 1584 were the inventions of "mathématiques mécaniques", in other words, statics considered as a branch of mathematics. In his treatise of 1567, Delorme had extolled the magical potential of geometry, "the subtlest, the most ingenious, and the most inventive of all the disciplines", which permits the imagination to conceive "the most incredible things, so difficult to comprehend". Yet at the same time, Delorme would emphasize that *le trait* yielded

26. Saint-Honorat, Alyscamps, Arles, 12th century. (Photo: R. A. Etlin)

27. Chapelle de Notre-Dame de Grâce, Saint-Honorat, Arles, 1616-17. (Photo: R. A. Etlin)



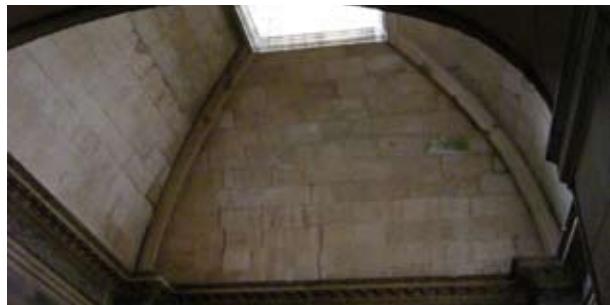
"numerous beautiful secrets in architecture" eminently "useful for the public's well-being".⁶⁰ The creative application of geometry, then, in the service of statics, permits the paradox of a "useful" acrobatic architecture of wonder and enchantment. This is the essence and the legacy of modern stereotomy.

¹ For an introduction to the subject of *la coupe des pierres* and to *le trait*, see Joël Sakarowitch, "From the Stone Carver's Techniques to Descriptive Geometry," followed by Luc Tamboréo, "Les traits du trait. Les lires avec des outils," in *El Arte de la Piedra. Teoría y Práctica de la Cantería. Cuaderno de Investigación*, no. 1 (Madrid: CEU Ediciones, 2009), 7-26 and 71-99 respectively.

² I offer special thanks to Jean de Yturbe, proprietor of the Château d'Anet, who permitted me to study thoroughly and photograph the public spaces, and to Jean-Marie Pérouse de Montclos and Étienne Jollet, for having facilitated my visits.

³ Charles Perrault, *Parallèle des anciens et des modernes en ce qui regarde les arts et les sciences*, in Max Imdahl, Hans Robert Jauss, et al., *Theorie und Geschichte der Literatur und der schönen Künste. Texte und Abhandlungen. Band 2*. 1964 (Munich: Eidos, 1964), 143 ("Second Dialogue: L'Architecture, la sculpture, et la peinture")¹: "Il n'y a peut-être rien de plus ingénieux dans tous les Arts, ny où les Mathematiques ayent plus travaillé que le trait et la coupe des pierres. De là sont venuës ces trompes étonnantes où on voit un édifice se porter de luy-mesme par la force de sa figure et par la taille des pierres dont il est construit; Ces voutes surbaissées et presque toutes plates, ces rampes d'escalier, qui sans aucuns pilliers qui les soutiennent, tournent en l'air le long des murs qui les enferment, et vont se rendre à des palliers également suspendus, sans autre appuy que celuy des murs et de la coupe ingenieuse de leurs pierres". These lines are quoted without a note as to their source in Charles Perrault's writings in Pierre Bourget and Georges Cattaui, *Jules Hardouin Mansart* (Paris: Vincent Fréal, 1956), 42. Bourget and Cattaui's book then served as a point of reference for several authors who repeated this quotation: Jean-Marie Pérouse de Montclos, *L'Architecture à la française XVIe, XVIIe, XVIIIe siècles* (Paris: Picard, 1982), 196-97; Antonio Beccchi, "Chambre H. Per una storia del costruire", in Antonio Beccchi and Federico Foce, eds., *Degli archi e delle volte. Arte del costruire tra meccanica e stereotomia* (Venice: Marsilio, 2002), 38; Francesco Defilippis, *Architettura e stereotomia. Caratteri dell'architettura in pietra da taglio in aree mediterranea* (Bari: Poliba, 2010), 39, where the author erroneously reports that Bourget and Cattaui had attributed these words to Charles's brother Claude, architect of the Observatoire (Paris, begun 1667), a major work of stereotomy. It is possible, of course, that Charles owed much of his understanding of stereotomy to his brother Claude. On the Observatoire, see note 12 below.

28. Chapelle de Castellane,
Saint-Honorat, Arles, 1630.
(Photo: R. A. Etlin)



29. Chapelle de Castellane,
Saint-Honorat, detail of
lantern. (Photo: R. A. Etlin)



⁴ Perrault, *Parallèle des anciens et des modernes*, 171 : "Voila où paroist l'industrie d'un Architecte, qui sçait se servir de la pesanteur de la pierre contr'elle-mesme, et la faire souûter en l'air par le mesme poids qui la fait tomber".

⁵ Whether the choice was conscious or subliminal is unknown. I showed these figures in my lecture, "La Stéréotomie française : la généalogie d'une architecture acrobatique," Politecnico de Bari, June 1, 2008.

⁶ For the notion of "erudite" stereotomy to refer to stereotomy based on drawings and possibly also their explication, see Sakarovich, "From the Stone Carver's Techniques to Descriptive Geometry," in *El Arte de la Piedra*, 16. Of course, as is well known, three sixteenth-century Spanish architects left comparable unpublished manuscripts basically toward the same time: Rodrigo Gil de Hontañón (c. 1550), Hernán Ruiz el Mozo (c. 1550), and Alonso de Vandelvira (c. 1575-91). See José Calvo López, "La literatura de la cantería: una visión sintética", in *ibid.*, 101-56.

⁷ Philibert Delorme, *Le premier Tome de l'architecture* (Paris: Federic Morel, 1567), fol. 110: "de quatre ou six pieds et plus". See also, *idem*, *Nouvelles Inventions pour bien bastir et a petits fraiz* (Paris: Federic Morel, 1560), fol. 27; second edition (Paris: Hierosme de Marnes and Guillaume Cavellat, 1576), 44.

⁸ Delorme, *Le premier Tome*, fol. 110: "Telles clefs suspendues sont à propos pour cela, par autant qu'il est bon que la voute soit chargée par le milieu...comme voulant monter contremort: mais telle clef suspendue l'empeschera pour raison des branches qui s'assemblent à ladicte clef".

⁹ Whereas Delorme welcomed the use of the hanging keystone, Brunelleschi preferred the weight of a lantern to stabilize the ogival cupola of the Florence Cathedral: "I have determined to turn the inner part of this vault in pointed sections, and following the outer sides, and to give to these the proportions and the curve of the quarter-acute arch, for the reason that this curve, when turned, ever pushes upwards, so that when it is loaded with the lantern, both will unite to make the vaulting durable". Brunelleschi's written memorandum from 1420, as reported in Giorgio Vasari, *Lives of the Painters, Sculptors and Architects*, trans. Gaston du C. de Vere, 2 vols. (1912; New York: Alfred A. Knopf, 1996), 1: 338. Vasari later emphasizes the main point of Brunelleschi's argument: "And because he could not live long enough, by reason of his old age, to see the lantern finished, he left orders in his testament that it should be built as it stood in the model and as he had directed in writing; protesting that otherwise the structure would collapse, since it was turned with the quarter-acute arch, so that it was necessary to burden it with this weight in order to make it stronger" (1:349). According to Rodrigo Gil: "It is good to know the correct size and thickness of the ribs and bosses of rib vaults, since we have seen many ruined either because their bosses were too heavy and thus much larger than what the ribs could hold, or else much too light so that the weight of the ribs lift them causing cracks to open in the walls" (fol. 22v). As reported in Santiago Huerta, "Geometry and equilibrium: The gothic theory of structural design", James Sutherland History Lecture, February 2, 2006, IStructE (London) [p. 4], (6 pages).

¹⁰ Delorme, *Le premier Tome*, fol. 87v: "et que la matiere est fort difficile à pratiquer et mettre en oeuvre".

¹¹ Jacques-François Blondel, *Cours d'architecture*, 5:320, as quoted in Pérouse de Montclos, *L'Architecture à la française*, 197: "Ils [les escaliers] doivent se soutenir en l'air par l'artifice de leur construction et par la manière dont on rejette le poids sur les murs". Pérouse de Montclos attributes this passage to Pierre Patte, who completed Blondel's treatise.

¹² Randy S. Swanson, "Late XVIIth century practice of stereotomy prior to the establishment of Engineering Schools in France," in *Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003* [henceforth PFICCH], ed. Santiago Huerta (Madrid: I. Juan de Herrera, SEDHC, 2003), 1878 (1875-85). See also, *idem*, "Practical and Theoretical Applications Of Geometry At Claude Perrault's Observatoire de Paris (1667-1672)", *Nexus* (2002), 243 (237-51). I thank Carolyn Y. Yerkes, Curator of Avery Classics at the Avery Architectural and Fine Arts Library, Columbia University, for bringing this earlier version of Swanson's essay to my attention and more generally for facilitating my research.

¹³ Charles Perrault, *Parallèle des anciens et des modernes*, 171-72: "Voilà ce que n'ont jamais connu les Anciens, qui bien loin de sçavoir faire tenir les pierres ainsi suspenduès, n'ont sçu inventer aucune bonne machine pour les éllever". On this last point about hoisting machines, Perrault, of course, errs.

¹⁴ This description of the nymphaeum has been taken from: http://www.atlastours.net/jordan/jerash_map.html. I thank Lyndsay Bratton for taking photos for me of ancient Roman stereotomy in Jordan.

¹⁵ Auguste Choisy, *L'Art de bâtir chez les Romains* (Paris: Librairie générale de l'architecture et des travaux publics, 1873), 140-41; Pérouse de Montclos, *L'Architecture à la française*, 113-14.

¹⁶ Perhaps the best current history of stereotomy is Arturo Zaragoza Catalán's *El arte de corte de piedras en la arquitectura valenciana del cuatrocientos: un estado de la cuestión. Discurso de ingreso del académico electo Ilmo. Sr. D. Arturo Zaragoza Catalán*, Leido en al salón de Actos de la Academia el día de 29 de enero de 2008 (Valencia: Real Academia de Bellas Artes de San Carlos de Valencia, 2008). See especially p. 15 on the Near Eastern legacy.

¹⁷ See Sara Marandola, "Rilievo e analisi strutturale del mausoleo cosiddetto di Ummidia Quadratilla a Cassino (Fr)" in *Monumenta. I mausolei romani, tra commemorazione funebre e propaganda celebrativa. Atti del Convegno di Studi Monte Porzio Catone, 25 ottobre 2008*, Comune di Monte Porzio Catone, Istituzione "Area delle Muse" – Polo Museale, ed. Massimiliano Valenti (Rome: Exorma, 2010), 192 (183-94). I thank Rabun Taylor for providing me with this article and Michael Waters for taking photos for me.

¹⁸ I thank Michael Waters for directing my attention to the joint between the spiraling surfaces of the stair in successive drums of Trajan's Column. For documentation of Trajan's Column to help visualize the complexity of this negative space, see the exploded perspective, as well as the section, in Mark Wilson Jones, *Principles of Roman Architecture* (New Haven: Yale University Press, 2000), 165-66.

¹⁹ Roberto Marcolongo, "La meccanica di Leonardo da Vinci," *Atti Reale Accademia di Scienze fisiche e matematiche di Napoli* 2, no. 19 (1932),

30. Abbey of Montmajour,
outside Arles, crypt, 12th
century. (Photo: R. A. Etlin)

31. Chapelle de la Sainte-Croix,
Abbey of Montmajour, 12th
century. (Photo: R. A. Etlin)

32. Chapelle de la Sainte-
Croix, Abbey of Montmajour,
12th century. (Photo: courtesy
N. Lamoureux)





33-35. François Mansart,
Château of Blois, 1635. (Photo:
R. A. Etlin)

in Marcolongo, *Memorie sulla geometria et la mecanica di Leonardo da Vinci* (Naples: S.I.E.M. – Stabilimento Industrie Editoriali Meridionali, 1937), 237: "Che cosa è arco. Arco non è altro che una fortezza causata da due debolezze; imperocché l'arco negli edifiti è composto di 2 quarti di circulo, i quali quarti circuli ciascuno debolissimo per sé desidera cadere e oponendosi alla ruina l'uno dell'altro, le due debolezze si convertano in unica fortezza" (ms. A, 50r). Also quoted in Edoardo Benvenuto, *La scienza delle costruzioni e il suo sviluppo storico* (Florence: Sansoni, 1981), 324, and idem, *An Introduction to the History of Structural Mechanics: Part II: Vaulted Structures and Elastic Systems*, trans. Aurelia V. von Germela (New York: Springer, 1991), 309.

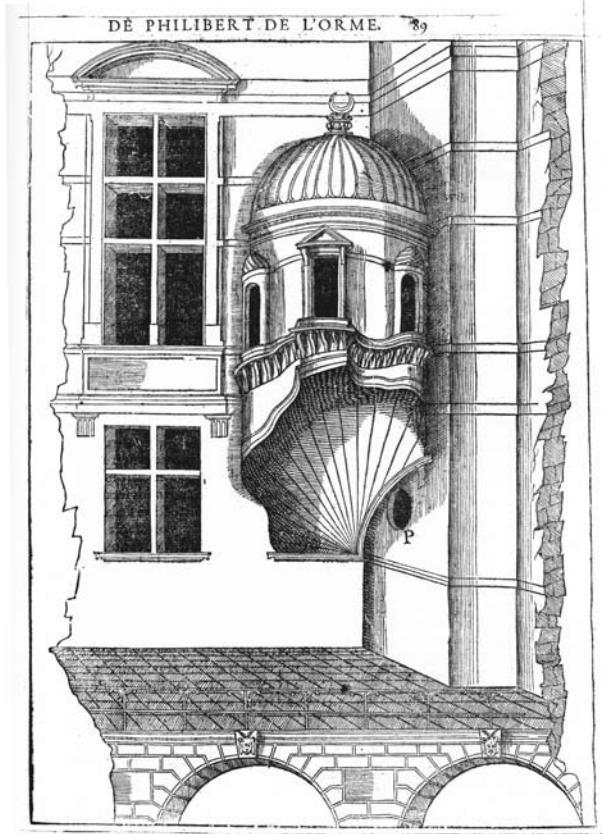
²⁰ Seneca, *Epistulae Morales*, 95.53: "societas nostra lapidum fornitioni simillima est, quae casura, nisi in vicem obstant, hoc ipso sustinetur". I thank Gareth Williams for identifying the source in Seneca's writings for this quotation and Joseph Solodow for the translation. This line is quoted in Benvenuto, *An Introduction to the History of Structural Mechanics: Part II*, 309 n. 2.

²¹ For a late Gothic use of a trumpet vault at the base of a stair tower in Lyon Cathedral, see Nicolas Reveyron, "Influence de la charpenterie et rôle des charpentiers dans l'architecture de pierre à la fin du Moyen Âge à Lyon", *Bulletin Monumental* 154 (1996), 152, 157 (149–65). This southeast tower of the choir also uses the embedded diamond-shaped die that Delorme would advocate to strengthen a construction (*Le premier Tome*, fol. 225v–226). In the Lyon tower, the die are placed within stones that appear to be placed vertically rather than horizontally, with two stones extending below the curved profile of the stair such that from a distance they would appear to be miraculously suspended in space. (In an e-mail communication of April 1, 2012, Nicolas Reveyron explains that these seemingly vertical stones are the ends of stone beams). Thus, the possible influence of this precedent on Delorme deserves further consideration.

²² In *Traité élémentaire de la coupe des pierres ou art du trait*, Simonin, a professor of mathematics who collaborated in writing this book with the architect and teacher Abbé Claude Mathieu de Lagardette, argued that the vertical trumpet vault issued from the logic of the flying buttress: "Leurs successeurs allèrent plus loin. Ils crurent qu'il seroit beau d'exécuter des voûtes qui, non-seulement, ne seroient pas contrebutées, mais encore qui sailleroient au-delà du mur. C'étoit passer d'un excès à l'opposé; cependant, comme tout ce qui exige de grands efforts, paroit tenir du prodige, on se passionna pour ces nouveautés. Les trompes dans l'angle eurent sur-tout bien du succès. Il paroît, par ce qui nous reste des 15^e et 16^e siècles, qu'on faisoit alors peu d'édifices considérables, où l'on ne crût en devoir mettre". *Traité élémentaire de la coupe des pierres ou art du trait, par Mr. Simonin, professeur de mathématique. Mis au jour par Mr. Delagardette, architecte pensionnaire du roi* (Paris: Joubert, 1792), 3.

²³ On the dating of this cathedral, as well as a view looking back to the main doors through the baldachin, see Yves Bottineau, *La Cathédrale Saint-Pierre de Nantes. Histoire et description* (Nantes, Amis de la Cathédrale de Nantes [1980?]), 6, 8, 27.

²⁴ On the symbolism of this vault, see Richard A. Etlin, "Toward an Iconography of Stereotomy", to be published in the acts of the Fourth International Congress on Construction History, Paris, July 3–7, 2012.



36. Philibert Delorme,
Château d'Anet, undulating
trumpet vault carrying king's
cabinet, c. 1550. From *Le
premier Tome de l'architecture*,
1567, fol. 89.

37. Philibert Delorme,
Château d'Anet, main
entrance pavilion, c. 1551-52.
(Photo: R. A. Etlin)



²⁵ On Peyret's contribution to the design, see Richard A. Etlin, "Génesis y estructura de las bóvedas de Arles", in *Actas del Sexto Congreso Nacional de Historia de la construcción*, Valencia, October 21-24, 2009, ed. Santiago Huerta, et al., 2 vols. (Madrid: Instituto Juan de Herrera, 2009), 1: 425-34.

²⁶ See Luc Tamboréo and Joël Sakarovitch, "The Vault of Arles City Hall: A Carpentry Outline for a Stone Vault?", in *Proceedings of the Second International Congress on Construction History*, ed. Malcolm Dunkeld, et al. (Ascot: Construction History Society, 2003), 1899-1907; Etlin, "Génesis y estructura de las bóvedas de Arles", 429-31.

²⁷ On this theme, see Etlin, "Génesis y estructura de las bóvedas de Arles", 426-28.

²⁸ E.-L.G. Charvet, "L'Hôtel de ville d'Arles et ses huits architectes", *Réunion des Sociétés des Beaux-arts des départements en 1898*, 21, 416 (396-418).

²⁹ Vanessa Eggert, "Le Palais de la commune d'Arles. Naissance, appropriation et reconstruction d'un édifice emblématique", pdf, Site patrimoine de la ville d'Arles – www.patrimoine.ville-arles.fr.

³⁰ As reported by the consul Jean de Sabatier in Charvet, "L'Hôtel de ville d'Arles", 407, and Jean Boyer, "Jules Hardouin-Mansart et l'Hôtel de ville d'Arles", *Gazette des Beaux-Arts* 74 (1969), 9 (1-32). For the date of the clock tower, see Boyer, 2.

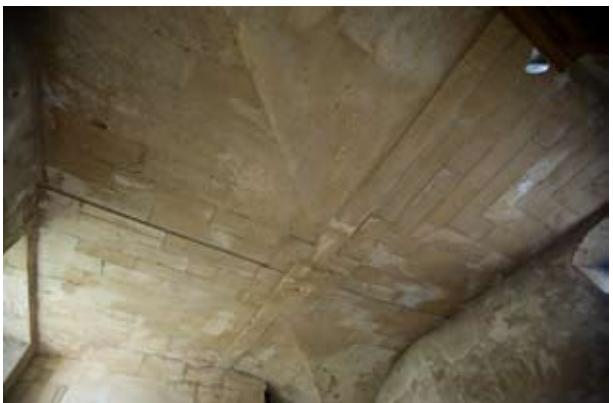
³¹ Marc Heijmans and Andreas Hartmann-Virnich explain that beginning in the second quarter of the twelfth century Saint-Honorat was rebuilt and that the tower was added during this new campaign. On the other hand, Vanessa Eggert dates the tower to the end of the twelfth-beginning of the thirteenth century. See Marc Heijmans and Andreas Hartmann-Virnich, "Les Alyscamps", 3, pdf extract from *Arles, le guide: musées, monuments, promenades* (Éditions du patrimoine, 2001), Site patrimoine de la ville d'Arles – www.patrimoine.ville-arles.fr; and Eggert, "Le Palais de la commune d'Arles", 10.

³² Heijmans and Hartmann-Virnich, "Les Alyscamps", 3: "La croisée est couverte d'une coupole sur trompes que surmonte un beau clocher octogonal dont les deux étages sont agrémentés d'un décor d'inspiration antique".

³³ See Stéphanie Zugmeyer, et al., "L'Amphithéâtre d'Arles. Histoire, architecture, archéologie, restaurations", pdf, Site patrimoine de la ville d'Arles – www.patrimoine.ville-arles.fr. The amphitheater was not cleared of these dwellings until 1851. See Jacques Peyret's engraving of 1686 (p. 2).

³⁴ Le chevalier de Romieu, "Portefeuille" (1726), as copied in Émile Fassin, "Arles, Hôtel-de-Ville. Notes et documents recueillis par Émile Fassin, 1896-1897". Médiathèque d'Arles, ms. 2412, fol. 25: "les ornements qui règnent au dehors représentent tout ce qui a du rapport à l'illustration de cette ville dans l'antiquité". On the relationship between Hardouin-Mansart and Peyret with respect to the design of the facades, see Boyer, "Jules Hardouin-Mansart et l'Hôtel de ville d'Arles", 10.

³⁵ On this chapel, see Jean Boyer, "La Chapelle de Notre-Dame de Grâce à Saint-Honorat des Alyscamps", *Bulletin des Amis du Vieil Arles*,



38-39. Philibert Delorme, Château d'Anet, main entrance pavilion, interior. (Photo: R. A. Etlin)

40. Philibert Delorme, Château d'Anet, main entrance pavilion, interior. (Photo: courtesy J. Calvo López)

no. 49 (June 1983), pdf extract, Site patrimoine de la ville d'Arles – www.patrimoine.ville-arles.fr.

³⁶ On this chapel, see Pérouse de Montclos, *L'Architecture à la française*, 150, 286.

³⁷ I thank Andreas Hartmann-Virnich for confirming in an e-mail communication of April 4, 2012, that these are, in effect, funerary chapels, with hollow floors for sepulchers and "a painted black horizontal frieze [still visible] on the wall which represents the textile wall hangings used in funeral ceremonies".

³⁸ For this comparison, see Pérouse de Montclos, *L'Architecture à la française*, 143 (fig. 93). The hemispherically domed chapel and its circumambulating annular barrel-vaulted corridor in the crypt of Montmajour would later serve as a model for a similar stereotomic arrangement in the crypt of Jacques-Germain Soufflot's Sainte-Geneviève, Paris, 1757-80.

³⁹ I am grateful to the late Nicolas Lamoureux for having provided me with photos of the interior of this chapel, as well as informing me about Henry Révoil's book listed below in note 41, for which he generously sent me a pdf.

⁴⁰ The similarity between the domes of the chapel and the two combined vaults at the city hall would have been stronger in what I believe was Hardouin-Mansart's initial project, which I have argued was probably changed in his subsequent absence by Peyret through the addition of the penetrating V-shaped wedge. See Etlin, "Génesis y estructura de las bóvedas de Arles", 429-31.

⁴¹ See, respectively, Henry Révoil, *Architecture romane du Midi de la France*, 2 vols. (Paris: V^e A. Morel, 1873), 1: 15; and Heijmans and Hartmann-Virnich, "Les Alyscamps". 4.

⁴² Le chevalier de Romieu, "Portefeuille" (1726), as copied in Fassin, "Arles, Hôtel-de-Ville". Médiathèque d'Arles, ms. 2412, fol. 25-26: "Lon trouve en entrant dans l'Hôtel-de-ville un grand vestibule, dont la voûte hardie par son peu de convexité, étant presque plate, peut tenir lieu parmi les premiers ouvrages d'architecture". See also, the manuscript notes by the Abbé Marcelin Chailan, after a 1739 manuscript by Antoine Arnaud, ibid., fol. 58: "mais ce qui frappe le plus dans cette salle, c'est la voûte, une des plus hardies, et qui contribua à la gloire de son auteur"; and Père Antoine Fabre, *Panégirique de la ville d'Arles, prononcé le 25 avril 1743* (Arles: Gaspard Mesnier, 1743), 97-98: "J'ai eu en vuë l'Hôtel de Ville, quand j'ai parlé d'un Monument moderne, qui égale toutes les beautés des anciens.... Les Curieux y admirent sur-tout un grand Vestibule, dont la Voute hardie, passe pour un des plus ingénieux Ouvrages de l'art".

⁴³ See, for example, Jean-Marie Pérouse de Montclos, "La Voûte de l'hôtel de ville d'Arles est-elle le produit de la tradition locale ou une importation parisienne?", in *Culture et création dans l'architecture provinciale de Louis XIV à Napoléon III. Travaux et colloques de l'Institut d'Art, publications de l'Université de Provence* (1983), 123 (123-28): "La voûte couvrant le vestibule de l'hôtel de ville d'Arles est le chef-d'œuvre de la stéréotomie française". I thank the author for having provided me with a copy of this essay. See also, idem, *L'Architecture à la française*, 116; Giuseppe Fallacara, *Verso una Progettazione Stereometrica/Towards a Stereometric Design* (Rome: Aracne, 2007), 26.

- 44 Bourget and Cattaui, *Jules Hardouin Mansart*, 9-12, 42.
- 45 Bourget and Cattaui, *Jules Hardouin Mansart*, 10.
- 46 For an overview of the theme of the purposefully difficult vault, see Enrique Rabasa Díaz, "Soluciones innecesariamente complicadas en la estereotomía clásica", in *El Arte de la Piedra*, 51-69. For a discussion of the dynamic illusionism of Delorme's chapel at the Château d'Anet, see Richard A. Etlin, "Architectural and the Sublime", in Timothy Costelloe, ed., *The Sublime: From Antiquity to the Present* (Cambridge University Press, 2012), 258-69 (230-73).
- 47 Delorme, *Le premier Tome*, fol. 88v: "D'avantage par dessous ledit cabinet on voit comme la moitié de la voute est rempante...qui rend le trompe beaucoup plus difficile. Et pour la forme estrange qu'a ceste voute de trompe, on voit la moulure, qui est autour par le devant de ladicte trompe racourcie, ralongée et rempant, autour d'icelle voute, qui est une chose admirable à voir, et digne d'y considerer comme la nature du traict conduict ce degauchissement si estrange".
- 48 Delorme, *Le premier Tome*, fol. 90v-91: "Desquelles si je me fusse bien assuré, et que je les eusse fait faire, au lieu que la voute de la trompe a de saillie par le milieu de A à D, dix ou douze pieds, je luy en eusse baillé vingt ou vingt et quatre, et par le devant je l'eusse faict en forme ovale, et d'une façon la plus estrange et la plus difficile que j'eusse peu penser: ou bien je y eusse erigé un cabinet dont on se fust beaucoup plus esbahy, que lon ne faitc encores, de voir si grande saillie".
- 49 On the eighteenth-century's reaction against trumpet vaults, see Pérouse de Montclos, *L'Architecture à la française*, 219-22.
- 50 Simonin, *Traité élémentaire de la coupe des pierres*, 3: "Philibert Delorme...employe presque le quart de son [quatrième] livre, à traiter de sa trompe ondée d'Anet; tant sa tendresse paternelle étoit grande pour cette production. Cette trompe passoit encore pour une merveille dans le siècle dernier".
- 51 On the rise of the Renaissance architect as skilled in drawing the antique style but not necessarily trained in the area of building, see, for example, Krista De Jonge, "Chantiers dans le milieu de la Cour des anciens Pays-Bas méridionaux aux XVI^e-XVII^e siècles: organisations et innovations techniques", in *Édifice & Artifice: Histoires constructives. Recueil de textes issus du Premier congrès francophone d'histoire de la construction*, Paris, 19-21 juin 2008, ed. Robert Carvais, et al. (Paris: Picard, 2010), 917-26.
- 52 Delorme, *Le premier Tome*, fol. 14: "De sorte qu'il vaudroit trop mieux à l'Architecte, selon mon avis, faillir aux ornements des colonnes, aux mesures et fassades (ou tous qui font profession de bastir s'estudent le plus) qu'en ces belles reigles de nature, qui concernent la commodité, l'usage, et proufit des habitans, et non la decoration, beauté, ou enrichissement des logis, faictz seulement pour le contentement des yeux, sans apporter aucun fruit à la santé et vie des hommes". For clarity of understanding, I have rearranged the order of the French text in my translation. Delorme repeats this critique at the head of bk. 1, chap. 8 (fol. 19v).
- 53 Eugène-Emmanuel Viollet-le-Duc, *Entretiens sur l'architecture* (1863; Ridgewood, N.J.: Gregg Press reprint, 1965), 1: 348: "Que pourrions-nous dire de mieux?" Viollet includes the following text as well: "Ne voit on point, je vous prie, qu'à faute d'avoir bien approprié, tourné et accommodé un logis, il rend les habitants tristes, maladifs, désplaisants, et accompagnez de toutes disgraces et incommodeitez? desquelles on ne peult le plus souvent rendre raison, ne moins sçavoir d'où elles viennent" (fol. 14-14v).
- 54 In *Les nouvelles Inventions*, fol. 52v, within the context of discussing wooden ceilings, Delorme stresses the importance both of tall windows and of not aligning windows so as to avoid making rooms into "les lieux melancholiques". He also lists the buildings in which he applied this principle, which include the Château de Saint-Maur for Cardinal Jean Du Bellay, "la salle et galerie" of the Château d'Anet, and the royal Château de Saint-Léger. In *Le premier Tome*, fol. 249-249v, Delorme discusses the importance of tall windows that rise up close to the ceiling and refers the reader to the discussion of windows in his earlier book. Probably because of the careful attention to the orientation of wind and sun, as well as to enhanced illumination through the asymmetrical arrangement of windows, Rabelais would praise Du Bellay's château as a "paradis de salubrité" (as quoted in Anthony Blunt, *Philibert de l'Orme* [London: A. Zwemmer, 1958], 22). For a plan and its variant, see *Le premier Tome*, fol. 17v-18.
- 55 On this structural danger, see Giuseppina R. Uva, "Learning from traditional vaulted systems for the contemporary design. An updated reuse of flat vaults: Analysis of structural performance and recent safety requirements", in PFICCH, 2015-21, especially 2017.
- 56 Quoted in Becchi, "Chambre H. Per una storia del costruire", 44. See also p. 45 (photocopy of La Hire's first page with this statement), and in idem, "Before 1695: The statics of arches between France and Italy", in PFICCH, 357 (353-64).
- 57 Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge: MIT Press, 1995), 193-95, and fig. 109. For an earlier publication of this stair, see Pérouse de Montclos, *L'Architecture à la française*, 85, 87 (fig. 41).
- 58 Becchi, "Chambre H. Per una storia del costruire", 46-49, and idem, "Before 1695", 357-59.
- 59 Christiane L. Joost-Gaugier, *Raphael's Stanza della Signatura: Meaning and Invention* (Cambridge: Cambridge University Press, 2002), 165-66.
- 60 Delorme, *Le premier Tome*, fol. 86-90v, 124-124v: "Bref, je vous ay descouvert et montré sous l'artifice desdicts traicts plusieurs beaux secrets en l'Architecture...qui est maîtresse trescertaine des choses incroyables et incertaines. (...) Et seront lesdictes demonstrations extraictes de Geometrie, la plus subtile, plus ingenieuse et plus inventive de toutes les disciplines.... qu'elles rendent les hommes subtils et ingenieux à inventer plusieurs choses singulieres et prouffitables pour le bien public" (fol. 86v).



41. Monastery of Notre-Dame de la Couture, Le Mans, 1720-39. (Photo: R. A. Etlin)

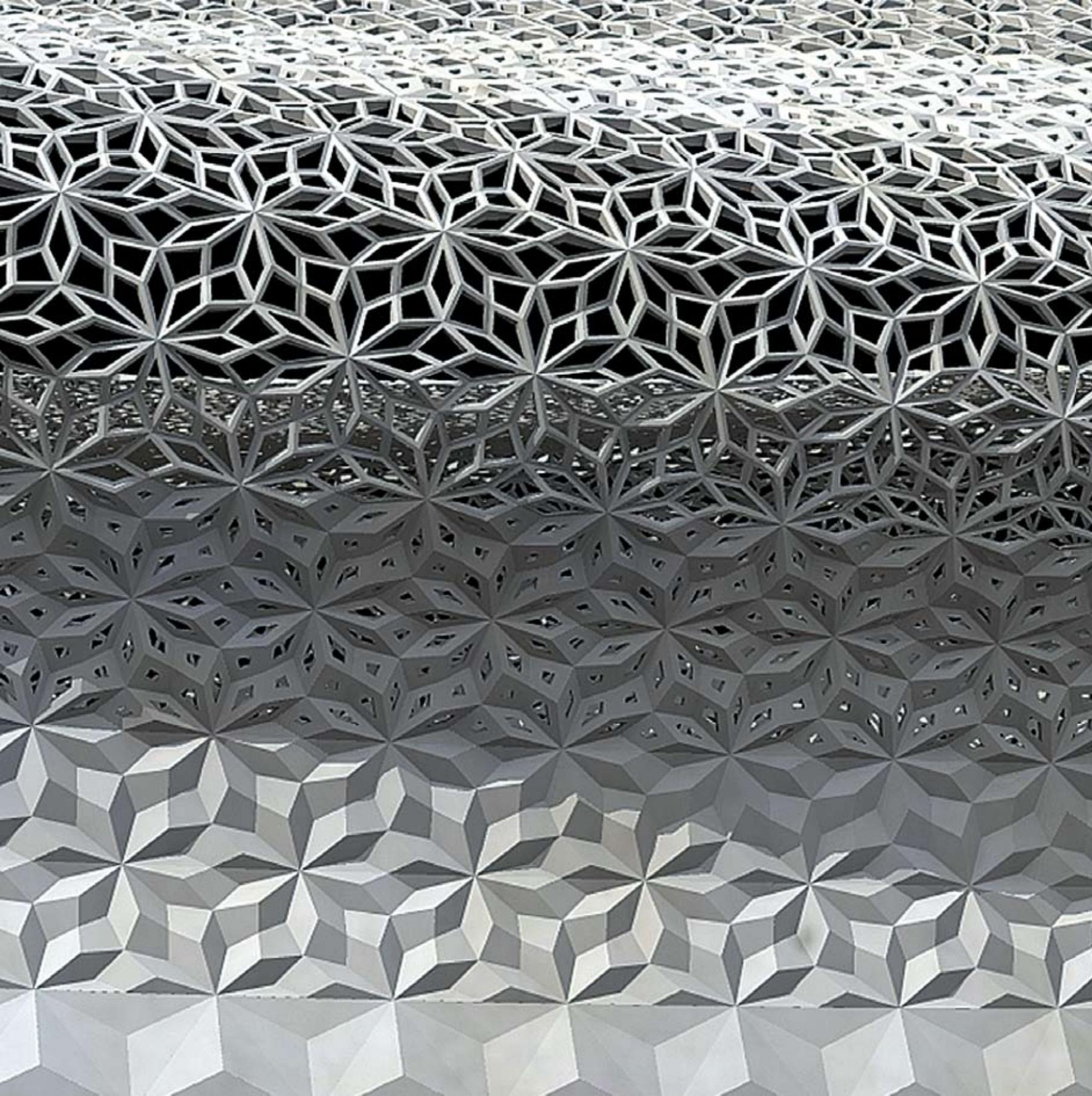
Sessant'anni di Stereotomia 1951-2011

...e che la disciplina è molto difficile da professare e mettere in opera. Perché non la si può facilmente insegnare attraverso la lettura e la scrittura. Per la quale mi si potrà scusare, se in tutti questi discorsi non sia stato capace di spiegare bene e far intendere, come avrei voluto e desiderato: dato che mi impegno con tutte le mie forze e la piccola grandezza di spirito. Ma voi sapete che tutte le nuove scritture e invenzioni non sono mai esenti da grandi difficoltà e lavoro.

P. de l'Orme, *Le Premier Tome de l'Architecture*, 1567, Libro IV, Prologo, f. 87v

La stereotomia, al pari di un essere vivente, ha conosciuto i tre momenti fondamentali: la nascita, l'evoluzione e il suo declino. Se provassimo, con una semplificazione sintetica finalizzata alla comprensione, ad associare una dimensione temporale alla vita della stereotomia misurerebbe circa trecento anni: la nascita apparterrebbe al XVI secolo con Philibert de l'Orme, l'evoluzione al XVII secolo con Girard Desargues, e l'inizio del declino a partire dal XVIII secolo con la proliferazione di trattati non più brillanti. La morte arriverà, paradossalmente con il conseguimento del suo apice teorico nel XVIII secolo con la formulazione della geometria descrittiva ad opera di Gaspard Monge nell'anno III della Repubblica Francese. La nuova speculazione teorica separa la *prassi* dall'*astrazione concettuale* puntando più su questa ultima a discapito della prima. Non saranno più le opere architettoniche a custodire la magnificenza del pensiero bensì l'*astrazione* a determinarne il senso di necessità. Inoltre nel cambiato clima culturale, la pubblicazione dell'*Essay sur l'architecture* dell'Abate Laugier

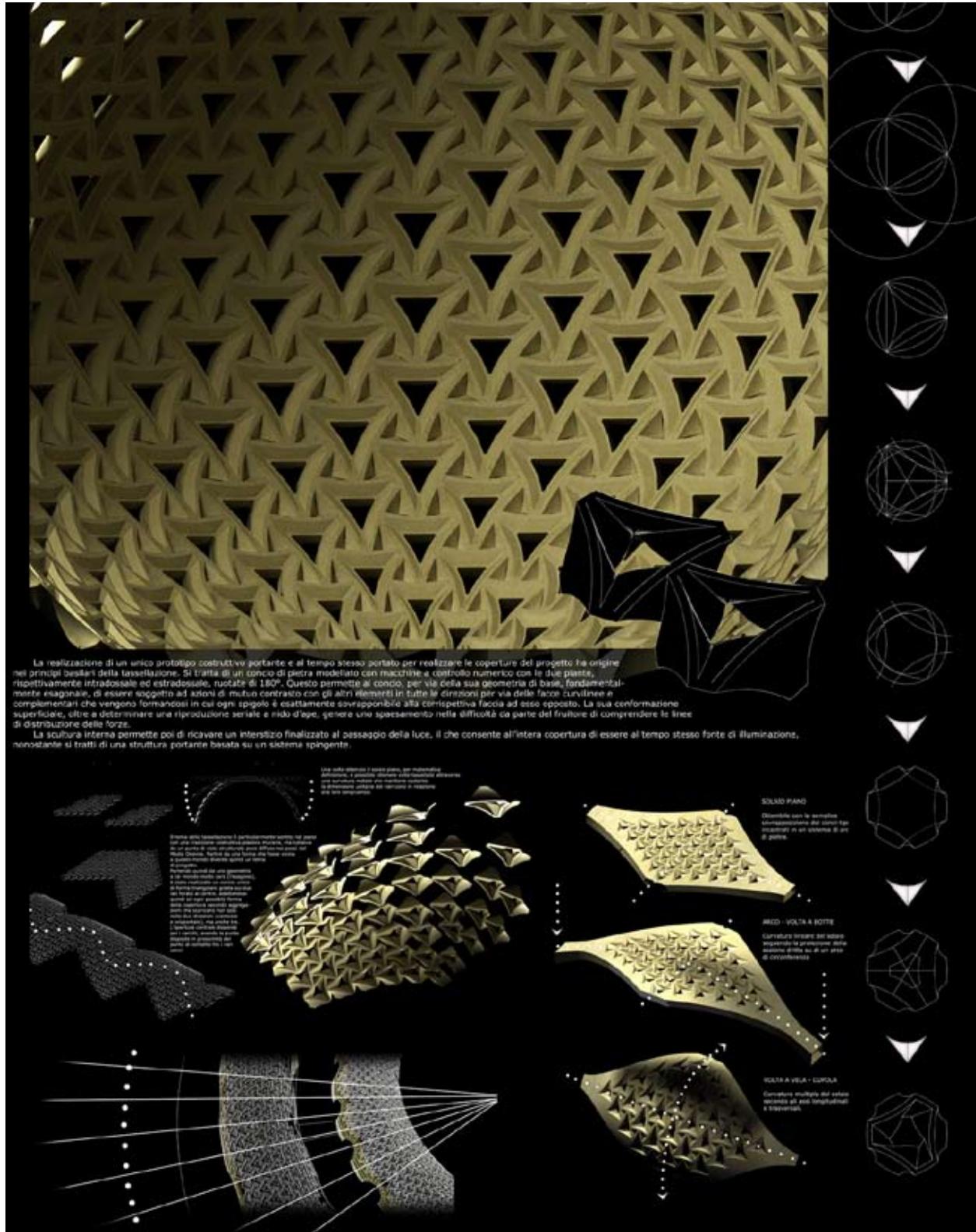
rappresenta un'aspra critica contro l'eccessiva bizzarria della costruzione lapidea di tipo stereotomico a cui fecero seguito altre eminenti voci tra cui quella sarcastica di Antoine-Chrysostome Quatremère de Quincy che dichiara: *l'art du trait est baroque!* L'adozione sempre maggiore di nuove logiche e materiali da costruzione preparerà il mondo ad una nuova logica costruttiva basata sulla leggerezza e sull'elasticità dei materiali. Alla prima vita della stereotomia ne segue una seconda con una nuova evoluzione genetica: la sua rinascita nel XIX secolo è in veste didattica finalizzata alla formazione tanto degli studenti dell'*Ecole des Beaux-Arts* che dell'*Ecole Polytechnique*. La programmazione didattica delle due importanti istituzioni francesi condizionerà fortemente l'impostazione didattica di tutte le scuole europee. La fase di evoluzione della nuova vita delle stereotomie è la fase in cui storicamente ci troviamo e ha origine nella prima metà de XX secolo dopo il vuoto delle due guerre mondiali. Il presente saggio indaga lo stato dell'arte e la possibile evoluzione futura della stereotomia attraverso la ricostruzione di una mappa geografico/culturale dei centri di ricerca degli scritti e delle persone che si occupano e si sono occupate dell'argomento. Negli ultimi anni l'attenzione e le ricerche sulla stereotomia hanno segnato un passo nuovo ed inedito rispetto al passato: si è passati da un interesse di tipo teorico/accademico ad uno di tipo progettuale/applicativo. Si cerca, entrando esattamente nello spirito dei famosi stereotomisti appartenenti alla prima fase di nascita della disciplina, di fare ricerca attraverso la realizzazione di prototipi esemplari da testare e immettere nel mercato delle costruzioni. I laboratori di ricerca





universitari si stanno trasformando in atelier artigianali all'avanguardia in cui, con l'ausilio di strumentazione informatica e macchine utensili robotizzate, si possono costruire al vero porzioni di edifici da sottoporre a veri test di tipo morfologico/costruttivo e strutturale. La ricerca applicata finalizzata alla costruzione di manufatti di stereotomia risulta essere l'unica strada da percorrere al fine di proseguire verso lo sviluppo ed evoluzione della disciplina. La ricaduta di tale approccio risulta essere foriera di ottimi risultati e proficue ricadute economiche. I risultati relativi alla nuova e specifica metodologia didattica, secondo cui gli studenti entrano con entusiasmo nel vivo della disciplina apportando personalmente il proprio contributo alla messa in opera del manufatto, innalzano il livello di comprensione di una disciplina, ritenuta ostica in virtù della propria complessa geometria tridimensionale, ampliando la diffusione della conoscenza. Dal punto di vista economico i laboratori di ricerca possono a tutti gli effetti mettere a punto nuovi sistemi costruttivi collaudati che possono incontrare l'interesse del mercato sempre più esigente dal punto di vista dell'innovazione morfologica e della performance strutturale. Si possono annoverare, nell'alveo di questa nuova fase della stereotomia, alcuni laboratori di ricerca esemplari che lavorano in questo asse: il laboratorio parigino GSA con GAIA Grands Ateliers de l'Isle d'Abeau; Il laboratorio Architektur und Digitale Fabrikation del dipartimento di Architettura dell'ETH di Zurich; Il laboratorio di Cantería medieval presso l'ETSAM di Madrid, Il laboratorio Masonry Research presso il MIT di Boston, e altri ancora. Ritengo utile a questo punto, secondo quelle che sono le mie conoscenze, tracciare una mappa

culturale relativa alla migrazione delle idee e ricerche sulla stereotomia, che a partire dagli anni cinquanta ha condotto la ricerca allo stato attuale. La descrizione diacronica che segue, delle persone e degli eventi, può servire ad inquadrare i luoghi e la specificità dei gruppi di ricerca che da anni lavorano su tematiche affini. Nel 1951, con la discussione della tesi di dottorato su Gaspard Monge e su Girard Desargues, René Taton allievo di Gaston Bachelard, apre la strada al futuro delle ricerche sulla storia delle scienze nella fattispecie sulla geometria descrittiva e le sue origini nella stereotomia che marcheranno profondamente gli studi futuri sulla disciplina in Francia. Il lascito degli studi di Taton sarà ereditato, come si dirà nel seguito, a quaranta anni di distanza da Jöel Sakarovitch che rappresenta attualmente un'esponente di spicco nelle ricerche sulla stereotomia in Francia. Nel 1964 fu creato in Francia, da André Malraux e André Chastel, l'inventario generale dei monumenti e del patrimonio artistico sotto la direzione del giovane ricercatore Jean-Marie Pérouse de Montclos che ebbe modo di visitare e studiare in modo capillare i monumenti storici nazionali mettendo a punto una metodologia per la catalogazione degli edifici e le loro parti che portò nel 1972 alla pubblicazione con le edizioni del Patrimonio di *Architecture. Méthode et vocabulaire*. Al pari del *Dizionario ragionato dell'architettura francese* di Eugène Viollet-le-Duc, Pérouse de Montclos studia analizza e tocca con mano le specificità dell'architettura francese al punto da pubblicare nel 1982 con la casa editrice Picard il noto libro *L'Architecture à la française, du milieu du XVe à la fin du XVIIIe siècle*. In questo libro il valore della stereotomia raggiunge un livello altissimo come componente essenziale dell'identità artistica francese, sembra quasi



95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyegyhaz del 1993



che l'invettiva di Philibert de l'Orme contro Bramante a proposito della superiorità tecnica francese assuma una dimensione totalizzante nelle pagine del libro per specificare, grazie a *l'art du trait géométrique*, la magnificenza dell'arte francese con e contro la prospettiva brunelleschiana. Per Pérouse de Montclos la stereotomia è un affare principalmente francese, nato e codificato in Provenza e Linguadoca, ben assimilato dagli spagnoli e quasi del tutto assente in Italia patria legata alla costruzione in mattoni e rivestimento marmoreo. Come si vedrà, è proprio da questa assunzione paradigmatica relativa alla paternità nazionalistica della stereotomia che si sono sviluppate alcune nuove linee di ricerca che spostano sia cronologicamente che geograficamente le origini della stereotomia intravedendo nell'aria arabo-siriana le prime formulazioni di quella che, a partire dal XVII secolo, verrà chiamata stereotomia.

Aprendo una brevissima parentesi, mi sembra utile ricordare che a cavallo tra gli anni cinquanta e sessanta, in pieno movimento moderno, Fernand Pouillon contro la corrente brutalista del cemento armato realizza una quantità immensa di edifici in pietra portante, in Francia e Algeria, riaprendo e sfruttando le cave provenzali di Fontvieille, Estaillades e Pont-du Gard già utilizzate dai Romani nelle realizzazioni di infrastrutture e anfiteatri. È curioso sottolineare che prima di iniziare la sua carriera di architetto, Pouillon lavora come rigattiere ed antiquario, a contatto quindi con l'antico, certamente a conoscenza dei celebri trattati di stereotomia francese pur non adoperandola nelle proprie costruzioni. Fernand Pouillon costruisce con la pietra, scrive sulla

pietra: è noto il suo libro *Le pierres Sauvages* del 1964 sulla descrizione dell'abbazia medioevale *le Thoronet*, e realizza a metà del XIX secolo quello scambio economico/culturale tra occidente ed oriente, proprio attraverso il trasporto di enormi quantitativi di pietra dal porto di Marsiglia ad Algeri, che in passato fu il vettore della cultura dei paesi affacciati sul *Mare Nostrum*.

Dopo questa parentesi su Pouillon, di cui si parlerà nel seguito in riferimento alla sue influenze, riallacciandoci a quanto si diceva in precedenza si può sostenere che proprio da oriente e attraverso le crociate e gli scambi commerciali giunge in Provenza la cultura costruttiva araba di origine euclidea che integrata con l'evoluzione rinascimentale della scienza prospettica costruisce le basi per la moderna scienza del taglio delle pietre. Il crescente interesse nei confronti del patrimonio edilizio storico, l'evoluzione delle tecniche di restauro e la necessità di interpretare razionalmente e non più empiricamente le strutture in muratura portante conducono nel 1966 Jacques Heyman, matematico e professore di strutture della Cambridge University, a scrivere *The stone skeleton* un'opera assolutamente paradigmatica fra i maggiori testi di ingegneria civile dell'epoca. Seguiranno nel 1967 *On shell solutions for masonry domes*, e nel 1972 *Coulomb's Memoir on Statics: An essay in the history of civil engineering* ripubblicata nel 1997 dall'Imperial College Press di Londra. Gli studi avviati e sviluppati da Jacques Heyman, come si vedrà, sono alla base dell'evoluzione dell'asse di ricerca strutturale che oggi è presente negli studi dell'associazione Edoardo Benvenuto, nel gruppo Masonry Research dell'M.I.T. coordinato da John A. Ochsendorf, e nell'Istituto Juan de Herrera diretto da Santiago Huerta Fernández



dell'ETSAM di Madrid.

Nel 1968, nel "Journal of the society of architectural historians", Werner Müller indagava il rapporto tra la tecnica stereotomica di Guarino Guarini e la sua produzione architettonica con un noto saggio dal titolo *The authenticity of Guarini's Stereotomy in his Architettura Civile*. Müller arriva alla conclusione che, secondo la sua conoscenza, gli unici autori che riescono a sublimare architettonicamente la tecnica costruttiva stereotomica sono Philibert de l'Orme e Guarino Guarini. Riconoscendo la stereotomia come raffinato mezzo tecnico/geometrico oggetto di specifiche e numerose trattazioni disciplinari si sottolinea il fatto che questi saperi non necessariamente conducono ad una buona architettura e solamente pochissimi autori si sono spinti ad indagare la stereotomia come mezzo propulsore finalizzato alla produzione di nuove forme architettoniche. Nei venti anni che intercorrono tra gli anni cinquanta e settanta si delineano i cinque principali assi di ricerca che proseguono ancora oggi con maggior diffusione ed evoluzione tecnologica:

1. R. Taton: nell'alveo della storia delle scienze si indaga sulle origini ed evoluzioni della geometria descrittiva, proiettiva rinvenendo nella stereotomia le loro origini;
2. J.M. Perouse de Montclos: nell'alveo della storia dell'arte e dell'architettura la stereotomia diviene fulcro dell'identità nazionale;
3. F. Pouillon: nell'alveo della progettazione architettonica, la stereotomia, intesa principalmente come semplificazione della costruzione lapidea, diventa una lezione totalizzante per la costruzione a regola d'arte contro il brutalismo modernista;
4. J. Heyman: nell'alveo dell'ingegneria civile e

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993

della matematica applicata al calcolo strutturale la stereotomia viene indagata nella sua valenza geometrico/meccanica.

5. W. Müller: nell'alveo della storia dell'architettura la stereotomia diventa il mezzo tecnico/culturale per la definizione di uno stile personale nella produzione di morfologie archetipiche.

Questi filoni di ricerca, che prima dell'età moderna potevano ritenersi totalmente integrati nelle speculazioni progettuali e costruttive, giungeranno alle soglie del XXI secolo ancora settorializzati e parcellizzati all'interno di chiusi ambiti accademici. L'integrazione dei saperi è il fine verso cui la progettazione architettonica tende, armonizzando gli specialismi che concorrono inevitabilmente ad una focalizzazione puntuale di problematiche che necessitano di interdisciplinarità e apertura culturale.

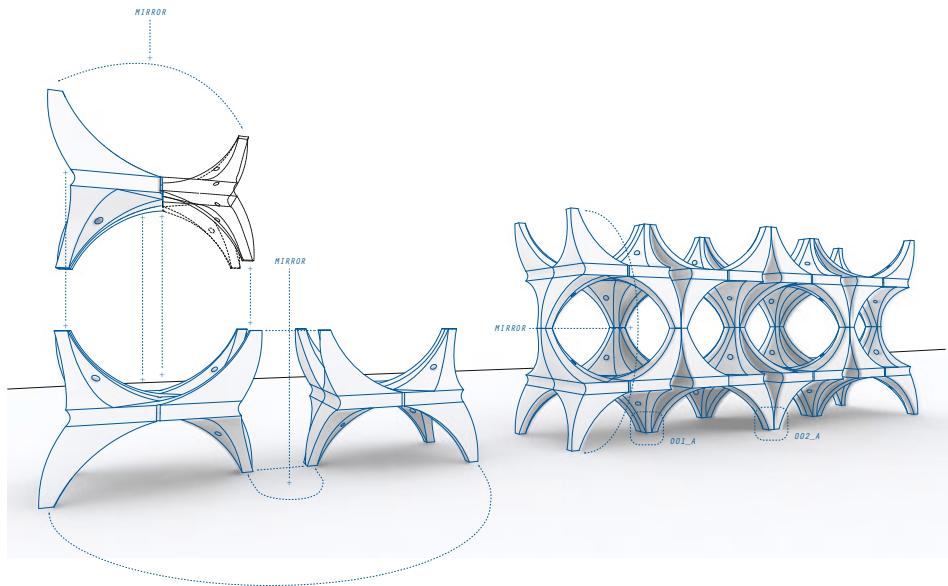
Continuando nel nostro excursus cronologico a partire dagli anni settanta, sotto le linee guida tracciate dai maestri di cui si è detto, si sviluppano, in Europa prima e a seguire negli Stati Uniti, nuove ramificazioni di ricerca dal comune seme della stereotomia. Come si può ben leggere nel portale dell'Associazione Edoardo Benvenuto, di cui si dirà nel seguito, in particolare all'interno della sezione *Bibliotheca Mechanico-Architectonica*¹:

Le ricerche storiche sui rapporti meccanica-architettura sono entrate nella fase della maturità all'inizio degli anni Settanta del secolo scorso. La data sulla quale tutti concordano è il 1972, annus mirabilis

¹ http://www.bma.arch.unige.it/IT/it_presentazione.html Per una completa ricerca bibliografica sull'argomento trattato si consiglia di visitare il portale: http://www.bma.arch.unige.it/IT/it_biblio_stereo_alpha.html

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



nel quale viene pubblicato lo splendido volume di Jacques Heyman dedicato all'*Essai de Coulomb* (1773): *Coulomb's Memoir on Statics. An Essay in the History of Civil Engineering*. Quel libro indicò una rigorosa strategia di ricerca, ben nota agli storici di professione, ma ancora sconosciuta ai cultori di structural mechanics, più avvezzi al calcolo di una trave in calcestruzzo armato che all'interpretazione di un documento che del calcolo chiarisca la genesi e spieghi le ragioni. Da allora Heyman è diventato un Maestro indiscusso di un nuovo approccio alla storia della meccanica strutturale e molti altri ricercatori hanno seguito le sue orme, non dimenticando la lezione di Clifford Truesdell, che nel campo della rational mechanics aveva delineato un analogo percorso di indagine nel saggio encyclopedico *The Rational Mechanics of Flexible or Elastic Bodies: 1638-1788* (1960). Negli anni seguenti gli scritti di Heyman e Truesdell hanno influenzato il lavoro di alcuni studiosi italiani che si sono soffermati, in particolare, sullo studio della grande tradizione italo-francese. Edoardo Benvenuto, Salvatore Di Pasquale e Antonino Giuffrè hanno letto e riletto i "classici", offrendo originali chiavi di lettura e sottolineando il carattere innovativo dell'approccio storico all'arte e alla scienza del costruire. I saggi da loro pubblicati tra il 1981 e il 2002 scandiscono le tappe di una stagione "italiana", che si è dolorosamente conclusa nel 2004 con la scomparsa di Salvatore Di Pasquale, ultimo rappresentante della triade di amici e colleghi (Giuffrè muore nel 1997, Benvenuto nel 1998).

Edoardo Benvenuto, Salvatore Di Pasquale e Antonino Giuffrè hanno rappresentato, nell'alveo delle ricerche sulla scienza delle costruzioni nel suo sviluppo storico, i tre pilastri



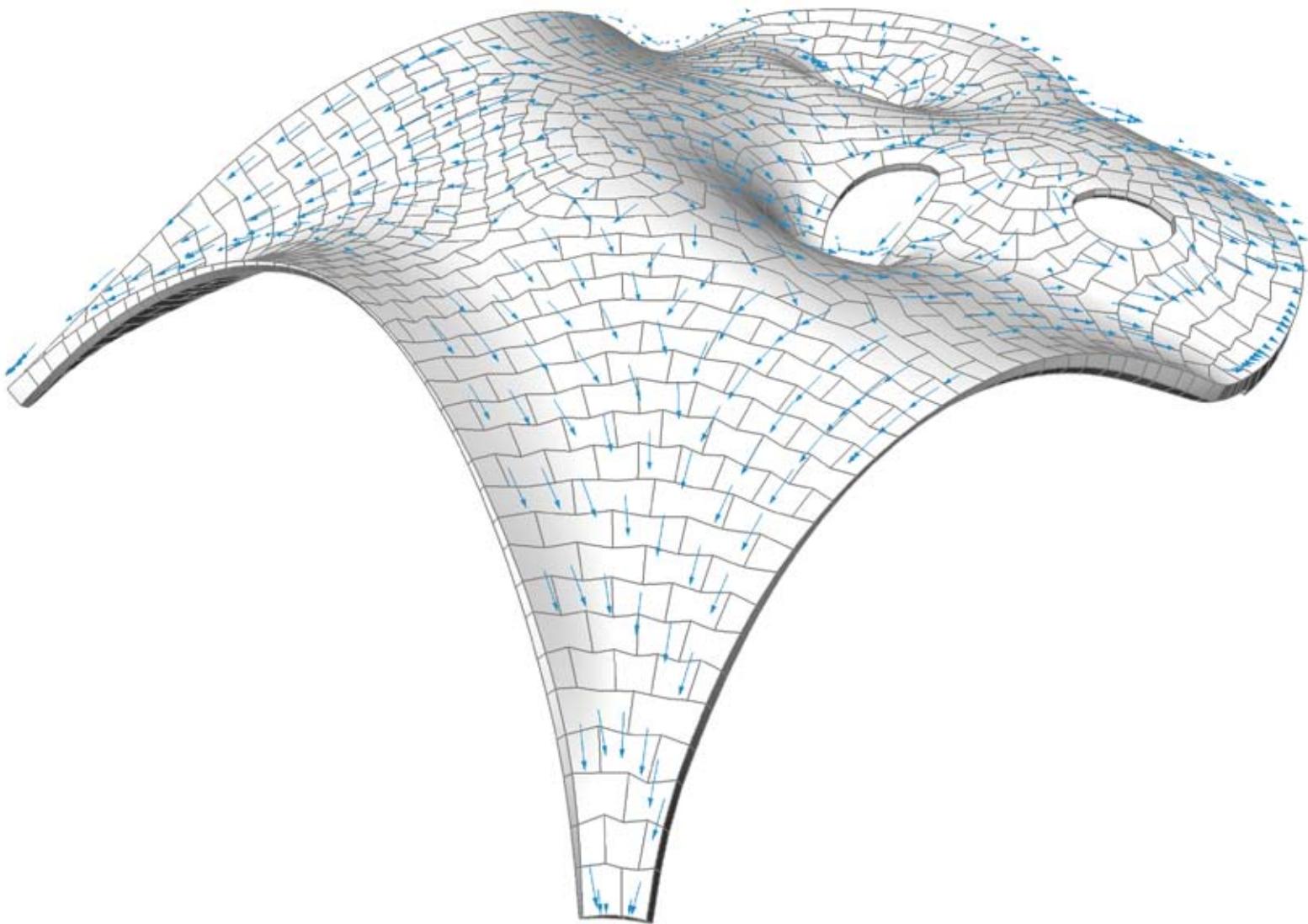
della cultura italiana che nel XX ha marcato grandi successi nel panorama internazionale². L'eredità di Edoardo Benvenuto si formalizza nel 1999 a Genova con la costituzione dell'“Associazione Edoardo Benvenuto per la ricerca sulla Scienza e l'Arte del Costruire nel loro sviluppo storico” allo scopo di onorare la memoria di Edoardo Benvenuto (1940-1998). La Presidenza dell'Associazione è affidata al prof. Giovanni Benvenuto, la Presidenza Onoraria al prof. Jacques Heyman.

Nel 1982 Sergio Luis Sanabria, della Princeton University, pubblica nel “Journal of the Society of Architectural Historians” uno studio dal titolo *The mechanization of design in the 16th century: the structural formulae of Rodrigo Gil de Hontañón*. Risulta evidente, dal titolo del saggio, come la traslazione dei concetti strutturali elaborati all'interno delle scienze delle costruzioni influenzino anche altri ambiti della ricerca: la meccanizzazione del disegno e le formule strutturali. Sette anni dopo, nel 1989, all'interno del volume 30 di “Technology and Culture”, Sanabria pubblica *From Gothic to Renaissance stereotomy: The design methods of Philibert de l'Orme and Alonso de Vandervira* influenzato dagli studi condotti da Jean-Marie Pérouse de Montclos su Philibert de l'Orme. Nel 1983, ancora negli Stati Uniti, Alberto Perez-Gomez pubblica un noto libro dal titolo *Architecture and the Crisis of Modern Science* in cui si sottolinea come, allo stato attuale, la geometria abbia perso il suo mirabile ruolo e sia divenuta uno sterile strumento nelle mani dei tecnici in un periodo in cui paradossalmente

² Si consulti: Enzo Siviero, Ilaria Zampini, *L'ingegneria italiana del Novecento: ricerca in corso presso lo IUAV di Venezia*. <http://www.aising.it/docs/atticonvegno/p1051-1060.pdf>

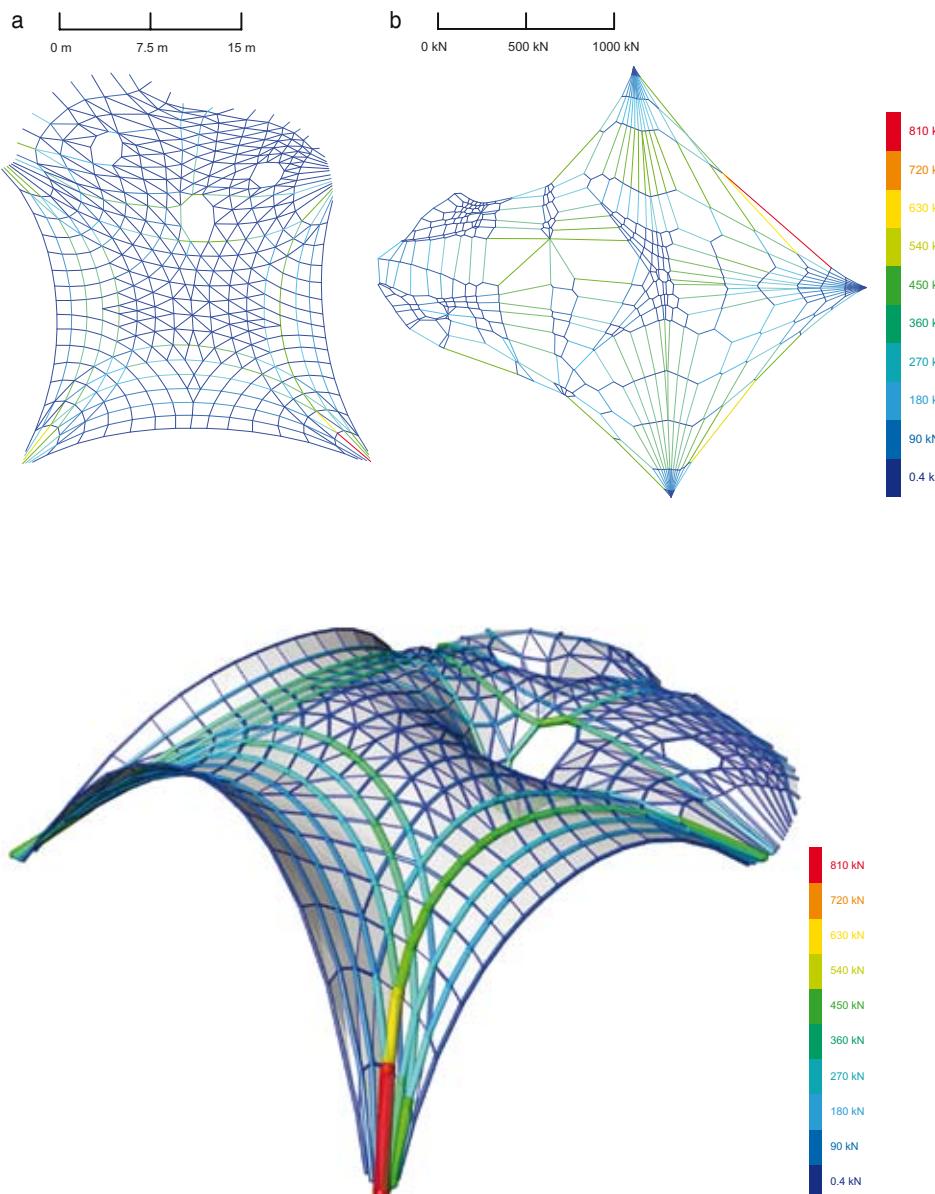
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

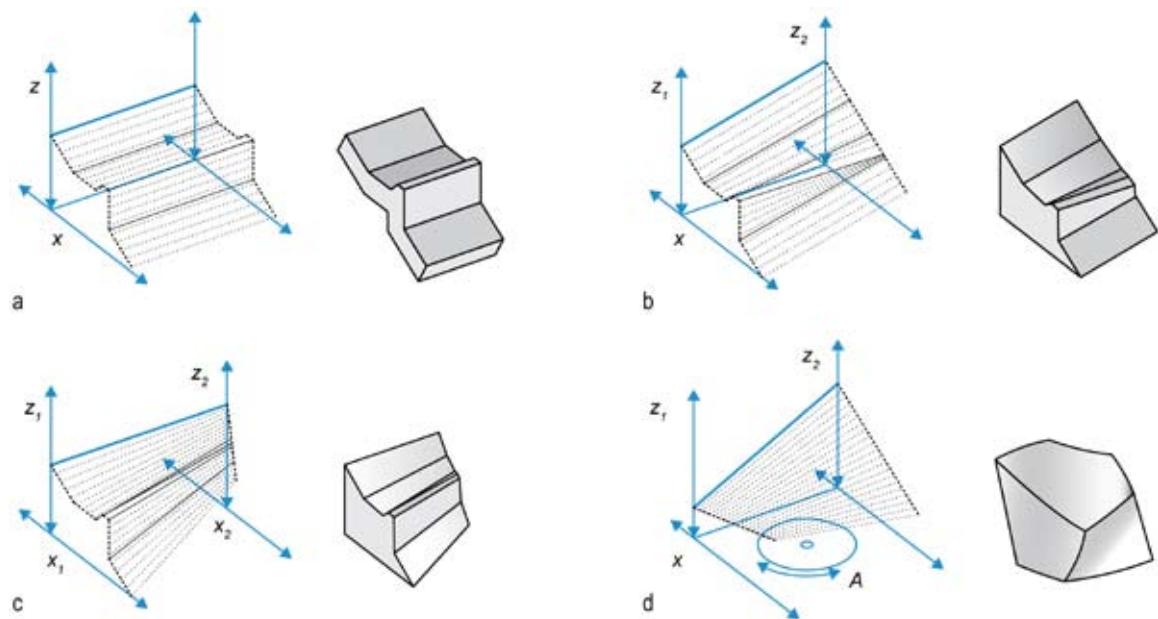
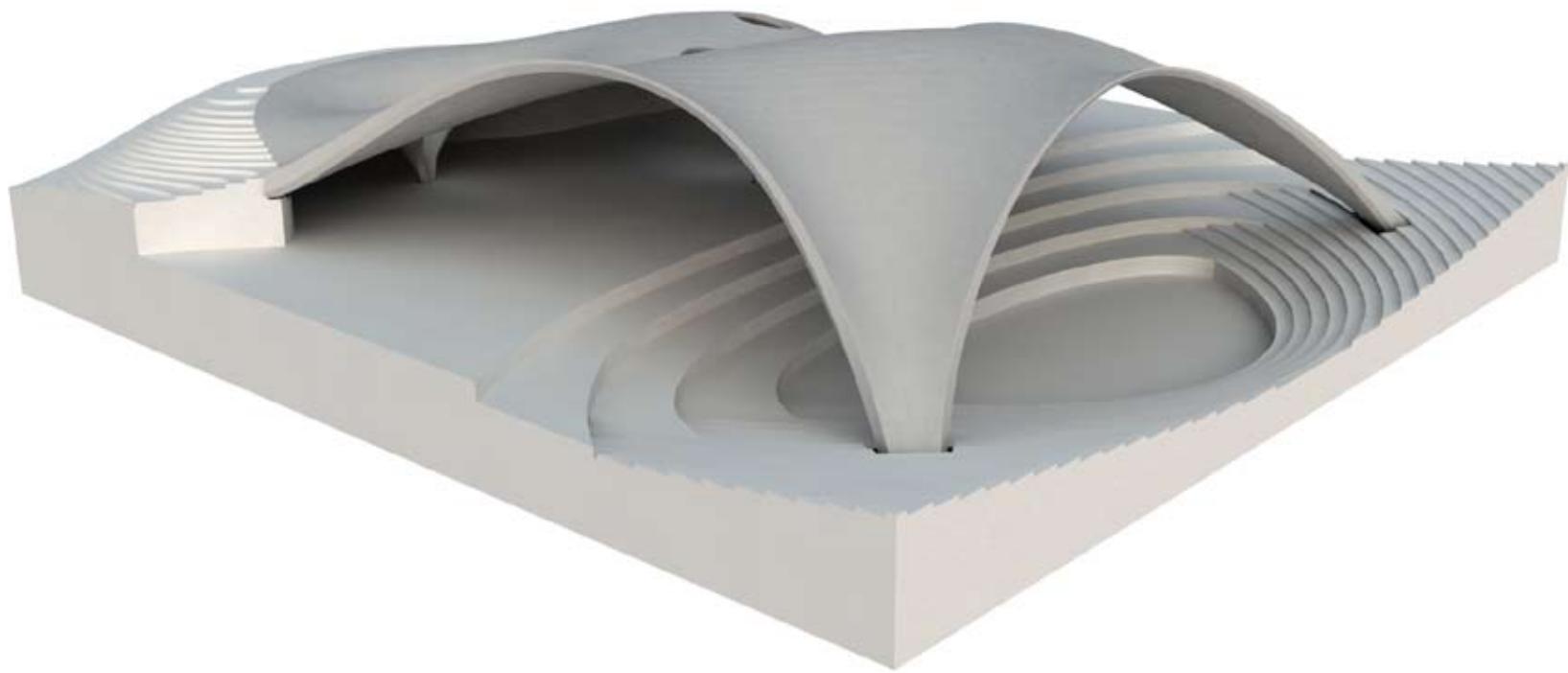


95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993

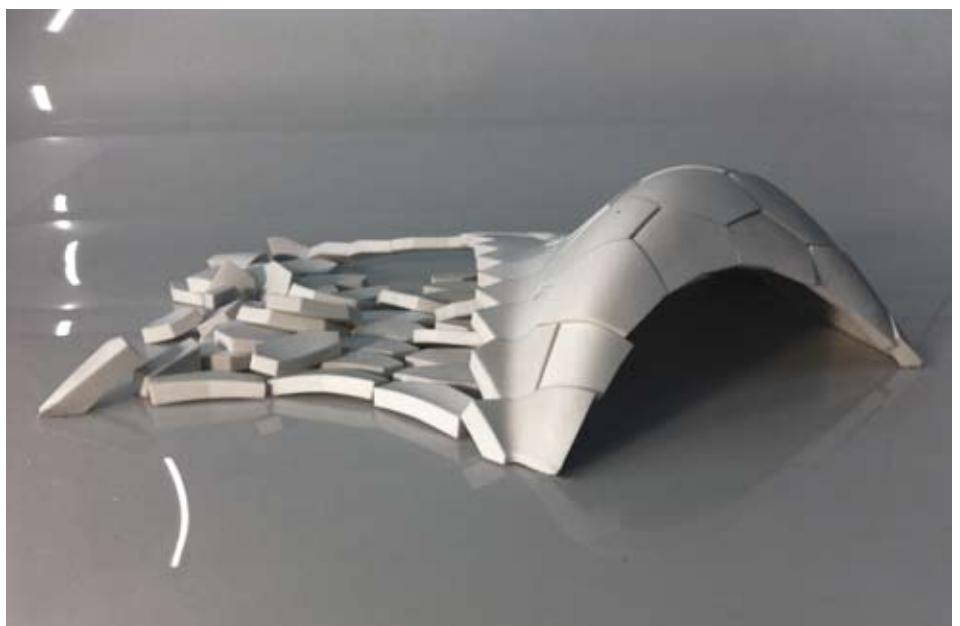
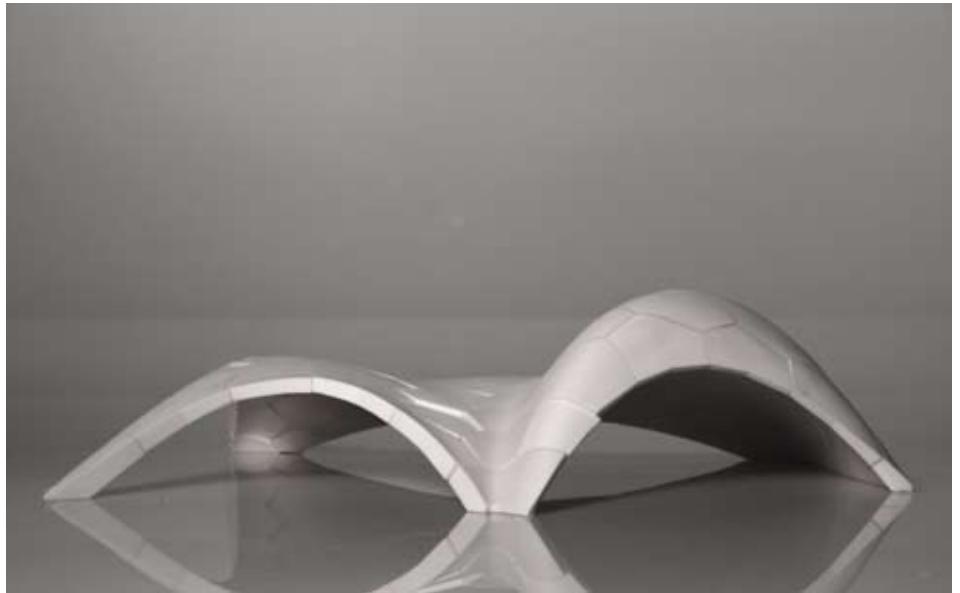


le tecniche di misurazione e costruzione si siano intensificate. Perez-Gomez dimostra che l'architettura odierna è il risultato e una conseguenza della regressione della geometria costruttiva. Sotto la direzione di Alberto Perez-Gomez nel 1983, Marc Schneider discute una tesi di dottorato, presso la Virginia Polytechnic Institute and State University - Blacksburg su Girard Desargues dal titolo *Girard Desargues. The architectural and perspective geometry: a study in the rationalization of figure*. Marc Schneider, docente di Storia dell'Architettura e Restauro presso la Virginia Tech e l'University of Wisconsin Madison, è impegnato attualmente alla stesura definitiva del suo nuovo libro sulla storia della stereometria francese e sulla geometria del taglio delle pietre applicata all'architettura. Ha curato nel dicembre del 2010 una mostra presso l'Architecture Building Kibel Gallery di Washington dal titolo *Stairways in the Air: Paradoxes of Weight and Vision in the Stereotomy of Renaissance and Baroque Architecture*. Nel 1984 Philippe Potié in Francia, da storico dell'architettura, si interroga sui rapporti tra teoria e progetto architettonico nell'opera di Philibert de l'Orme pubblicando, con la casa editrice EPHESS di Parigi, un libro dal titolo *Philibert de l'Orme la théorie du projet architectural à la Renaissance*, a cui seguiranno i saggi dal titolo *Le projet constructif de Philibert de l'Orme*, e nel 1989 *Philibert De l'Orme. Figures de la pensée constructive* come tesi di dottorato discussa a Grenoble che diventerà libro omonimo pubblicato nel 1996 con la casa editrice Parenthèse di Marsiglia. Lo studio di Potié pone l'accento, sulla scia di W. Müller, del rapporto tra tecniche stereometriche, generazione della forma architettonica e ottimizzazione costruttiva della stessa nell'opera di de l'Orme.



95. Utensili da lavoro, disegno di C. Gaul

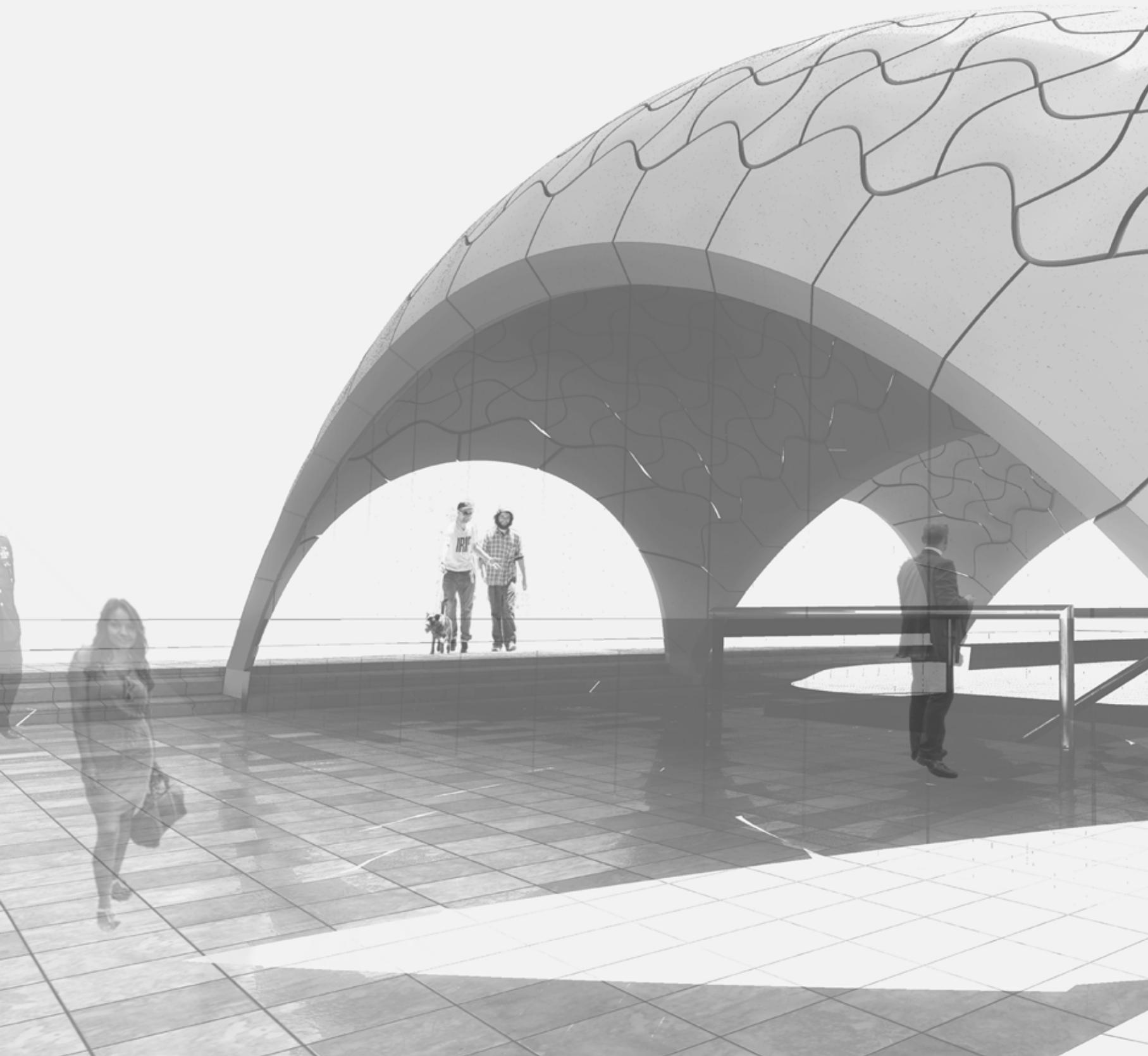
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



Sono famosi i disegni esplicativi tridimensionali dell'apparecchiaitura stereotomica della cupola della cappella di Anet.

Seguono le indagini di J.L Gauthier nel 1985 con la pubblicazione di *Stéréotomie, étude des arcs, voûtes, escaliers*, a Parigi presso l'École Nationale Supérieure des Beaux-Arts in cui l'attenzione è riposta sugli elementi della costruzione come nella prassi dei trattati classici di stereotomia.

Nel 1986 Antonio Bonet Correa apre, in Spagna, il filone di studi sui trattatisti rinascimentali nazionali sul modello di J.M. Perouse de Montclos, con le ricerche sul trattato di Ginés Martínez de Aranda, architetto barocco Andaluso e nel 1989 su *Los tratados de cortes de piedra españoles en los siglos XVI, XVII y XVIII*. Tredici anni dopo, nel 1999 José Calvo-López discute presso l'ETSAM di Madrid la propria tesi di dottorato sull'analisi puntuale dei disegni e tracciati geometrici del trattato di Ginés Martínez de Aranda sotto la direzione di Enrique Rabasa Díaz. Nel 1986 Palacios Gonzalo José Carlos legge la famosa fabbrica spagnola dell'Escorial *sub speciae stereotomica* analizzando le apparecchiature granitiche del monumento. Quattro anni più tardi, nel 1990, Palacios dà alle stampe l'esito della sua tesi di dottorato con il noto *Trazas y cortes de cantería en el Renacimiento Español* edito a Madrid dall'*Instituto para la Conservación y Restauración de Bienes Culturales*. Il volume è noto per i magnifici disegni autografi dell'autore e le felici e brillanti intuizioni sul *modus operandi vandelviresco*. Palacios dopo anni di insegnamento presso la Facoltà d'architettura di Louvain ritorna ad insegnare all'ETSAM di Madrid con una cattedra teorico/pratica sulla costruzione delle volte gotiche spagnole e nel 2009 pubblica il volume *La cantería medieval*:

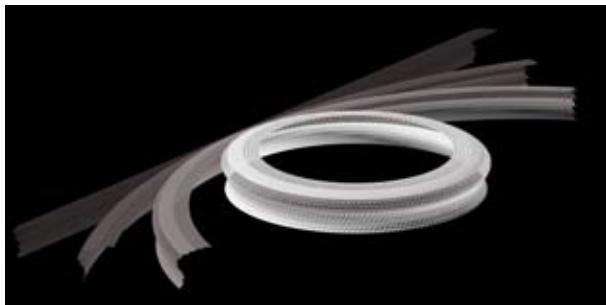




la construcción de la bóveda gótica española.
Nei laboratori applicativi Palacios insegna concretamente la costruzione di tipiche volte gotiche in scala ridotta con conci ricavati da blocchi di gesso scagliola.

Nel 1988 Robin Evans, storico inglese di grandi capacità critiche, pubblica, nella rivista di cultura Eidos, uno studio importante su *La trompe d'Anet* famosa volta conica a sostegno del *cabinet du roy* al castello di Anet costruito nel XVI secolo da Philibert de l'Orme. Evans sottolinea in maniera evidente, con grafici puntuali, come un tracciato geometrico bidimensionale possa, in virtù delle intrinseche regole proiettive, incidere profondamente e completamente sulla definizione tridimensionale dell'opera stereotomica. Quindi si sottolinea come la stereotomia, attraverso il *trait géométrique*, da mero espediente tecnico possa assumere un valore concettuale più alto nelle mani dell'architetto che ne sfrutta i potenziali morfologico/espressivi. La stereotomia diviene una "impalcatura" geometrica nascosta che determina il carattere espressivo dell'opera architettonica. La morte prematura di Robin Evans non gli consente di vedere la stampa del suo ultimo eccellente lavoro pubblicato postumo nel 1995 dall'MIT Press dal titolo *The Projective Cast: Architecture and Its Three Geometries*, opera fondamentale negli studi tra geometria e architettura. Tra i recensori del libro si annoverano Andrew Ballantyne, Philip Tabor e Robert Tavernor.

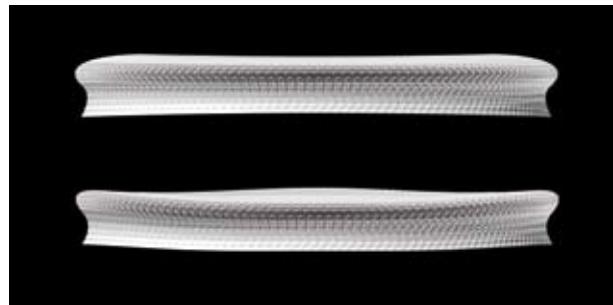
Nel 1989 Jöel Sakarovitch, docente di Storia della Scienza all'Università René Descartes (Paris V), discute una tesi di laurea in architettura dal titolo *Théorisation d'une pratique, pratique*



d'une théorie. Des traités de coupe des pierres à la géométrie descriptive, presso l'École d'Architecture de Paris-La Villette. Sull'eredità degli studi avviati da R. Taton, Sakarovitch approfondisce e sviluppa le relazioni tra la matematica, la stereotomia e l'architettura pubblicando numerosi saggi sull'argomento (ricordiamo nel 1994 con le edizioni Blanchard il libro scritto con J. Dhombres, dal titolo *Desargues en son temps*) sino alla redazione dell'opera più importante pubblicata nel 1998 con le edizioni Birkhäuser di Basel dal titolo *Épures d'architecture. De la coupe des pierres à la géométrie descriptive XVIe-XIXe siècles*. Jöel Sakarovitch è co-direttore del Laboratorio di Ricerca GSA (Geometria Struttura Architettura) presso École Nationale Supérieure d'Architecture Paris Malaquais in cui con l'apporto di giovani ricercatori e dottorandi, tra cui il giovane compagno tailleur de pierres Luc Tamborero, si portano avanti ricerche teorico/pratiche sulla stereotomia sviluppate presso i Grands Ateliers de l'Isle d'Abeau.

Sino agli anni novanta le ricerche sulla stereotomia si accrescono e diffondono principalmente negli istituti universitari diventando principalmente argomenti di ricerca di appannaggio degli storici della scienza, dell'architettura e nella fattispecie della geometria descrittiva e proiettiva e della meccanica dei corpi rigidi.

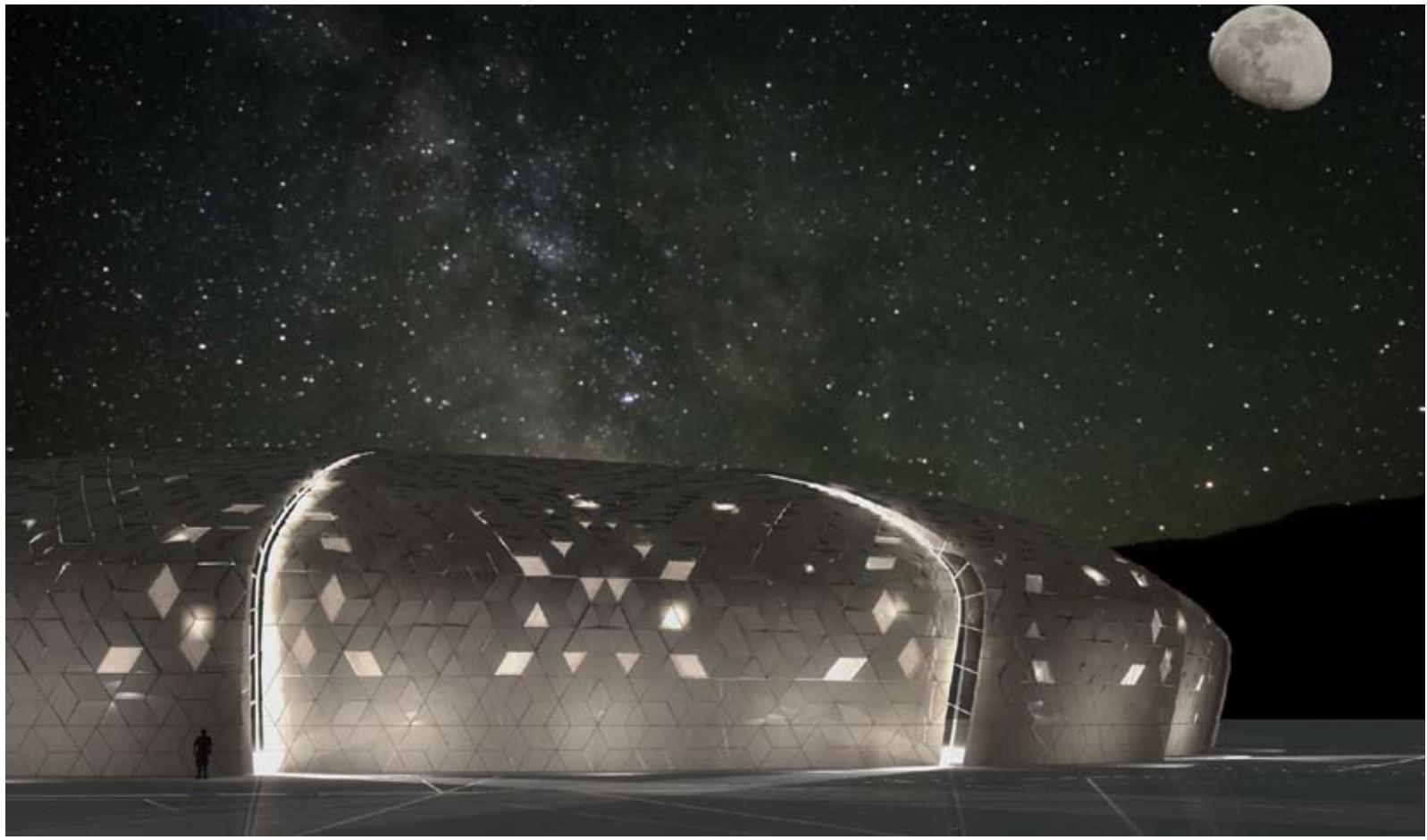
Nel 1992 Mark Cameron Burry, direttore dello Spatial information architecture laboratori presso RMIT di Melbourne originario della Nuova Zelanda, fonda il Construction Committee of Sagrada Família con lo scopo di proseguire nella costruzione della famosa fabbrica di Gaudí attraverso le ricerche dell'esatta forma geometrica del progetto originario del monumento usando programmi



parametrici di modellazione tridimensionale. Il grande interesse della ricerca è quello relativo alla sua componente applicativa nei confronti del cantiere della Sagrada Família. Nel 1993 Burry pubblica la monografia dal titolo Templo Expiatorio de la Sagrada Familia a cui faranno seguito molte altre pubblicazioni sull'argomento ricoprendo per più di vent'anni la carica di consulente scientifico del monumento. Burry sottolinea il necessario apporto di un appropriato modo d'impiego di strumentazioni digitali all'avanguardia nei confronti della fabbricazione di monumenti artistico/architettonici di grandissimo pregio. Sottolinea inoltre la enorme potenzialità dei sistemi CAD/CAM applicati al taglio delle pietre nei casi di costruzioni lapidee dalla geometria complessa e dalle dimensioni fuori dagli standard produttivi. Con Burry si apre una nuova strada alle ricerche sulla stereotomia che sembra riconciliare naturalmente la vera vocazione degli stereotomisti della storia passata per cui, all'evoluzione delle tecniche stereometriche, ha sempre corrisposto l'evoluzione dello stile e del carattere dell'architettura. Questa virata della ricerca sarà accolta *in primis* negli Stati Uniti per poi rientrare in Europa dopo qualche anno grazie all'arrivo di software di modellazione più sviluppati e capaci di gestire le complesse geometrie della stereotomia. C'è da sottolineare che se lo sviluppo dei programmi CAD più evoluti è principalmente americano, l'Italia risulta essere certamente all'avanguardia sul comparto macchine utensili a controllo numerico. I laboratori universitari e di grandi aziende si muniranno quindi di programmi di modellazione anglo-americani e macchine utensili italiane o quantomeno a componentistica europea italo-tedesca.

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



A partire dal 1994 Preston Scott Cohen, docente presso Harvard Graduate School of Design (GSD), avvia una serie di ricerche sperimentali riguardanti il rapporto tra morfologia architettonica e stereotomia interrogandosi sulla possibilità delle sue tecniche proiettive di influenzare notevolmente la ricerca sulla forma dell'architettura contemporanea. Preston Scott Cohen, nell'ambito della sua produzione artistica, crea un ponte tra l'utilizzo delle più potenti tecnologie di modellazione digitale e la geometria descrittiva del XVII secolo. Utilizzando i processi di distorsione di forme comuni, per mezzo di proiezioni oblique ed altre tecniche proiettive, arriva alla definizione di una ratio procedurale finalizzata alla creazione di complesse forme geometriche dal sapore "plasticamente decostruito". Contested Symmetries and Other Predicaments in Architecture, testo edito nel 2001 dalla Princeton Architectural Press, rappresenta il precipitato teorico della sua produzione intellettuale. In esso si teorizza la nozione di Permutazione Stereotomica, elaborata dal 1993 al 1998.

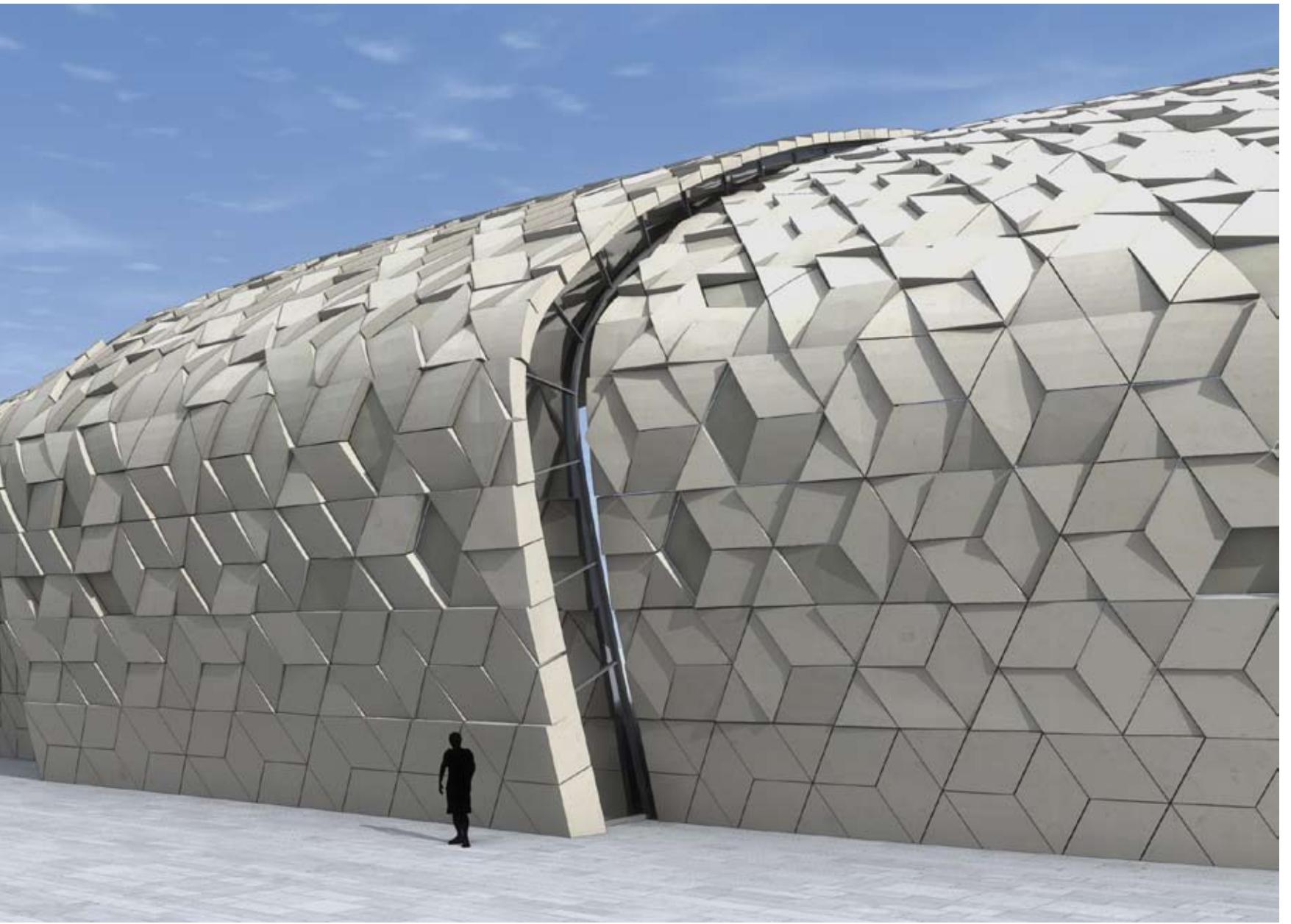
Altra figura di spicco nelle ricerche sulla geometria proiettiva e le sue evoluzioni nella modellazione digitale di tipo topologica applicata alla fabbricazione con macchine utensili a controllo numerico è Bernard Cache che nel 1995 pubblica con la MIT Press un libro dal titolo "Earth Moves" ripubblicato nel 1998 con la francese Editions HYX con il titolo "Terre meuble".

L'idea alla base del lavoro è quella di poter manipolare *infograficamente* la materia e successivamente realizzare il prodotto della modellazione con l'utilizzo di macchine utensili nello stesso rapporto evolutivo che

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





storicamente ha legato la tecnica stereotomica alla definizione di uno stile architettonico. Cache ha fondato la Objectile company nel 1996, insieme a Patrick Beaucé e Jean-Louis Jammot, in collaborazione con la software house francese MISSLER. Dal settembre 1998, Bernard Cache è professore associato nella Faculty of Architecture, Landscape and Design (AL&D) dell'Università di Toronto. Attualmente riveste la carica di Direttore della Sezione Cibernetica dell'ESARQ (Barcellona) Escuela de Arquitectura - Universidad Internacional de Catalunya. L'attività di speculazione teorico-artistica di Bernard Cache, concretata nel progetto *Objectile*, è una mescolanza di saperi ingegneristici, matematici, tecnologici e non ultimi filosofici, finalizzata al lavoro del disegno industriale e la produzione di forme curve e variabili di ogni proporzione. La produzione copre principalmente ambiti che dalla scultura sconfinano alla componentistica edilizia architettonica. *Objectile* ha messo a punto un originale modo di produzione, usando *objectile software* sulla base dell'implementazione del già esistente software della Missler Topcad-Topsolid. Quest'ultimo rappresenta la soluzione Cad/Cam finalizzato all'elaborazione degli algoritmi delle complesse geometrie progettate e la produzione attraverso macchine a controllo numerico. Lo slogan che sintetizza la logica progettuale del programma *Objectile* è la seguente: "le forme non sono disegnate ma calcolate. Perché il calcolo permette di concepire le superfici a curvatura complessa ove le inflessioni non sono gestibili attraverso la modellazione informatica tradizionale. Ogni forma può dar luogo a variazioni illimitate che si presentano sotto la forma di video-

interattività". Gli esiti produttivo-formali di *Objectile* ricoprono la scala dell'oggettistica, in cui la progettazione investiga ed esalta le infinite possibilità formali della geometria euclidea per mezzo dei sistemi CAD/CAM. Tale produzione incarna, per certi aspetti, il principio del rivestimento e il mito dell'origine tessile della parete teorizzati da Gottfried Semper rappresentando l'orizzonte ideale, più o meno esplicito, delle complesse operazioni digitali che virtualizzano intrecci e qualità tattili delle superfici. Bernard Cache è autore di numerosi saggi scientifici sul rapporto tra geometria modellazione e costruzione assistita digitale in cui è possibile intravedere nella stereotomia l'antecedente storico di tali ricerche. In Italia nel 1997 Camillo Trevisan, professore del dipartimento di disegno dello IUAV di Venezia, sotto la direzione di Massimo Scolari, elabora la prima interessante ricerca di interrelazione tra stereotomia e modellazione CAD di tipo parametrico con uno studio specifico sulla *trompe d'Anet* di P. de l'Orme mettendo a punto il programma *Trompe*. Programma CAD per la generazione dei modelli tridimensionali e dei "cartoni di sviluppo" di generiche *trompe coniche*, a partire dal trait³. Il lavoro è parte integrante della pubblicazione dal titolo *Per la storia della stereotomia. Geometria, metodi e costruzione*. Parallelamente all'avvio delle prime ricerche che indagano le complessità della geometria stereotomica per mezzo di modellatori infografici tridimensionali si assiste al progressivo incremento di studi storico-tematici sull'argomento. Filippo Camerota nel 1994 discute la tesi di dottorato presso lo

³ in www.iuav.it/dpa/ricerche/trevisan/trompe.htm, 1997

95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993









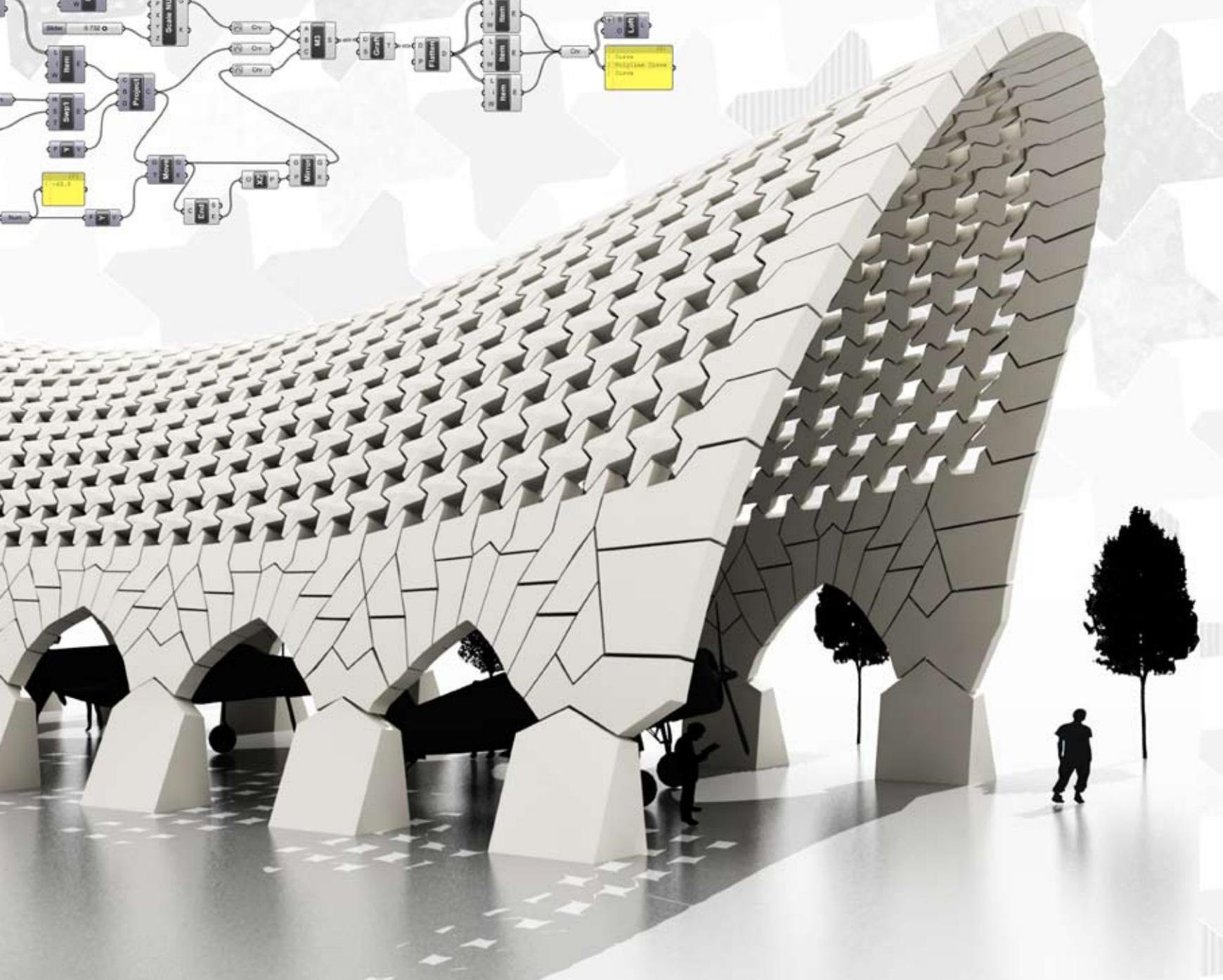
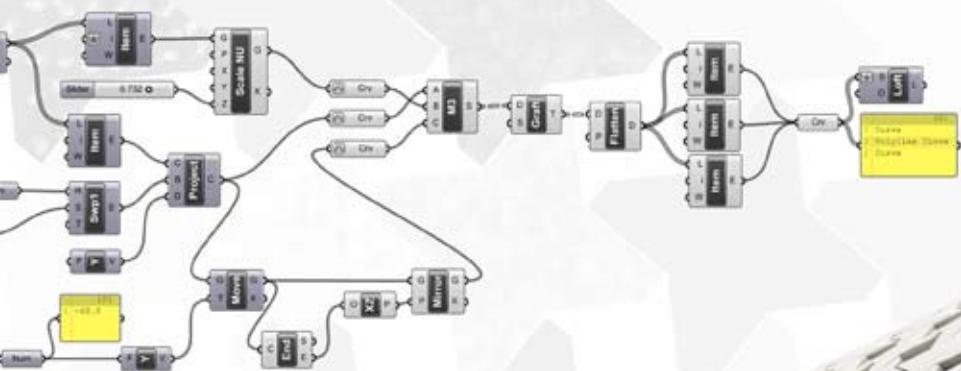
IUAV dal titolo *Prospettiva aedificandi. Ottica, stereotomia e architettura obliqua* sottolineando, secondo il preceitto di Desargues, lo stretto rapporto teorico tra discipline che possono apparentemente essere considerate differenti: la geometria proiettiva (la prospettiva), la stereotomia e l'ottica.

L'attenzione posta sullo studio della geometria proiettiva si focalizza nel 1994 grazie alla pubblicazione del libro su Girard Desargues dal titolo *Desargues en son temps* (Blanchard, Paris) a cura di Dhombres e Sakarovitch in cui è presente un saggio di Mario Docci, Riccardo Migliari e Carlo Bianchini dal titolo *Les "vies parallèles" de Girard Desargues et de Guarino Guarini, fondateurs de la science moderne de la représentation*. I docenti del dipartimento di Disegno della Facoltà di Architettura di Roma la Sapienza indagano le relazioni tra i due maestri per determinare le origini della tecnica della doppia proiezione ortogonale al fine di realizzare elementi stereotomici per l'architettura. Sempre a partire dal 1994 Enrique Rabasa Díaz, docente dell'ETSAM di Madrid, pubblica nella Revista de Expresión Gráfica Arquitectónica un saggio dal titolo *Los arcos oblicuos en la traza de cantería*, a cui faranno seguito altri saggi sull'argomento sino alla pubblicazione nel 2000 del noto testo dal titolo *Forma y construcción en piedra. De la cantería medieval a la estereotomía del siglo XIX*, edito dalla Akal di Madrid.

La stereotomia, nella maggior parte degli studi citati, è intesa come tecnica costruttiva legata principalmente alla pietra, pur non avendo nel suo etimo il riferimento esplicito allo specifico materiale. È utile ricordare che dall'analisi delle prefazioni ai trattati, soprattutto ottocenteschi, che ricostruiscono le trame dello sviluppo storico della disciplina, riscontriamo a chiare

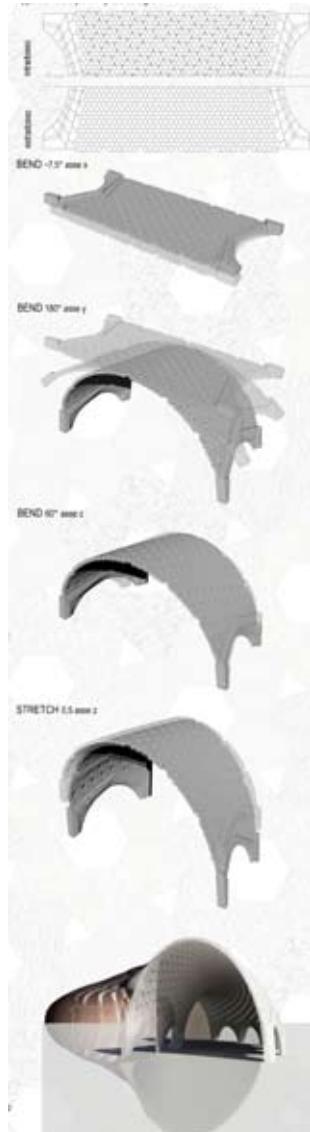
95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



lettere la derivazione della scienza stereotomica dalle tecniche costruttive dell'arte del carpentiere.

Tale impostazione teorica è ben esplicitata nel titolo del poderoso trattato di Amedée François Frézier, *La theorie et la pratique de la coupe des pierre et du bois*, in cui è possibile leggere che la stereotomia, o arte della *coupes des pierres*, non è che una applicazione dell'*art du trait géométrique* dei carpentieri, modificata per la specifica natura della pietra. Leroy nel 1844 riporta nel suo trattato che, con ogni probabilità, i carpentieri, a cui l'uso frequente del filo a piombo restituisc l'idea esatta di linee proiettanti, abbiano per primi utilizzato il metodo delle proiezioni per determinare la forma esatta degli assemblaggi dei nodi lignei o dei letti di contatto di conci di pietra. Ancora Chaix, nel suo trattato del 1890 sostiene che, prima che Gaspard Monge creasse la Geometria Descrittiva, i carpentieri e gli apparecchiatori usavano il metodo proiettivo. *L'art du trait géométrique* è sinonimo, nei trattati storici della disciplina, di tecnica proiettiva finalizzata alla costruzione edilizia sia in pietra che in legno.

Nel 1995 Kenneth Frampton, nell'importante lavoro del 1995 edito dalla MIT Press, dal titolo *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, usa di contro la contrapposizione dialettica tra stereotomia, intesa come costruzione pesante in compressione, e carpenteria, intesa come costruzione leggera e in tensione, come categoria critica per poter analizzare l'architettura. Frampton nei suoi studi sui rapporti tra costruzione e architettura, eredita l'impostazione teorica di Gottfried Semper che in *Die vier Elemente der Baukunst*, rifiutando indirettamente l'interpretazione della

capanna primitiva secondo il valore teorico assegnato dall'abate Laugier nel suo *Essai sur l'Architecture*, individua i quattro termini fondativi dell'abitazione e quindi, per traslato, dell'architettura. L'abitazione primordiale per Semper era costituita da: basamento, focolare, intelaiatura—tetto e membrana di chiusura. Secondo questa suddivisione tassonomica (dagli influssi metodologici propri delle scienze naturali), vagliata dagli studi sull'edilizia vernacolare diffusa in tutto il mondo, Semper suddivide l'arte del costruire in due "evoluzioni" fondamentali: la tettonica dell'intelaiatura e la stereotomia del basamento.

All'interno di tale ipotesi, basata sul valore della tecnica costruttiva quale categoria critica dell'architettura, i due termini sono esemplificati in: opere di terra—costruzioni pesanti (stereotomia, dal greco "taglio dei solidi") e opere di copertura—costruzioni leggere (tettonica, tekton che in greco antico significa "carpentiere"). *Earthwork* e *roofwork* sono per Frampton, quindi, i due termini paradigmatici, due modi di costruire dialetticamente opposti, attraverso i quali è possibile leggere, interpretare e indirizzare il progetto d'architettura. Con l'opera di Frampton la stereotomia fuoriesce dagli specialismi disciplinari e diventa categoria critica nelle mani dell'architetto nella duplice istanza dell'analisi storica e della progettazione architettonica. Tale semplificazione assiomatica consente la diffusione internazionale dei due termini: stereotomia e tettonica. Parallelamente a questa apertura terminologica si assiste alla proliferazione di studi specifici: 1996, Antonio Becchi, *Stereotomia e interpretazione meccanica delle costruzioni in muratura*, in Gambarotta L. (a cura di), *La meccanica delle*

murature tra teoria e progetto, Pitagora, Bologna 1996, pp. 17-24; 1998, Giovanni Mochi, *Il rapporto tra conoscenza scientifica ed esperienza pratica: l'evoluzione della stereotomia tra XVIII e XIX secolo*, tesi di dottorato, Università di Ancona; 1999, Andrea Giordano, *Cupole, volte e altre superfici. La genesi e la forma*, Utet, Torino; 2000 Riccardo Migliari (a cura di), *Il disegno e la pietra*, Gangemi, Roma per i Quaderni del dottorato di ricerca in cui tra vari saggi si segnala il lavoro di Bianchini C., *Strumenti logici ed operativi per lo studio dei sistemi voltati in pietra: la codifica ottocentesca di Jean-Baptiste Rondelet*; 2002, Antonio Becchi e Federico Foce, *Degli archi e delle volte: Arte del costruire tra meccanica e stereotomia*, Marsilio Editori, Venezia.

Dal 2002 John A. Ochsendorf, docente del Masonry Research Group dell'M.I.T., in continuità evolutiva con gli studi avviati da J. Heyman, conduce numerose ricerche sul comportamento meccanico delle strutture storiche focalizzando l'attenzione sul calcolo a rottura delle strutture in muratura portante. Ochsendorf ha recentemente fondato la ODB Structural Engineering Consultants formata da Ochsendorf, De Jong e Block, società di ingegneria per il calcolo e la progettazione di nuove strutture voltate in muratura portante finalizzata alla rinascita dell'architettura ispirata a Guastavano. L'evoluzione infografica dei metodi e modelli di calcolo ha condotto, nel 2006, il gruppo P. Block, T. Ciblac & J. Ochsendorf alla messa a punto di un software di calcolo sul "Real-time limit analysis of vaulted masonry buildings". Le ricerche del gruppo americano si focalizzano, oggi, anche sui metodi di calcolo e costruzione di strutture voltate di qualsiasi forma apparecchiate con conci lapidei di geometria variabile.

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993

Il rilancio della costruzione in pietra, seppur nella sua dimensione volutamente arcaica e megalitica, sul duplice piano teorico e professionale è riferibile al lavoro di Gilles Perroudin che nel 1998 fonda lo studio Perraudin Architectes con Elisabeth Polzella, e inizia una approfondita ricerca sulle strutture in pietra massiva utilizzando grandi blocchi di Pierre du Pont du Gard in una rigorosa disciplina costruttiva che caratterizza numerosi suoi edifici nel sud della Francia. Tra questi le cantine vinicole di Vauvert, Nizas e Solan, e il Centro Professionale "Marguerites" a Nîmes. Nel 2002 Perroudin fonda l'associazione Académie de la Pierre, di cui è presidente, allo scopo di divulgare le tecniche costruttive e la filosofia progettuale legata alla sua architettura lapidea strettamente ispirata all'opera del grande Fernand Pouillon.

A partire dal 2003, all'interno del First International Congress on Construction History (Madrid 2003), è possibile datare le prime pubblicazioni sul rapporto tra stereotomia e aggiornamento tecnico-morfologico del Dipartimento ICAR della Facoltà di Architettura del Politecnico di Bari sotto la direzione di Claudio D'Amato Guerrieri che già dagli anni novanta, dopo aver fondato la Facoltà barese ne stabilisce l'asse strategico e di ricerca sull'architettura lapidea con il suo conseguente riflesso pedagogico. Nell'alveo di queste ricerche si inseriscono tutte le pubblicazioni dello scrivente a partire dalla tesi di dottorato, discussa a Bari nel 2004, dal titolo *Il paradigma stereotomico nell'arte del costruire. Dalla natura sincretica della modellazione digitale, alla progettazione/costruzione di elementi architettonici in pietra da taglio*. Il nuovo possibile asse di



ricerca, su cui da anni chi scrive dispiega il suo impegno didattico e di ricerca progettuale, riguarda una nuova strada sperimentale sull'aggiornamento e rinnovamento della stereotomia come disciplina fondante di un nuovo paradigma progettuale. Gli scritti: 2003, G. Fallacara, *The formal unity of aerial vault's texture: the "trompes". The role of traditional "trait géométrique" for trompes design in the perspective of the employ of modern CAD/CAM project/execution processes*, in First International Congress on Construction History, Madrid; 2004, C. D'Amato e G. Fallacara *Procedimenti progettuali, stereotomia, e tecniche cad/cam: dal taglio "per sottrazione" al taglio "per addizione"*, in Il Giornale dell'Architettura. Nel settembre del 2005, all'interno del settore culturale del Marmomacc - Veronafiere a Verona, viene presentata la prima mostra italiana sulla stereotomia, a cura di C. D'Amato e G. Fallacara, dal titolo *L'arte della stereotomia. I compagnons du Devoir e le meraviglie della costruzione in pietra* con la pubblicazione omonima edita Librairie du Compagnonage a Parigi. All'interno della mostra viene presentato il prototipo di una scala elicoidale autoportante in pietra da taglio precompressa (illustrata nel capitolo relativo ai prototipi) i cui calcoli strutturali vengono elaborati da Marc Vinches che a partire dalla tesi di dottorato del 1988 presso l'Ecole de Mines de Paris ha elaborato modelli di calcolo ad elementi discreti più consoni al comportamento meccanico di una struttura stereotomica.

Nel 2006 viene pubblicata, a nome dello scrivente, la prima ricerca sul rapporto tra stereotomia e topologia con un saggio presentato al Second International Congress on Construction History, Cambridge UK dal titolo *Digital stereotomy and topological transformations:*

reasoning about shape building. L'ipotesi teorica, sulla deformazione topologica del celebre brevetto del 1699 di Joseph Abeille sulla volta piana, contenuta nel saggio, diviene manifesto e opera costruita alla 10° Mostra Internazionale di Architettura La biennale di Venezia sotto forma di portale di ingresso in pietra leccese alla mostra dal titolo Città di Pietra curata da Claudio D'Amato.

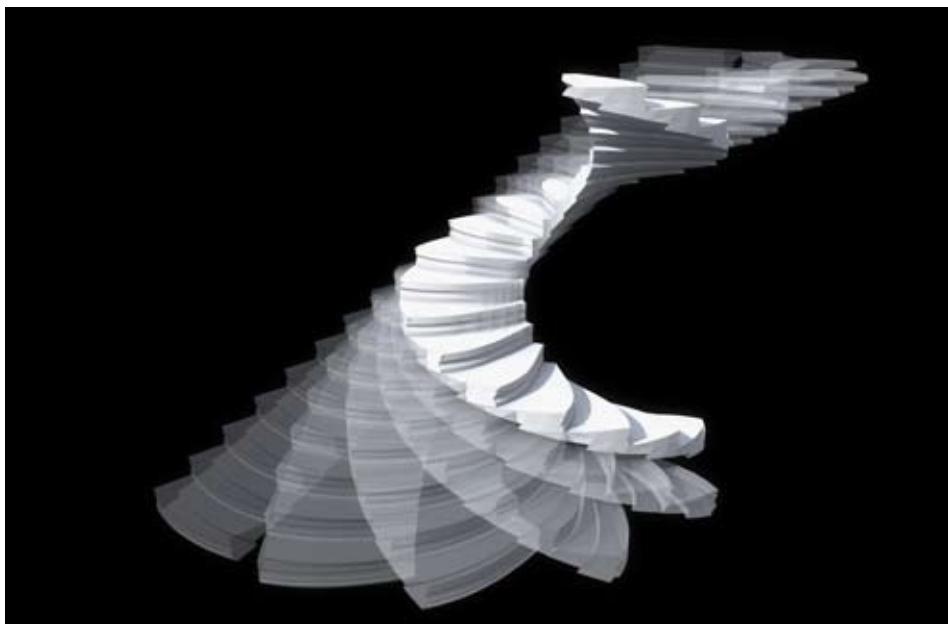
L'enorme potenzialità progettuale ed operativa, messa a punto dalla formalizzazione geometrica che lega la topologia alla stereotomia, viene puntualmente descritta nel libro dello scrivente edito da Aracne, editrice di Roma, nel 2007 dal titolo *Verso una progettazione stereotomica. Nozioni di stereotomia, stereotomia digitale e trasformazioni topologiche: ragionamenti intorno alla costruzione della forma*. Il libro viene presentato per la prima volta a Madrid all'interno della Summer School dal titolo *El Arte de la Piedra: Teoría y Práctica de la Cantería* organizzata da Palacios Gonzalo José Carlos e all'interno della Facoltà di Architettura dell'Universidad San Pablo, Madrid 2009. Nel 2009 vengono pubblicati gli atti della summer school dal titolo omonimo a cura di Sanjurjo Álvarez Alberto. Nel 2008 viene pubblicato, per le edizioni Aracne di Roma, il libro *Plaited Stereotomy – Stone Vaults for the Modern World* a nome di Richard Etlin, distinguished university professor alla Maryland University, Luc Tamborero, compagnon du devoir tailleur des pierres e lo scrivente. Il libro, presentato al Marmomacc 2008 in contemporanea alla mostra omonima, indaga la possibilità di paragonare l'apparecchiatura lapidea dei sistemi voltati agli intrecci tessili leggeri e flessibili. La contaminazione dialettica tra pesantezza del materiale lapideo e la leggerezza delle forme tessili rappresenta la principale leva di ricerca da

parte dello scrivente che ormai da anni indaga sulle potenzialità morfologiche insite in tale assunto concettuale come fondamento per l'aggiornamento della stereotomia. Le immagini presentate in questo saggio sono il frutto della ricerca da un lato e della didattica dall'altro che mutuamente si rispecchiano e fronteggiano in maniera dialettica.

Toward a Stereotomic Design: Experimental Constructions and Didactic Experiences è il titolo del saggio, presentato dallo scrivente al Third International Congress on Construction History svoltosi a Cottbus nel 2009, in cui si sottolinea come a partire dal XIX secolo la stereotomia da disciplina finalizzata alla costruzione edilizia si trasformi in disciplina didattica alla base della formazione tanto degli studenti dell'Ecole des Beaux-Arts che dell'Ecole Polytechnique. Il saggio, che può considerarsi il prodromo concettuale del presente libro, invita a coniugare reciprocamente la lezione teorica a quella pratico/costruttiva per avviare la stereotomia verso un nuovo e ricco orizzonte speculativo.

Dopo la presentazione della mostra Città di Pietra all'interno della 10° Mostra Internazionale di Architettura La biennale di Venezia del 2006, Stefano Zerbi dell'École polytechnique fédérale de Lausanne EPFL, autore di molti saggi sull'architettura lapidea, promuove la "Via della Pietra" come progetto volto alla promozione, attraverso la pietra naturale, della regione delle Tre Valli, Cantone Ticino, Svizzera.

In posizione geografica opposta rispetto al confine nord-italico, il gruppo di ricerca siciliano guidato dal prof. Marco Rosario Nobile, docente di Storia dell'Architettura e Conservazione dei Beni architettonici della Facoltà di Architettura dell'Università degli Studi di Palermo, promuove,



in cordata con docenti spagnoli guidati da Arturo Zaragozà Català, una ricerca coordinata sul Gotico Mediterraneo indagando monumenti e tecniche costruttive stereotomiche in area mediterranea nel XIII secolo. Tra le ricerche spicca il lavoro di dottorato (2003-2007) di Maria Mercedes Bares dal titolo *Stereotomia e tecniche costruttive nell'architettura del Mediterraneo: il Castello Maniace di Siracusa*.

A Venezia nel 2010, per i tipi di Cafoscarini, Francesco Bergamo e Gabriella Liva pubblicano un libro dal titolo *Stereotomia. Dalla pietra al digitale* con introduzione di Agostino De Rosa, docente di disegno presso lo IUAV. Il libro risente fortemente degli studi e ricerche pubblicate a partire dal 2000 dal gruppo di ricerca della facoltà di Architettura del Politecnico di Bari che nel 2011, con Francesco Defilippis, docente di progettazione della facoltà barese, presenta il libro dal titolo *Architettura e stereotomia*.

Caratteri dell'architettura in pietra da taglio in area mediterranea quale esito finale del lavoro sviluppato durante il dottorato di ricerca tra il 1996 e 1999.

Nel 2011 vengono pubblicati gli atti del convegno organizzato dal *Nexus Network Journal Architecture and Mathematics* dal titolo *From mediaeval stonemasonry to projective geometry* a cura di José Calvo López per la Birkhäuser Verlag in cui sono riuniti ricerche e saggi sulla stereotomia a cavallo tra medioevo e XVIII secolo.

La specificità delle indagini storiche e dei metodi tracciati dai ricercatori europei influenza fortemente le ricerche di Benjamin Ibarra-Sevilla, docente messicano presso la Minnesota University degli Stati Uniti, che dal 2009 studia le strutture voltate messicane del XVI secolo e la trasmissione del sapere stereotomico dall'Europa all'America.

Per concludere questa panoramica sulla mappa delle ricerche relative agli studi sulla stereotomia, che non ha la presunzione di essere né esaustiva né completa ma interamente basata sull'interpretazione dei dati e delle conoscenze a disposizione dello scrivente, è utile sottolineare che gli interessi sulla disciplina negli ultimi sessanta anni hanno mostrato da un lato una progressiva crescita sia numerica che nell'ottica della pluridisciplinarietà, dall'altro un rimarchevole spostamento dell'asse di indagine che dall'analisi prettamente storica, si indirizza verso la sperimentazione creativa nell'ottica della prassi costruttiva e progettuale. La tendenza, come si diceva all'inizio del saggio, è quella di ritornare alla sperimentazione progettuale e alla costruzione al vero dei manufatti/prototipo al fine di comprenderne al meglio sia il comportamento statico dell'impalcatura muraria sia quello morfologico-costruttivo.

A dimostrazione di ciò sono evidenti le numerose attività di ricerca di molti istituti universitari in cui alla speculazione progettuale e computistica si associa la realizzazione al vero dei prototipi: il laboratorio GSA di Paris Malaquais, diretto da Jöel Sakarovitch e Maurizio Brocato, associato agli ateliers GAIA di Lione; il gruppo ODB Structural Engineering Consultants diretto da John A. Ochsendorf; il laboratorio di progettazione CAD/CAM della Facoltà di Architettura del Politecnico di Bari, di cui fa parte lo scrivente diretto da Claudio D'Amato, con varie partnership: la MECASTONE di Luc Tamborero; la PIMAR; SNBR (Troyes); EAPA (Brignoles); Impresa LEOPIZZI 1750 (Parabita, LE); il MAS CAAD Master of Advanced

Studiees dell'ETH di Zurigo; il laboratorio di stereotomia gotica di José Carlos Palacios Gonzalo all'ETSAM di Madrid; i laboratori di costruzione stereotomica di Enrique Rabasa con Los Oficios de Leon; le attività pratiche dei Compagnons du Devoirs du tour de France. Le maquettes di studio e i prototipi in scala assolvono la duplice funzione, didattica e di verifica dell'ipotesi progettuale, aspirando sempre alla forma architettonica organica che potenzialmente contengono. Quando i prototipi diventano architetture rientrano nelle testimonianze del blog "Architettura di pietra" diretta da Alfonso Acocella e nelle manifestazioni di Vincenzo Pavan, direttore artistico del settore culturale della fiera internazionale del marmo *Marmomacc* di Verona, che da molti anni promuove l'architettura di pietra nella migliore espressione della contemporaneità. Ricercate in ogni angolo della terra le riflessioni sulla nuova architettura di pietra vengono filtrate e selezionate per essere promosse e divenire paradigmi cui riferirsi. La pietra, declinata nelle differenti forme ed espressioni architettoniche odierne, seppure non esplicitamente riferita alla stereotomia nel suo assunto storico/estetico lo è in quello ontologico con specifico riferimento alla cura del dettaglio che diventa parte essenziale del tutto. Nel lavoro di dettaglio, per le opere litiche, è contenuto il senso generale dell'opera, e infine nell'etimo della parola *dettaglio* dal provenzale *détail* (parola francese composta da *de* e *tailleur* che significa tagliare, nel senso di asportare materia) è contenuto il senso primordiale della stereotomia.

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993

16

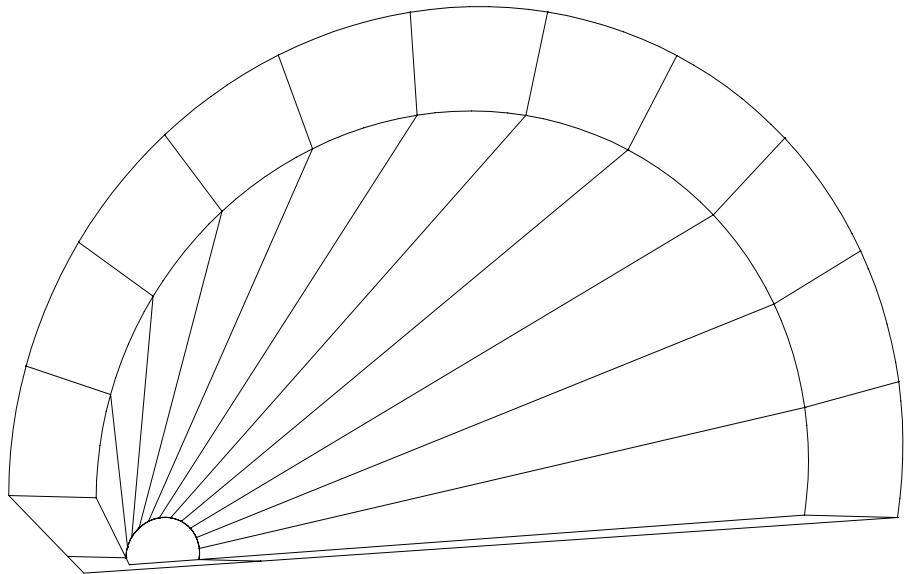
PROTOTYPES

of Modern Stereotomy

Paris	Trompe Biasise, 2003
Verona	Escalier Ridolfi, 2005
Venezia	Portale Abeille, 2006
Venezia	Obelisco Alexandros, 2006
Madrid	Ponte Truchet, 2007
Paris	Sphera, 2008
Verona	Stone Surfaces, 2008
Parabita	Foglia, 2009
Brignoles	SNBR Arch [1], 2009
Brignoles	SNBR Arch [2], 2010
Brignoles	Oblique Obelisk , 2010
Verona	Alveare, 2010
Brignoles	Viollet Le Duc Arch, 2010
Andria	Portale Murgia, 2011
Andria	Flexi Arch, 2011
Verona	Deco_wall, 2011

Trompe Biasise

Stage Trompe
Fondation Cubertin
Paris, 2003



The trompe is a conical vault of the type created by skilled masons which, since Medieval times, has permitted the construction of projecting stone architectural features (squinch, pendentive or corbel) that form small *cabinet* or function as the transition from a square shape plan, to an octagon, to a round dome. From a geometric point of view, the trompe does not differ much from the nested arch structures found in thick masonry. The complexity of the trompe varies according to the conicoidal form of the intrados, that is, by following the directive and generative curves that define its geometry. In this case, we are dealing with a *trompe biaise en talus rampante dans un encoignure surbiaise*: the intrados-extrados surfaces of the vault are defined by a skewed conical surface. This project was aimed at constructing a purely stereotomic structure using both infographic and manual techniques, connecting stone cutting techniques with anamorphosis. Thus the idea was to construct a relief sculpture *blasone* by the Atelier Saint Jacques on the intrados of the conical vault. The *blasone* represents the famous scallop shell of St. James. This stone sculpture, in order to be properly inserted onto the conical intrados surface of the vault, was designed using an anamorphic

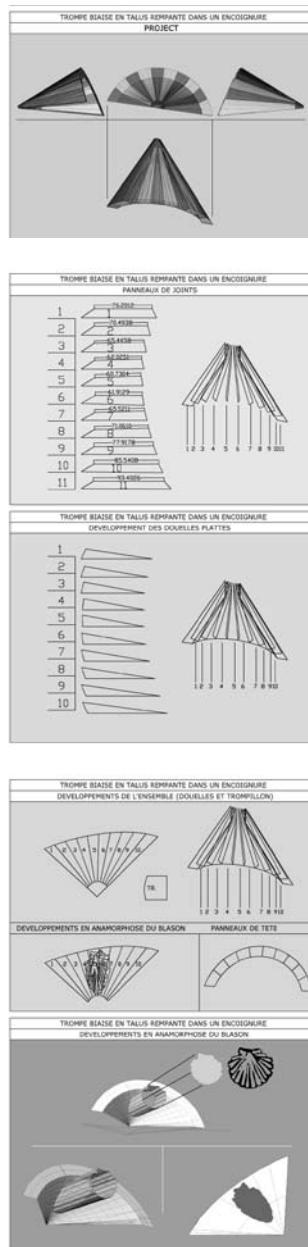
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



95. Utensili da lavoro, disegno di C. Gaul

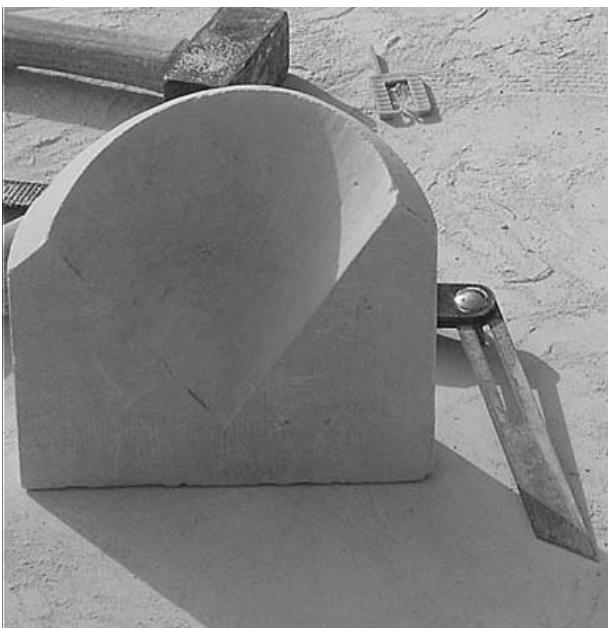
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



projection process, by which, when observed from any perspective point, except perfectly frontal, appears as a deformed architectural sculptural detail. Another key feature of the project was to experiment with a sculptural element on the parts of the intrados, distinct from the individual ashlar, that only when the vault is mounted reveals the whole design. By using three-dimensional infographic processes, new speculations regarding the following can be made:

- Anamorphic geometric determinants used in the creation of images;
- Decomposition/composition of relief sculpture and the verification of suitable work processes;

Anamorphic geometric determinants for the scallop design were obtained using a process of cylindrical projection of the true shape of the scallop onto the intrados. This kind of parallel projection of the intersection of the cylindroid with the base in profile of the scallop with the surface of the conical intrados of the trompe. From this intersection, the resultant spatial curve belongs to the conical surface and from which the image can be developed and be measured. This can then be plotted onto the pattern cards that then are transferred onto the ashlar with precision and no risk of error.

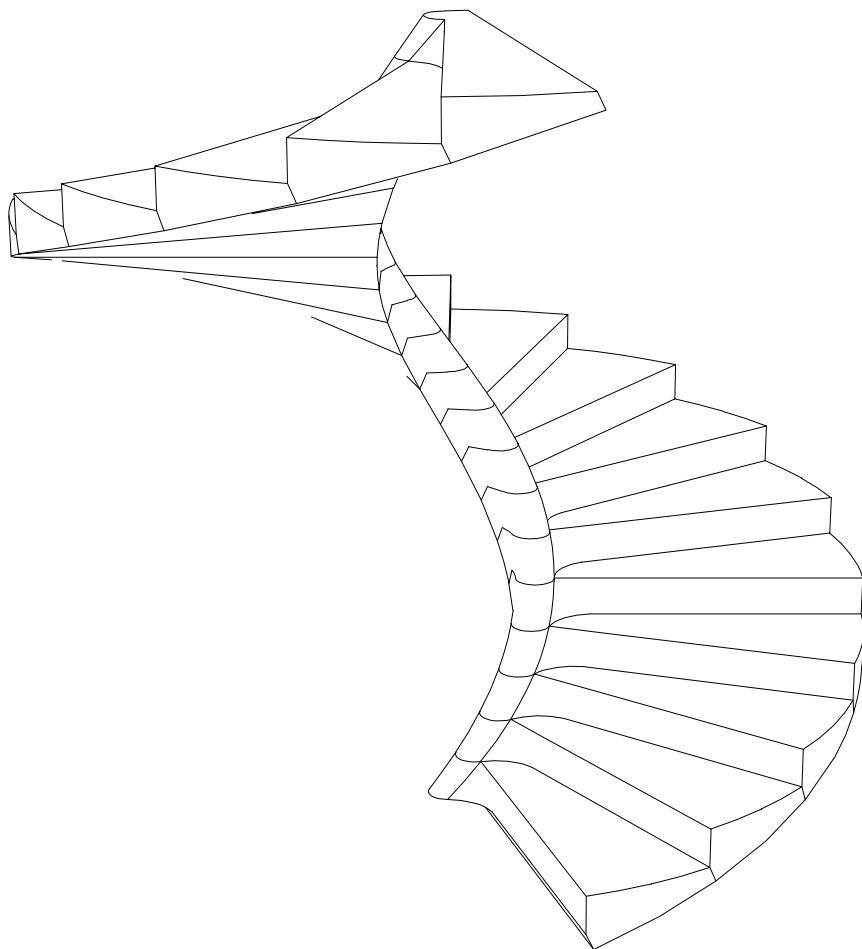


Escalier Ridolfi

Marmomacc 2005

VeronaFiere

Verona, 2005



Escalier Ridolfi is a prototype of a helicoidal staircase built in prestressed stone that attempts to recreate the idea of 'flying' stones. The geometric rule that underpins the design is evident in the very tradition of the helicoidal stone staircase with a circular plan, like that of the Caracol de Mallorca. The uniqueness of this stone structure lies in the principle that each step – 'base unit' - carefully shaped, is reiterated in a polar pattern to create the entire staircase. Once assembled, it responds perfectly to the criteria of geometric units at the base of stone architecture, due to the perfect continuity and adherence of each step to the intradex. The staircase forms a thrusting helicoidal 'vault' that is defined by several static-geometric parameters that inform the curved surface of the flight of steps. The static hypothesis at the base of the design consists in mutual absence, both at the level of the masonry itself (containing the horizontal thrust) and in the central load bearing nucleus (for the vertical discharge of weight) and in the reinforcements inside the stones (traction of cables and prestressed 'vault') that ensure the equilibrium of the whole structure.

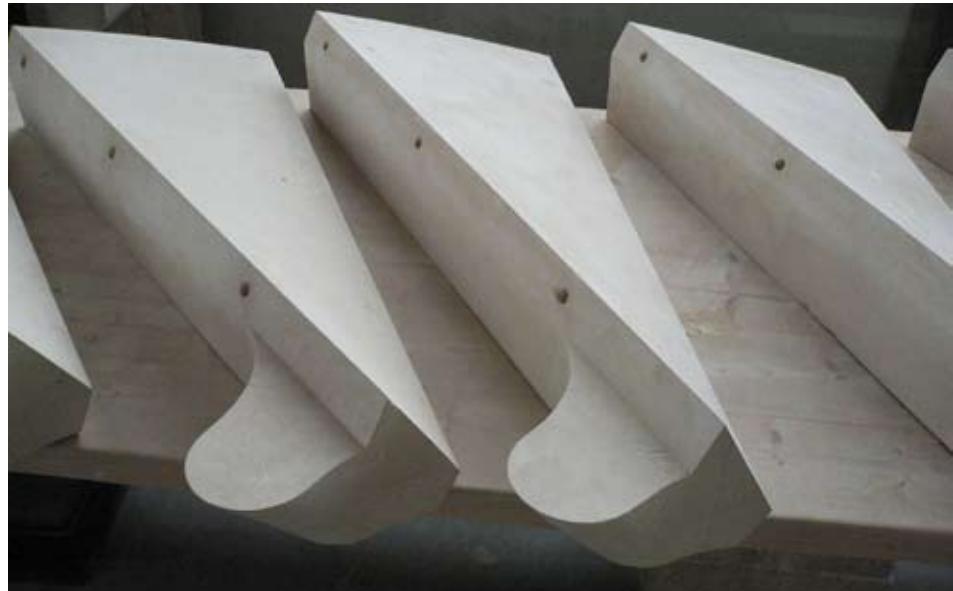
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



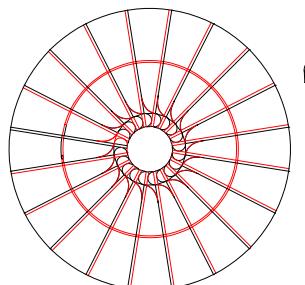
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

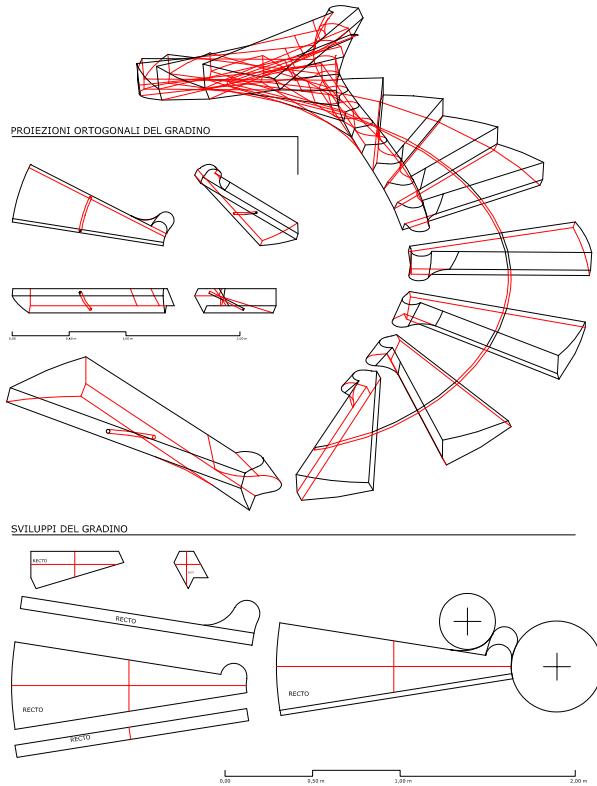
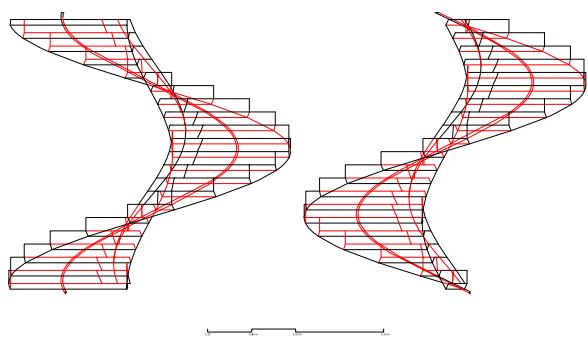




95. Utensili da lavoro, disegno di C. Gaul



96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

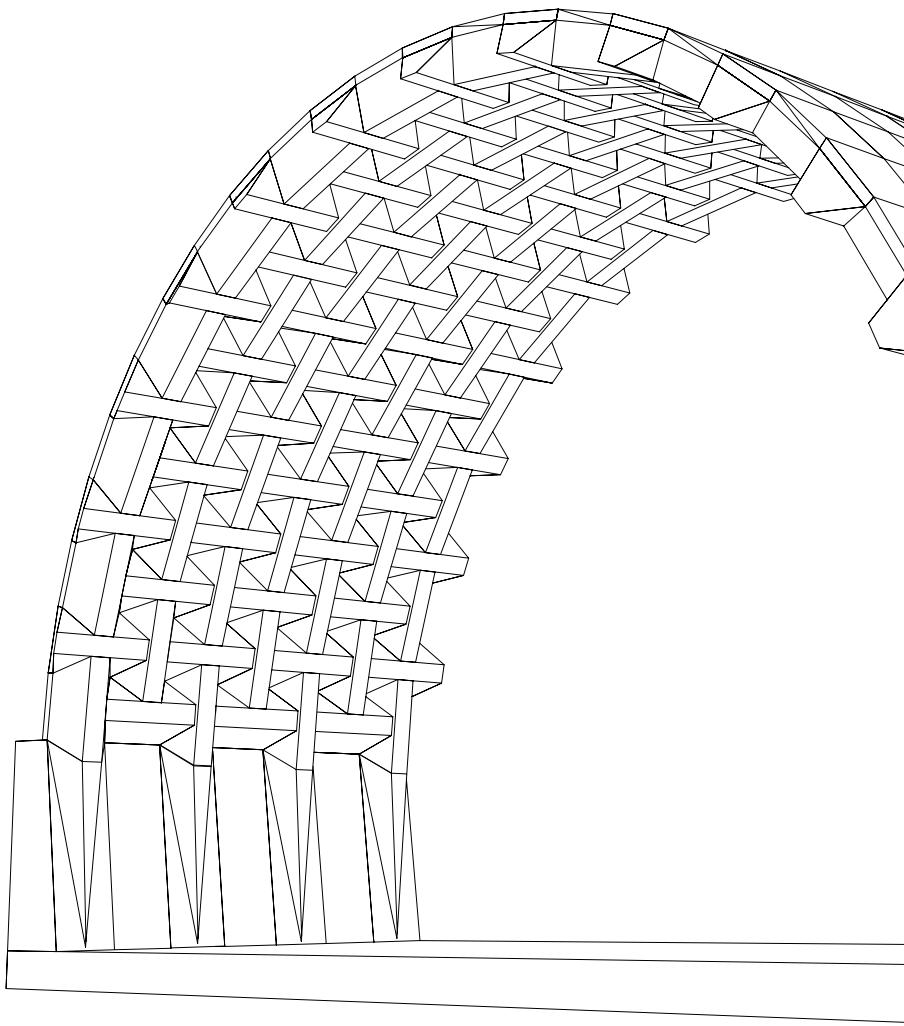


The challenge, from a research point of view, was to design and calculate a stone structure composed of discontinuous elements submitted to precompression through the post-tension of a harmonic steel cable in a helicoidal system. Unlike normal structural praxis, the structure was not assembled flat, but suspended, thus increasing the difficulty of calculation considerably.



Portale Abeille

Corderie dell'Arsenale
X Biennale Internazionale di Architettura
Venezia, 2006



The Portale Abeille is a barrel vault that, due to its complex stonework, transfers pressure in two directions: along the curve of the arch and perpendicular to the arch. This variation to the traditional static behavior of the barrel vault was made possible by using specific patented stonework, designed for the construction of a flat stone roof.

The stereotomic system known as *voute plate* is one of the most interesting technical-stylistic responses offered by stone masonry to the world of construction, a solution that has, however, been used very rarely. The flat vault (timbrel vault) defies common sense in its conjunction of two geometrically contradictory terms: 'vault', which by definition is a three-dimensional surface and 'flat' which by its very nature is two-dimensional. The historical problem raised in stereotomic speculation, is how to construct a ceiling using a thrusting vault that is lowered to the maximum level (zero rise). The static principle at the base of this type of vault presupposes that the loading path above the structure is both vertically and horizontally conducted, using a careful weaving together of wedge shaped ashlar, creating a successfully compressed vault. The first patented version of this structure was designed by Joseph Abeille (1669-1752) a

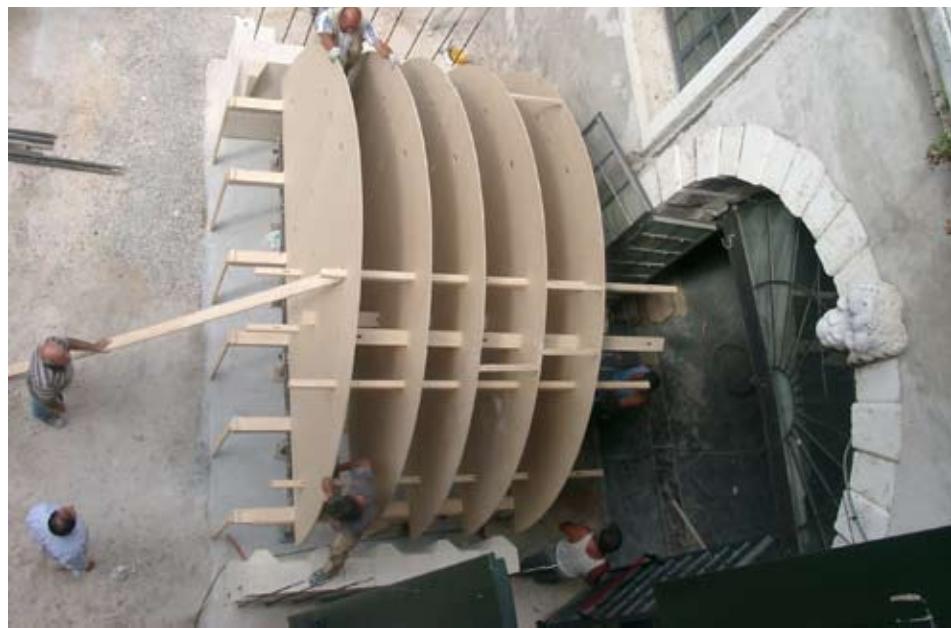
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

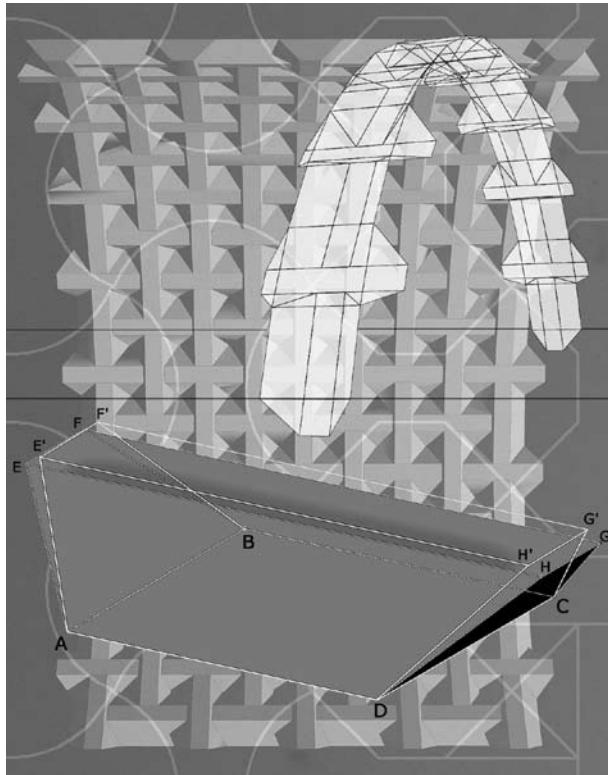
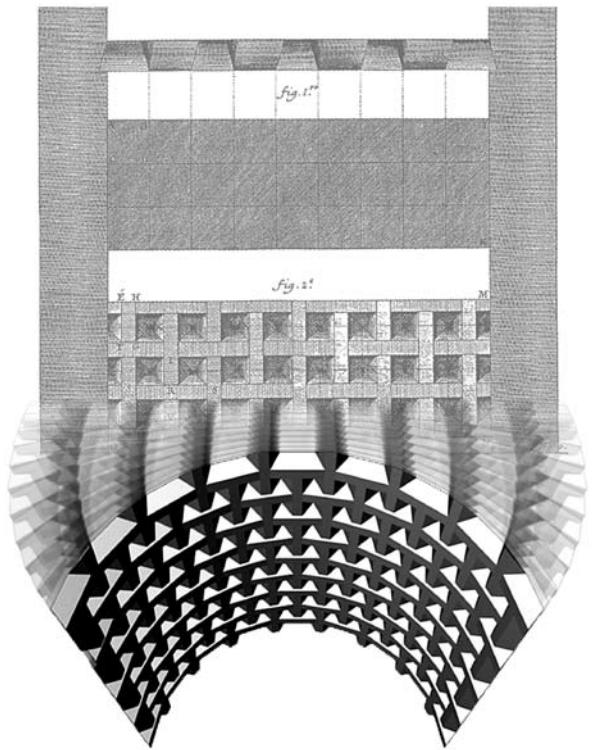


95. Utensili da lavoro, disegno
di C. Gaul

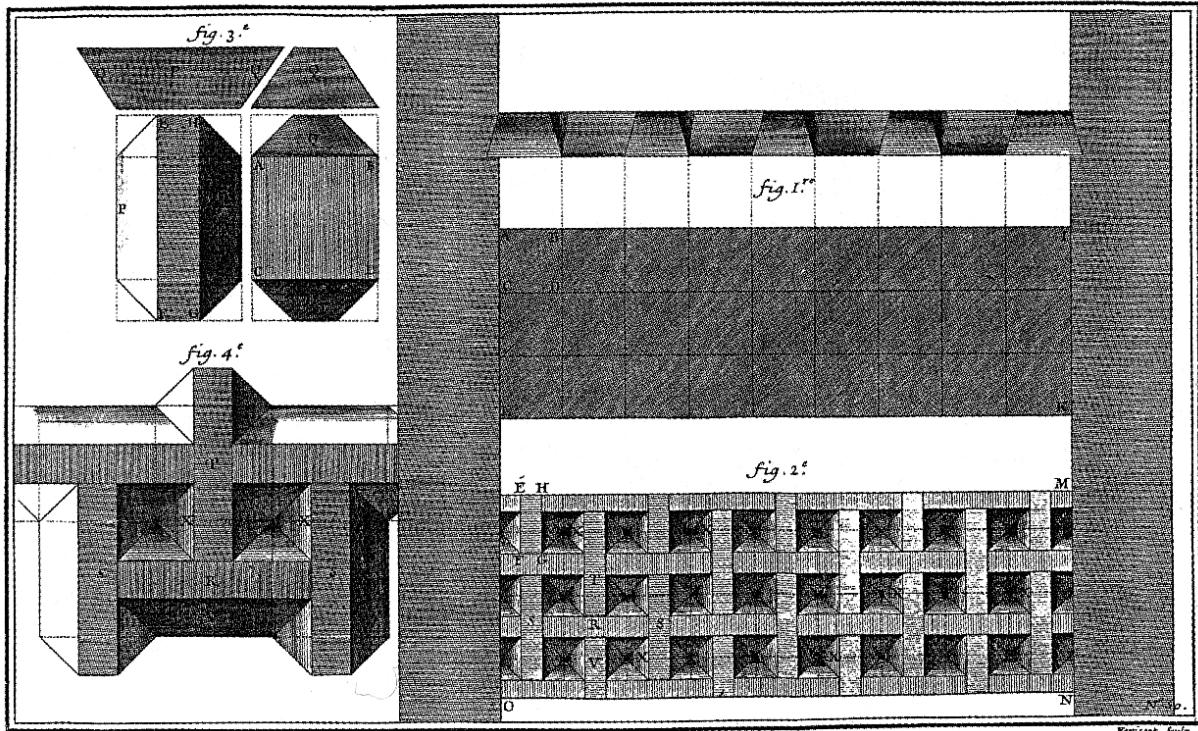
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





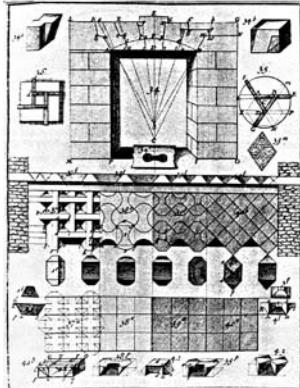


Voute Plate



95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





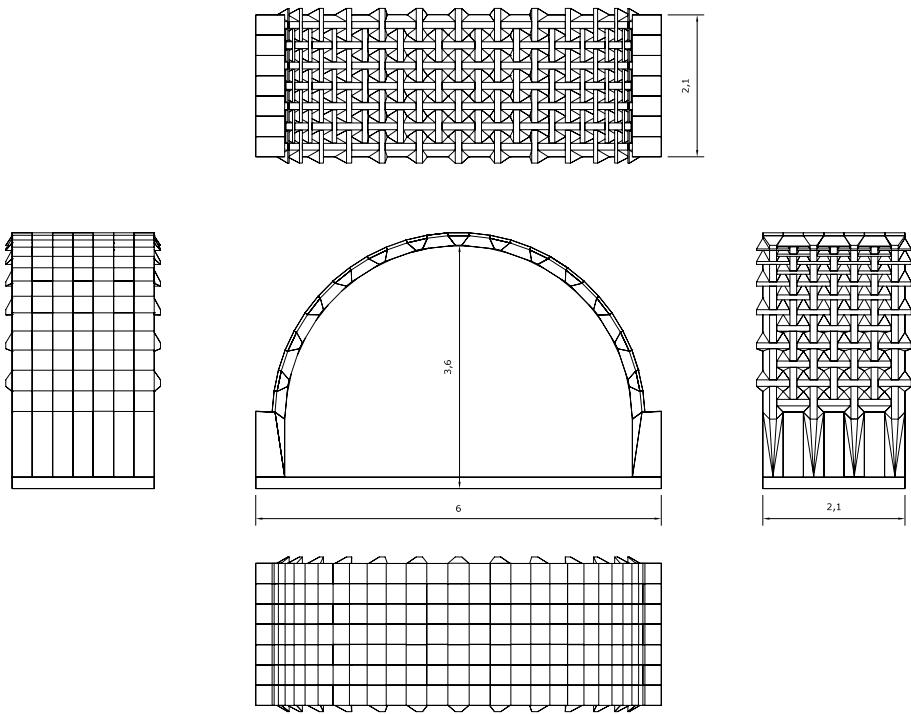
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

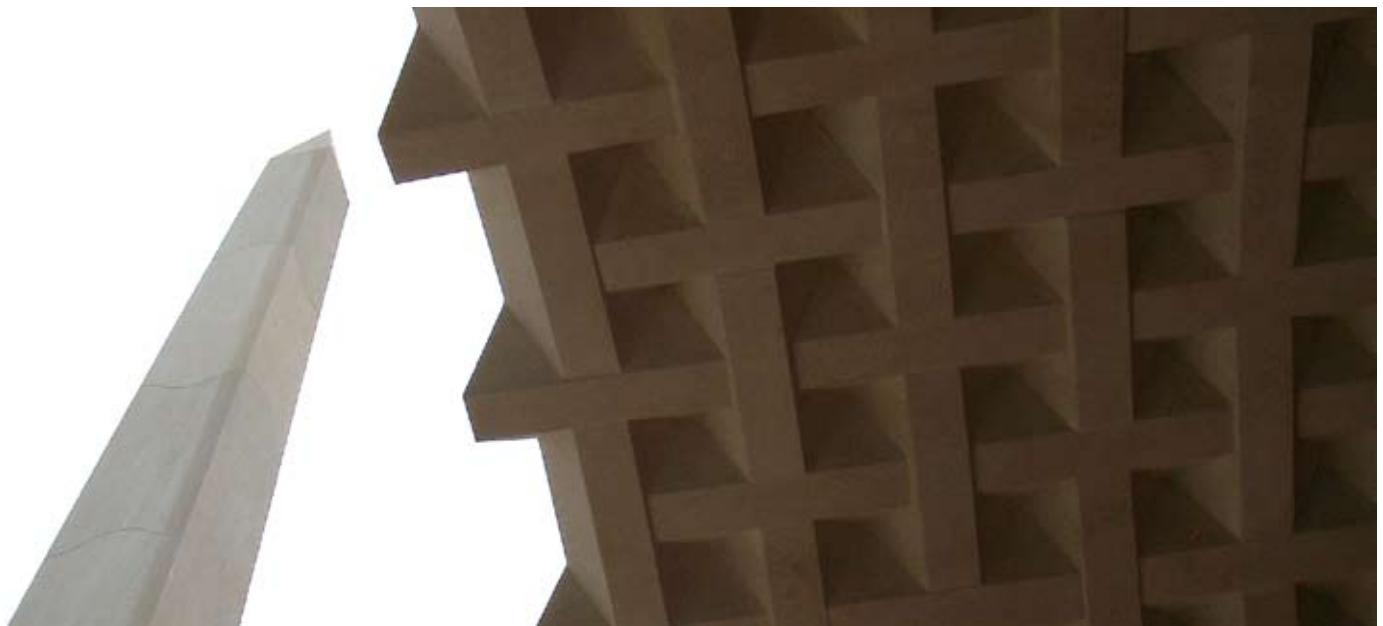


French engineer from Marseille. His patent was registered in 1699 in *Machines et inventions approuvées par l'Academémie Royale des Sciences*. The ashlar are reiterated as a series to form a flat vault in a polyhedron form whose two axial sections, in the shape of an isosceles triangle, have opposite directions. The static function of this solution is that of a flat, bi-directional plane that works in two directions in exactly the same way: each individual ashlar is maintained by, and maintains, the others in such a way that the vault works only when the construction of the whole is terminated. Two surfaces are visible when the vault is completed: the square, homogenous and continuous web of the extrados, and the intrados, characterized by an interesting pattern of plaiting with pyramid-shaped features.

The experimentation into the creation of Portale Abeille was based on the use of topological parametric-variational software which allowed us to bend and deform the patented vault, transforming the flat vault into a semi-cylindrical form which allowed us to find a new ashlar conformation. In order to transform the flat vault into a barrel vault, we identified a formal geometric variability range using the definition of modification parameters.



Deciding on a single curve for the vault meant using two serial ashlar types for the creation of the barrel vault. The more the parameters of deformation and curvature increase, the more the number of ashlar types in the new vaulted system increases as a consequence.



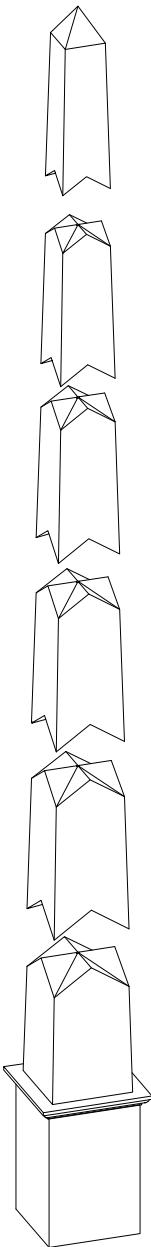


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



Obelisco Alexandros



Corderie dell'Arsenale
X Biennale Internazionale di Architettura
Venezia, 2006

The project *Alexandros* was begun as an attempt to resolve the problem of constructing a large obelisk in a small space: the lobby to the Arsenale building, constructed for the occasion of the Architecture Biennale, Venice. Moving away from notions typically connected to the construction of monoliths, like the obelisk, we decided to divide the work height-wise, into three large stone blocks. Structural research into joints was able to resolve the necessity of movement in a slim, obelisk structure. By studying historical obelisks in stone, we were able to identify edges and corners, where most of the force is concentrated, as the critical weak points in the structure, causing fracture and breaking. The joints designed for this project resemble the anatomical conformation of the knee joint, allowing movement of the blocks without the risk of damaging the stone. Like cartilage, neoprene was used in the joints, imitating the same spatial configurations of the contact surfaces of the large blocks. A steel cable was threaded through the vertical axis of the obelisk to prestress the whole structure. The tension of the steel cable, when added to the total weight of the blocks cut from Leccese limestone, was the same as if the whole structure had been constructed in granite.

95. Utensili da lavoro, disegno di C. Gaul

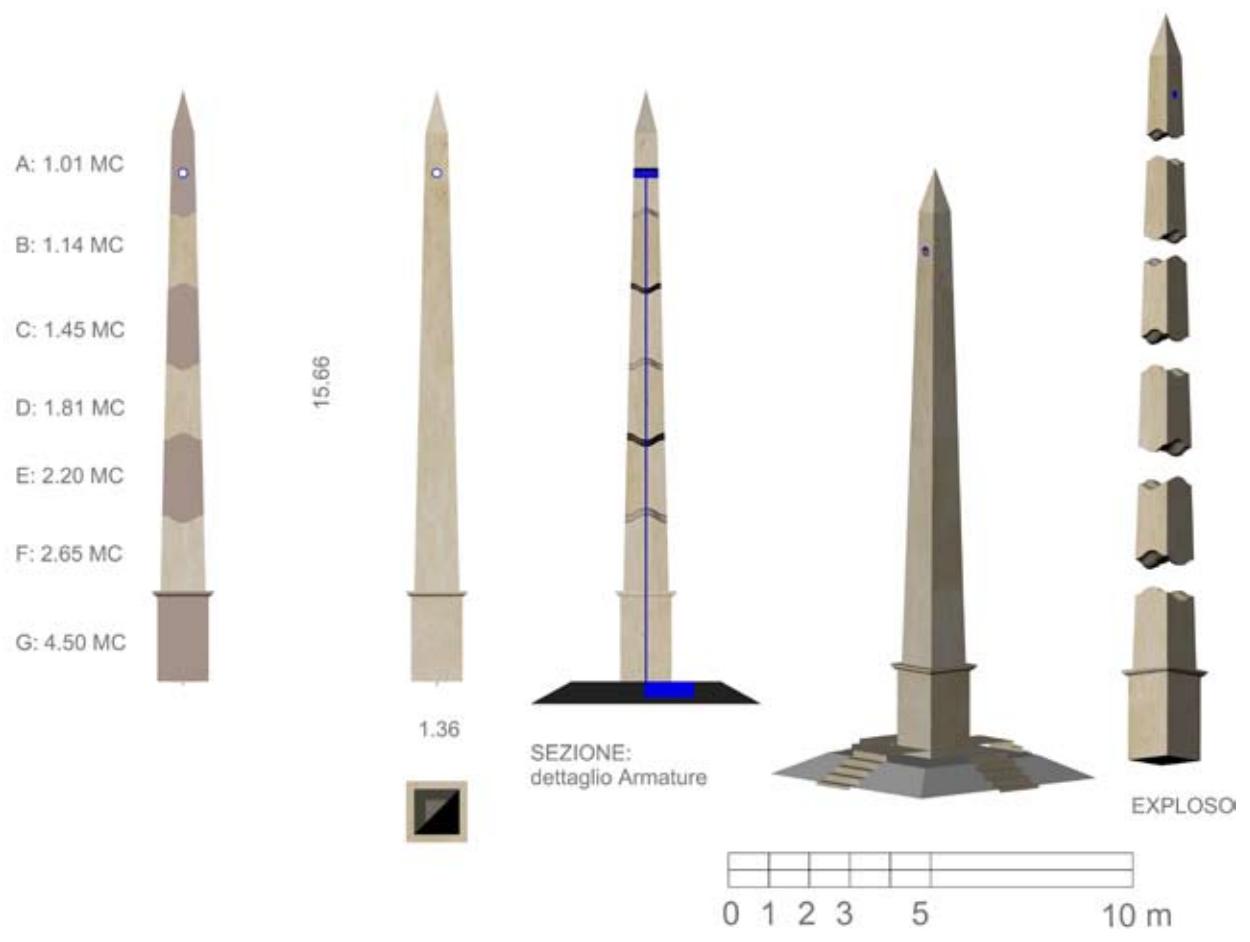
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993





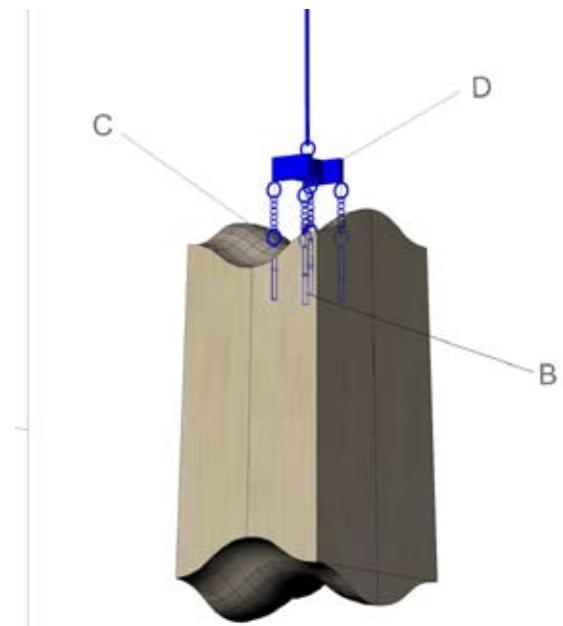
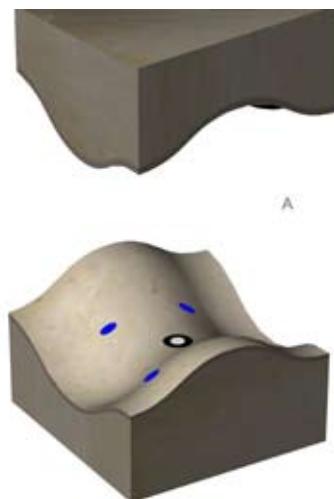


Another element of interest from the point of view of statics, is the suction effect created between the joints . The perfect joining of the blocks caused a pneumatic suction effect that, functioning as a 'glue', theoretically obviates the need for cables to reinforce the structure. This prototype represents a constructive solution of great interest in the construction of large pillars or stone columns.



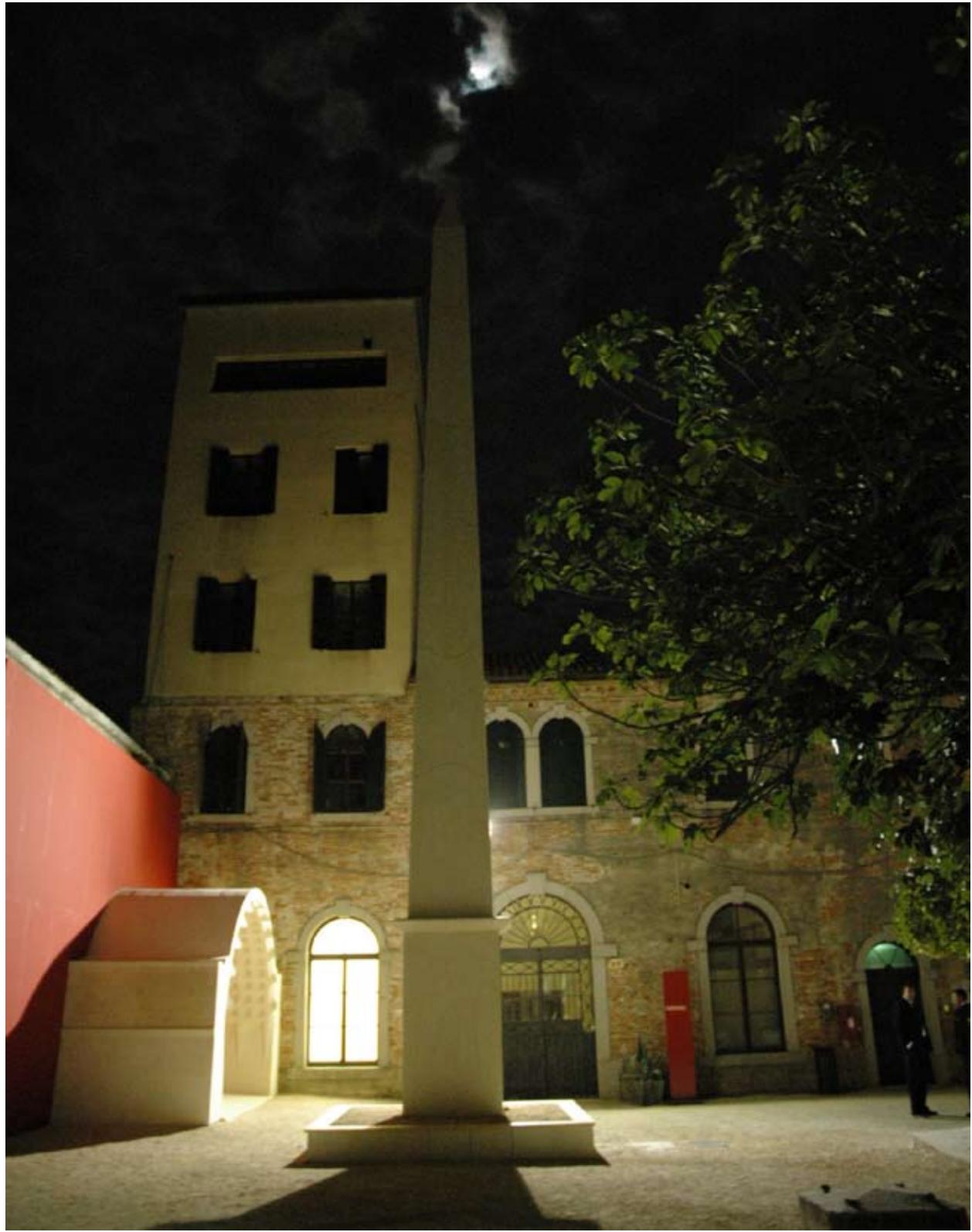
95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



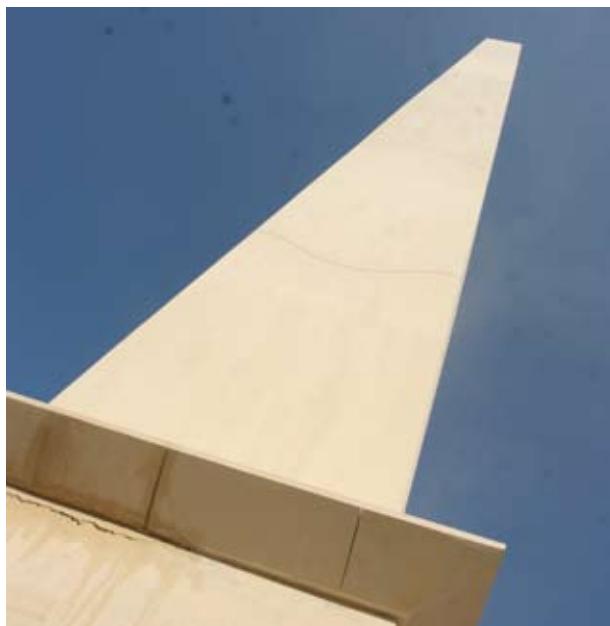
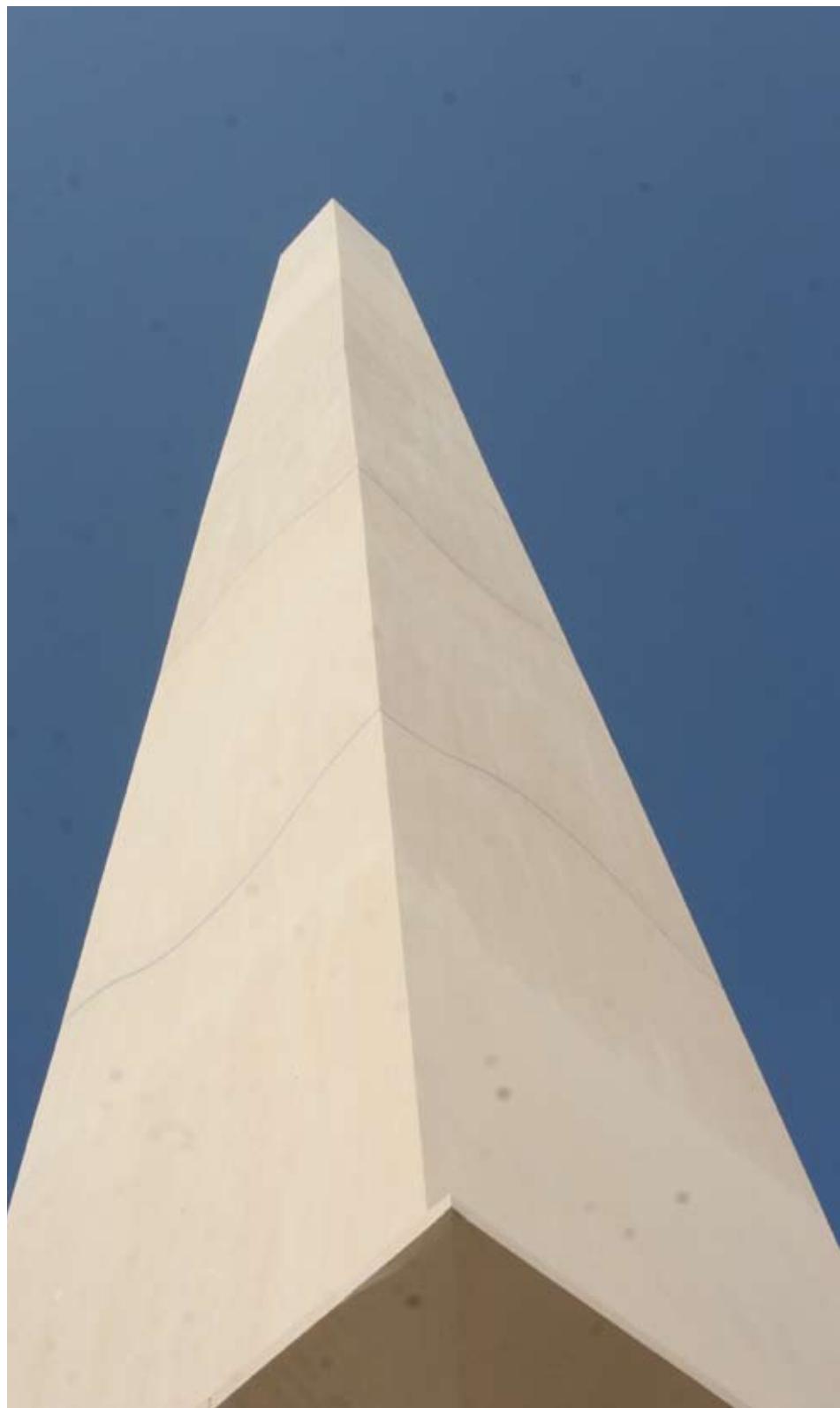






95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



95. Utensili da lavoro, disegno
di C. Gaul

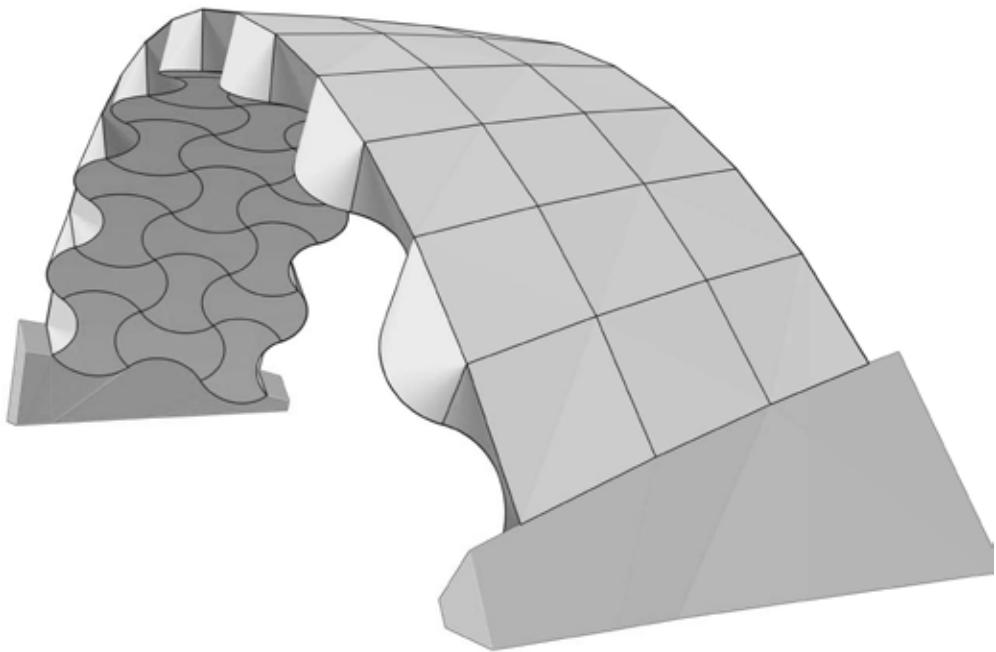
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



Ponte Truchet

Summer School
Universidad San Pablo CEU
Madrid, 2007

This project is an oblique barrel vault structure developed according to the solution for a flat vault that the Carmelite Father Sébastien Truchet patented in 1704 as the Abeille vault. The prototype was made according to the same modeling and topological variation techniques used in the design of the Portale Abeille, with the difference being that the Truchet ashlar are far more complex due to the surface curves. The same logic behind the joints used in the Alexandros obelisk was adopted here to build Ponte Truchet with an oblique projection. It is well known that the barrel vault has the problem of 'empty thrust', a problem that led stone masons in the Nineteenth and Twentieth centuries to study the best way to resolve such a static issue: stones worked into orthogonal and helicoidal shapes. These solutions are refined geometric-constructive solutions to an issue which, in that period, were resolved generally with steel or reinforced concrete. In order to pass from the flat vault of Truchet to an oblique barrel vault, worked with orthogonal lines between the blocks, the flat system was deformed several times to obtain a number of modular ashlar equal to 50% of the blocks in the entire thrust system.



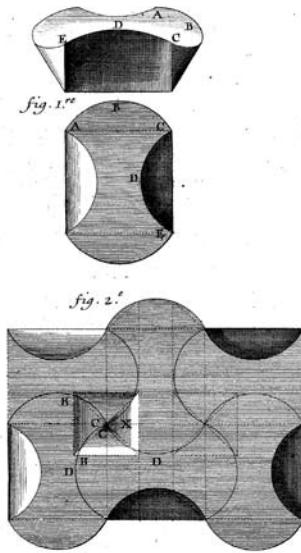


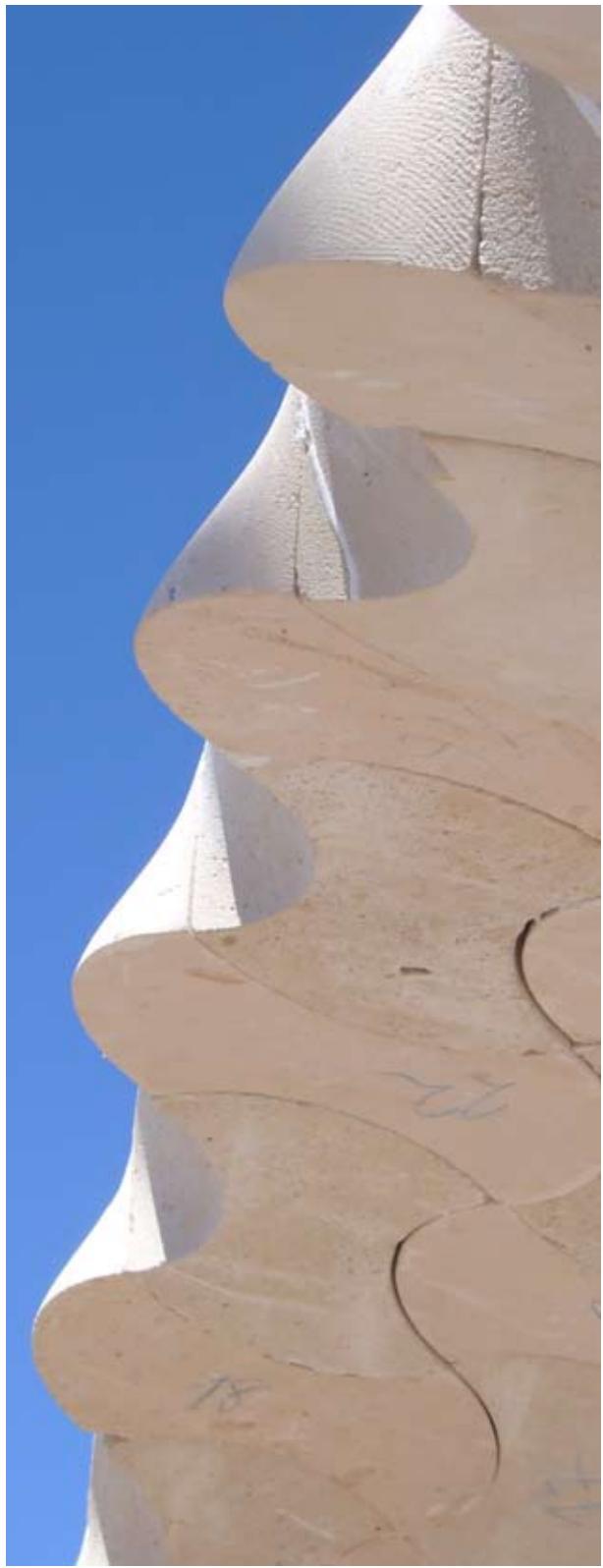
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

95. Utensili da lavoro, disegno di C. Gaul

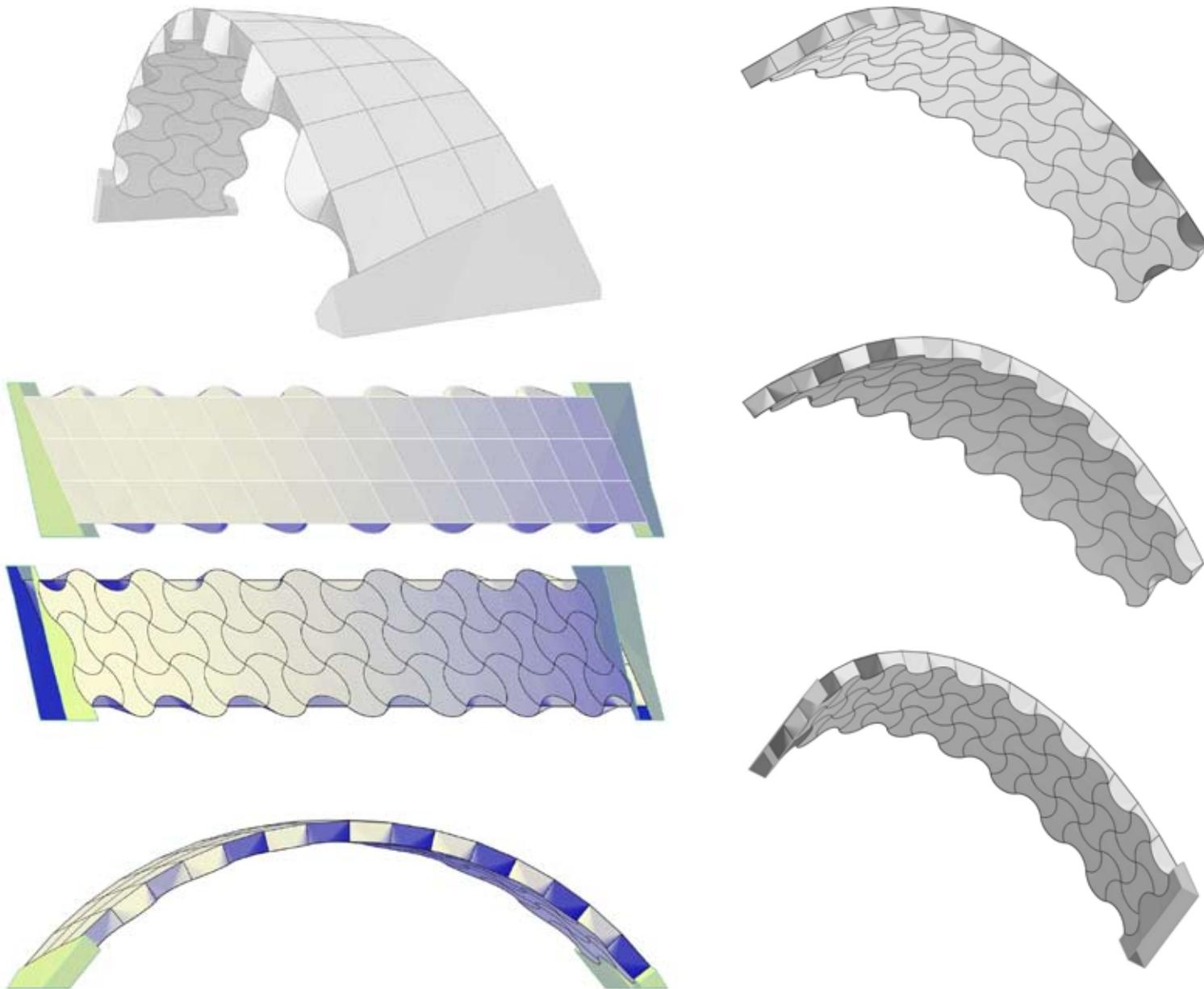
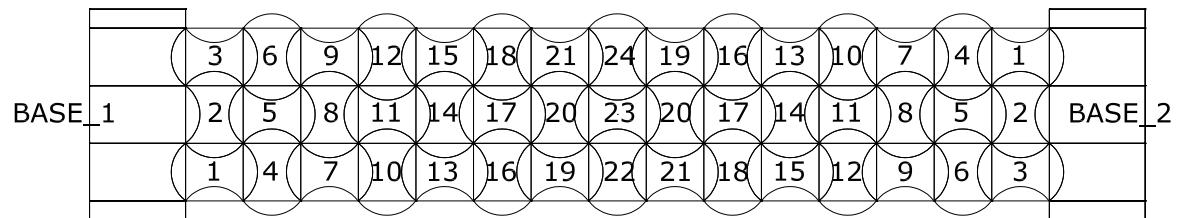
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

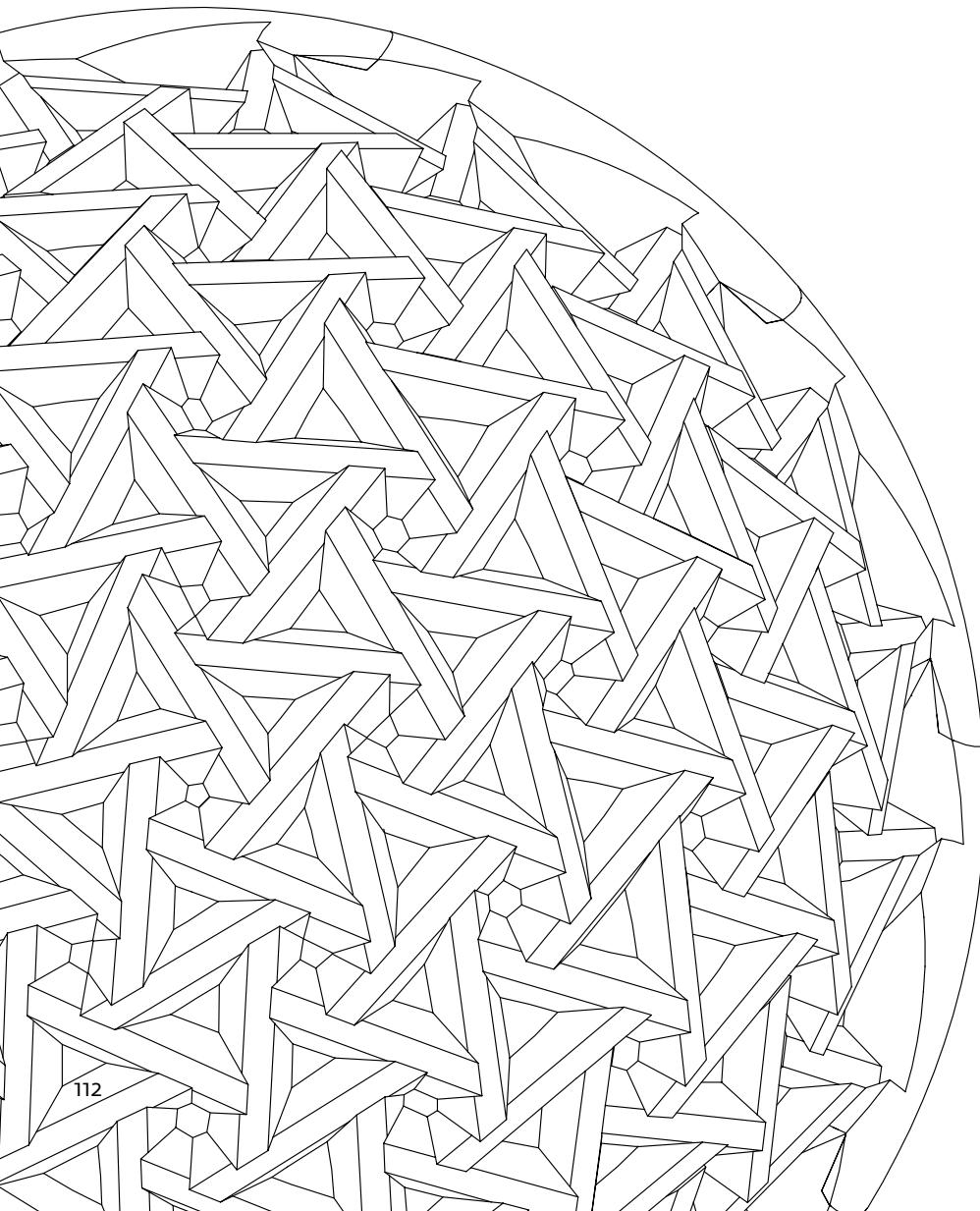




The blocks were cut using CAD/CAM and numerical control machines as the geometry of the blocks could not be reproduced by masons using manual cutting techniques. Regarding the final construction, as the keystone could not be inserted vertically, the structure was divided into two parts onto which the stone blocks were positioned, then one half of the structure was pulled towards the other, closing the vault. The hermetic closure of the two parts of the system , fitting together perfectly, effectively resolved static problems.

Sphera

Stage Sphera
Grands Atelier Isle d'Abeau
Paris, 2008



The interest in the possible formal declinations of Abeille's genial patented vault, led us to examine the relationship between the surface of the vault, the type of stonework employed and the minimum number of modular ashlar necessary for the complete tiling of the structure.

The desire to use the fewest possible geometric elements to 'fill' the space, without creating problems of continuity, responds to the necessity to simplify the phases of construction and mounting in any vaulted structure. The sphere project was an experiment to create a prototype of a spherical vault using the same ashlar as those patented by Abeille while at the same time applying the simplicity required by contemporary construction specifications. The tiling of a spherical surface with a single geometrical shape is, as is well-known, impossible. Thus we decided to use the joints between ashlar as irregular compensatory elements capable of covering the spherical surface: identical ashlar, different joints. It is due to the particular geometrical conformation of Abeille's ashlar that the irregularity of the joints is effectively masked.



95. Utensili da lavoro, disegno
di C. Gaul

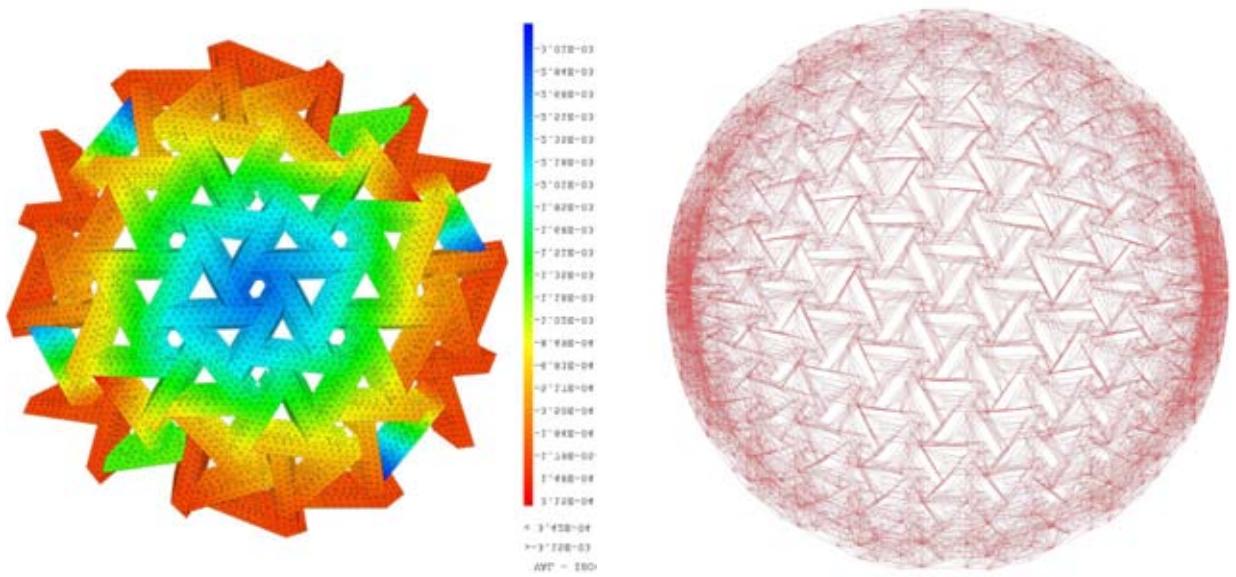
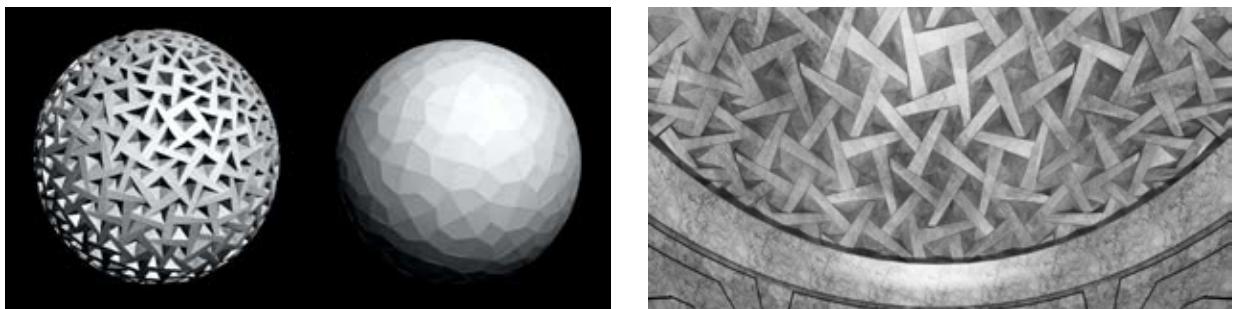
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

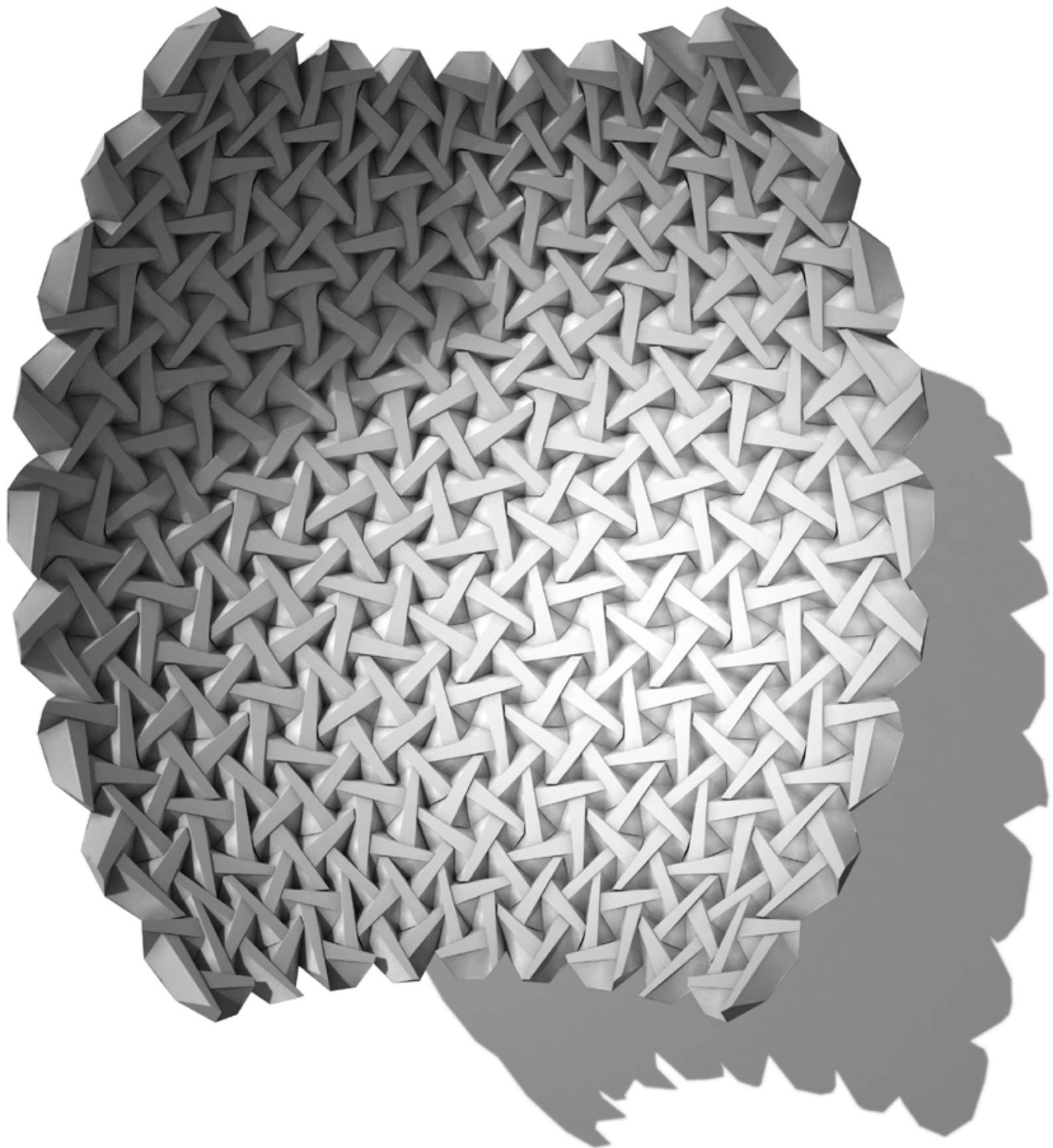




95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



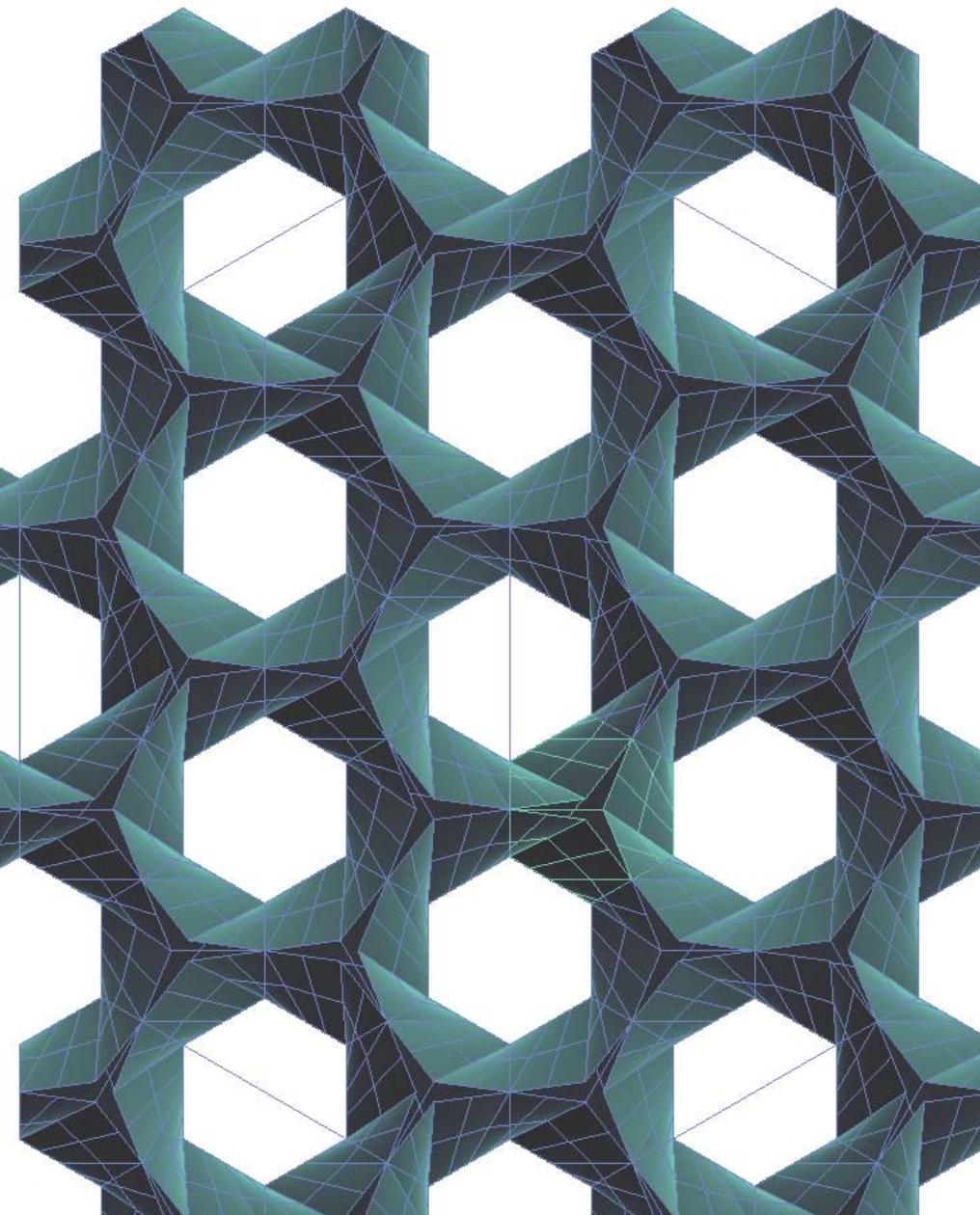
This prototype investigates the geometrical problems connected to the tiling of surfaces and is a concrete solution to the contemporary demands of the building industry to remain competitive and cheap in the construction of spherical vaults with plaited intrados.

Stone Surfaces

Marmomacc 2008

VeronaFiere

Verona, 2008

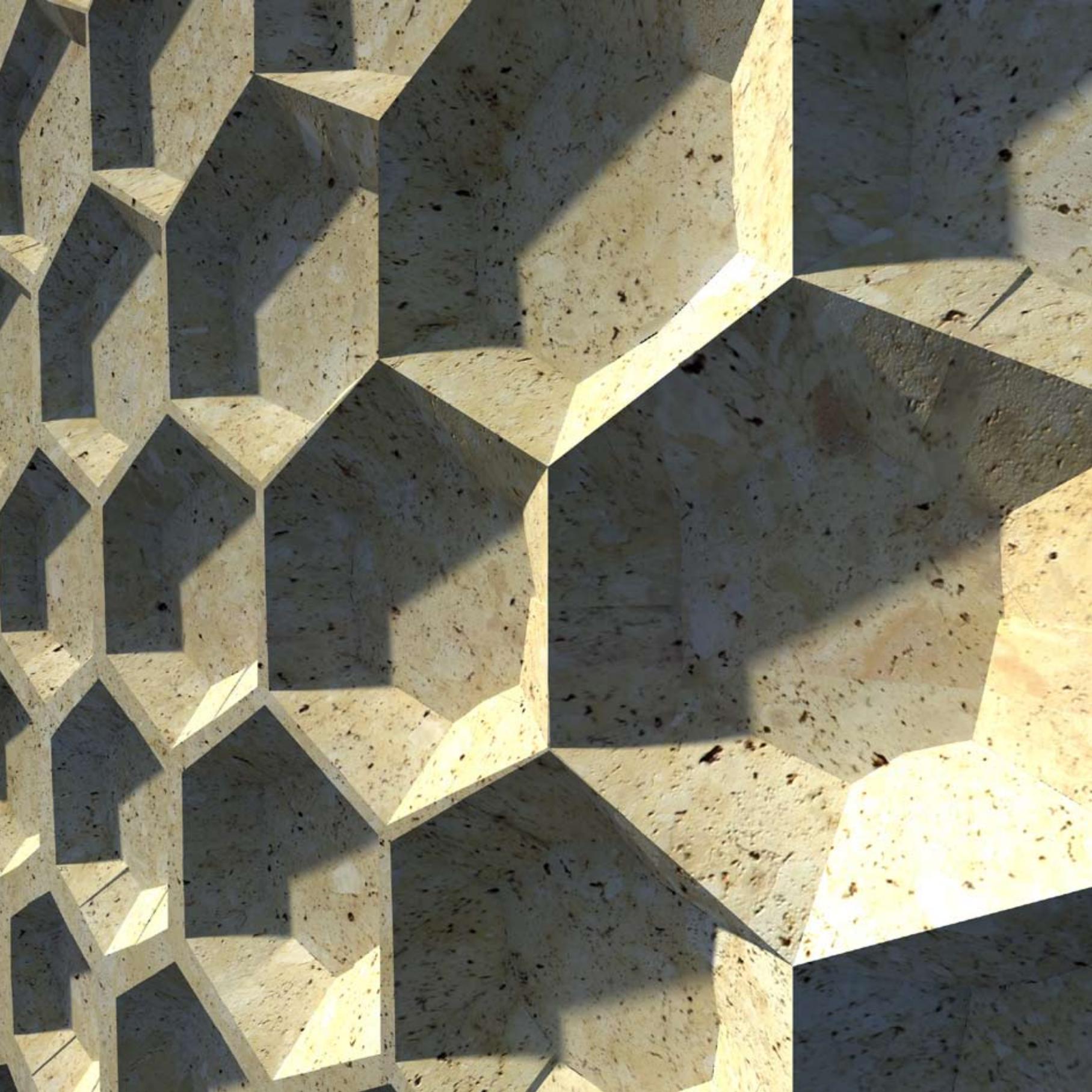


Marble and other ornamental stone has always been used to decorate both the insides and outsides of buildings and monuments. The load bearing qualities of stone is usually associated with less precious stone types, hidden within the masonry structure and often plastered or tiled with ceramics or marble. The idea behind the Stone Surface project was to give an aesthetic dimension to the external facies of a load bearing construction made of limestone.

We decided to re-interpret the ancient techniques of ornamental stone dressing known as 'specchiatura' or 'mirroring' in which the symmetry of the veins forming geometric patterns (squares or rhombus) in the slab are 'opened' revealing the natural veins and grain of the stone which in turn become a pattern to recompose and reiterate .

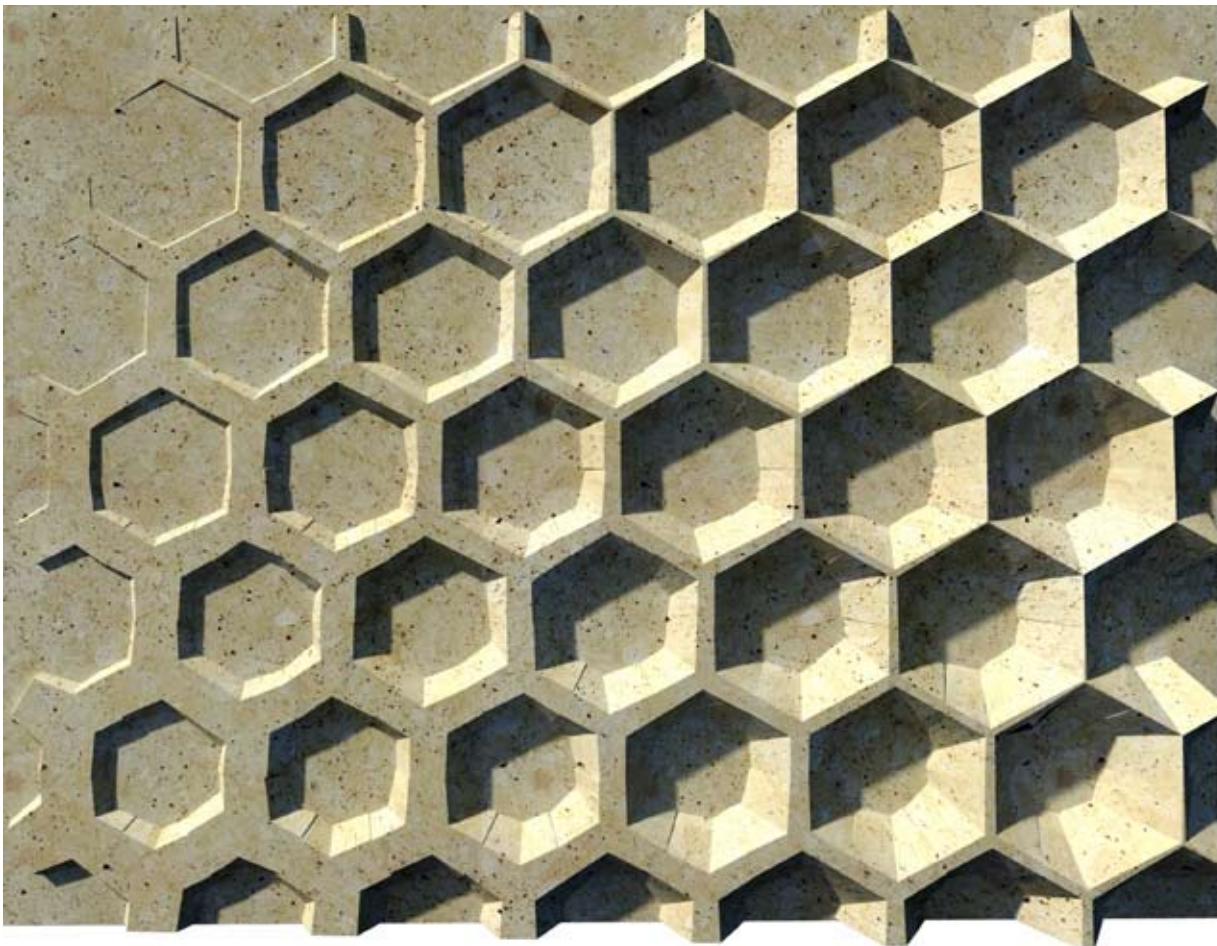
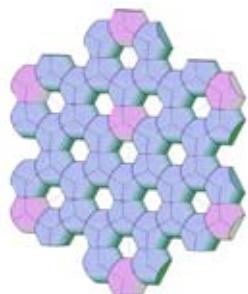
Today's infographic modelling variational parameters of the nurbs surface allow us to construct, using numerical control machines, the vein patterns in relief on the new stone surface.

Plastic veining, created by engraving a few centimeters into the surface of the stone, gives the whole stone edifice a highly aesthetic quality through this form of 'inscription' that in natural light assumes a chiaroscuro depth.



95. Utensili da lavoro, disegno di C. Gaul

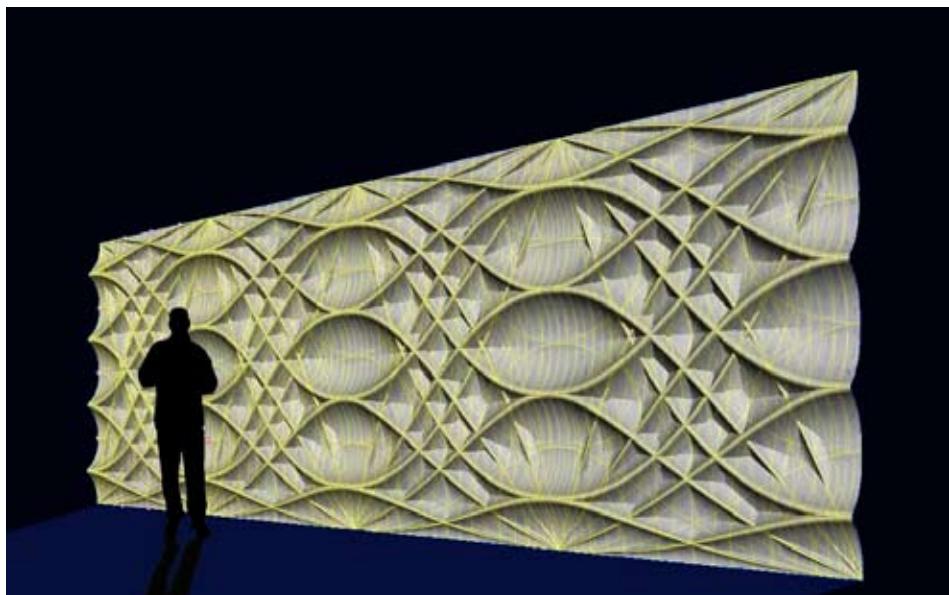
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



95. Utensili da lavoro, disegno di C. Gaul



96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

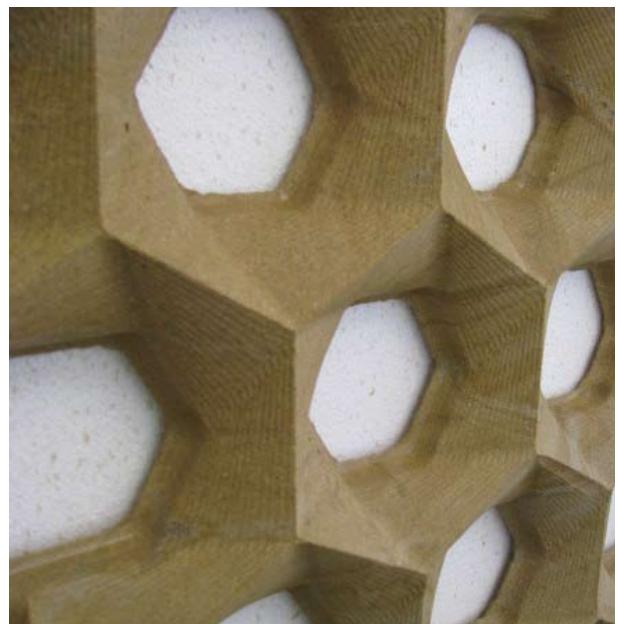
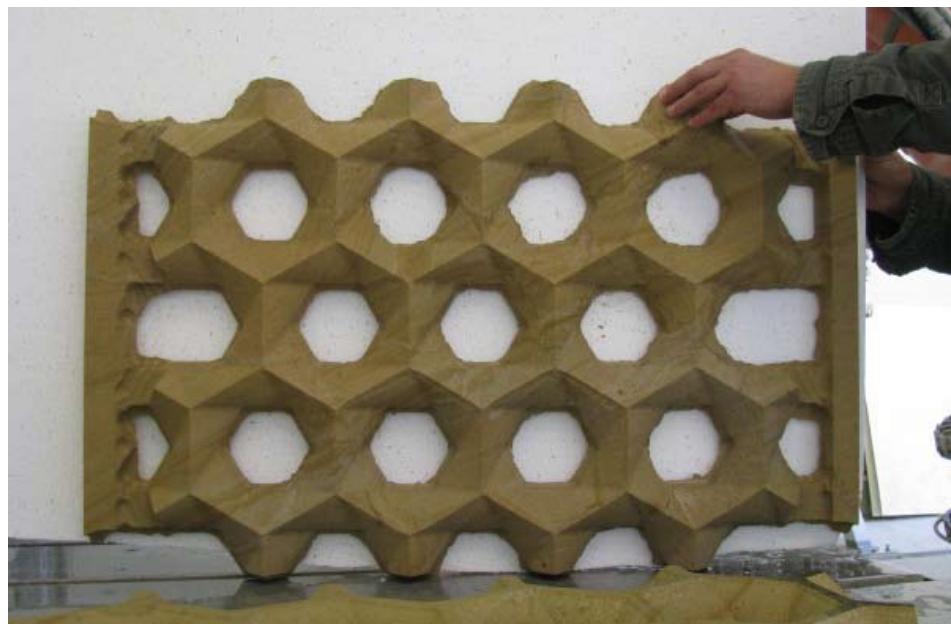


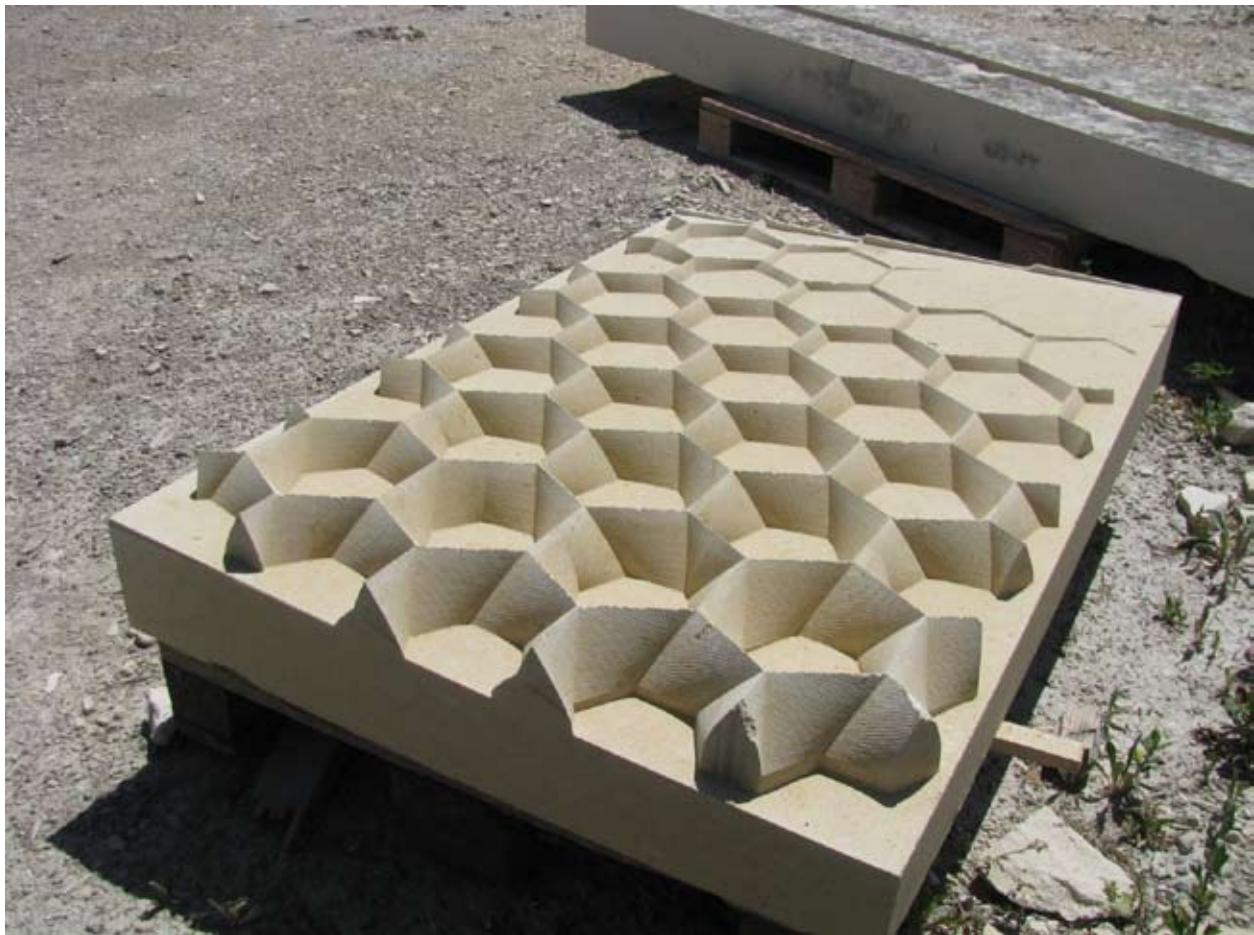
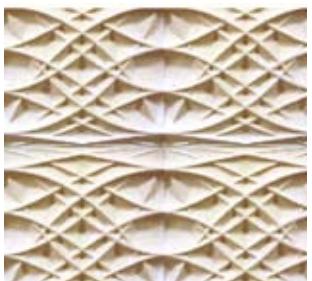
Three-dimensional infographic technologies offer the possibility to design patterns on flat or curved surfaces that can be infinitely repeated in a complex decorative mosaic, through rotation and mirroring. These prototypes were conceived of to give ordinary building stone an aesthetic dimension that could be of interest to the building industry, enabling it to utilize techniques that were hitherto inaccessible.

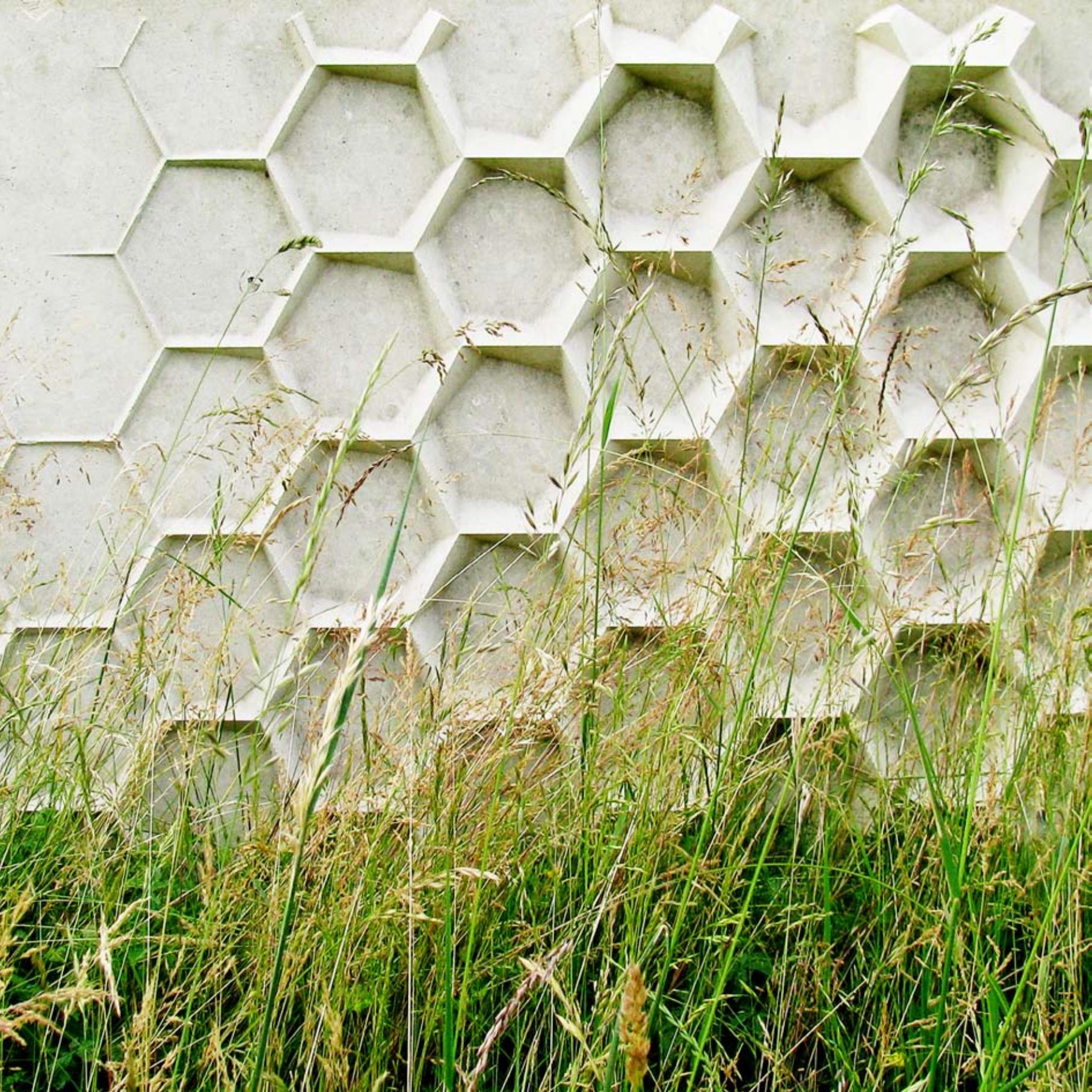


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993







95. Utensili da lavoro, disegno di C. Gaul

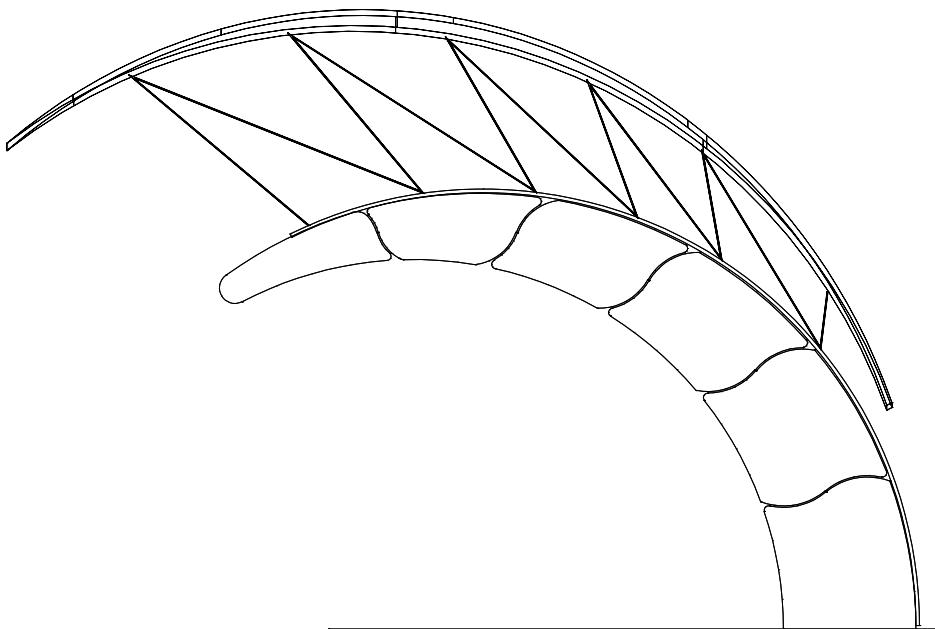


96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



Foglia

Domus Petrae inauguration
Enterprise "Leopizzi 1750"
Parabita, Lecce, 2009



The Foglia prototype is a large stone projection for the creation of balconies, generally, or canopies. The idea came from reading Reymann's Tract on the technique of constructing a dome without the use of scaffolding, using counter-weights attached to the ceiling during the construction phase. The static principle at the basis of this notion, is that the equilibrium of an arch under construction is obtained by introducing external forces that prevent the collapse of the structure. If the arch is conceptually divided into two, in order for there to be equilibrium between the parts, it is necessary to supply a counter-weight to the suspended keystone which is exactly in the middle of the structure that is still missing.

This force can be supplied by introducing a 'leash' into the extrados that through a traction system, blocks the keystone in the semi-arch, guaranteeing the compression of the ashlars. Paradoxically, in this way, the more traction applied, the more the load bearing system is static. The discrete elements are held together in delicate equilibrium of the blocks. The curved joints of the ashlars are coated in neoprene, applied in such a way as to allow the necessary movement to dissipate the dynamic energy that such a structure naturally incurs.



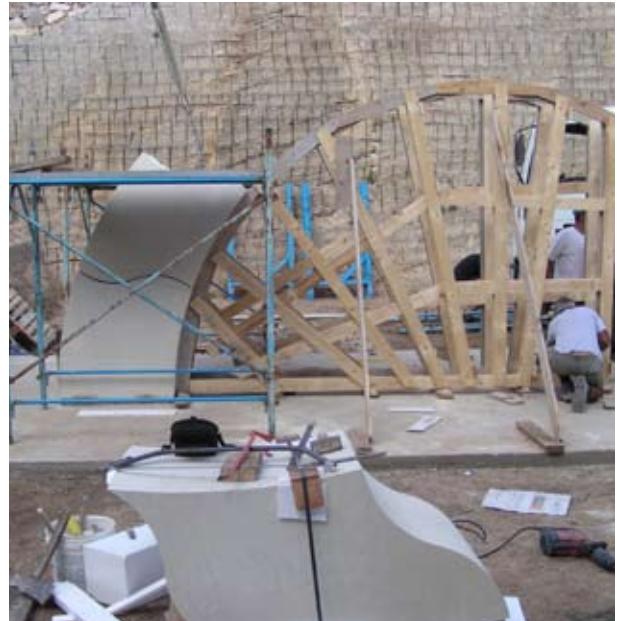
95. Utensili da lavoro, disegno
di C. Gaul

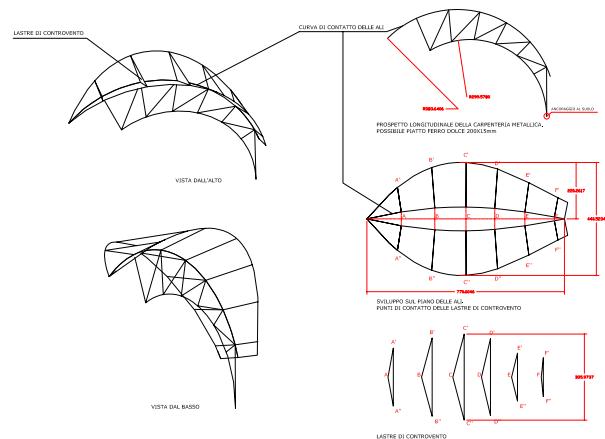
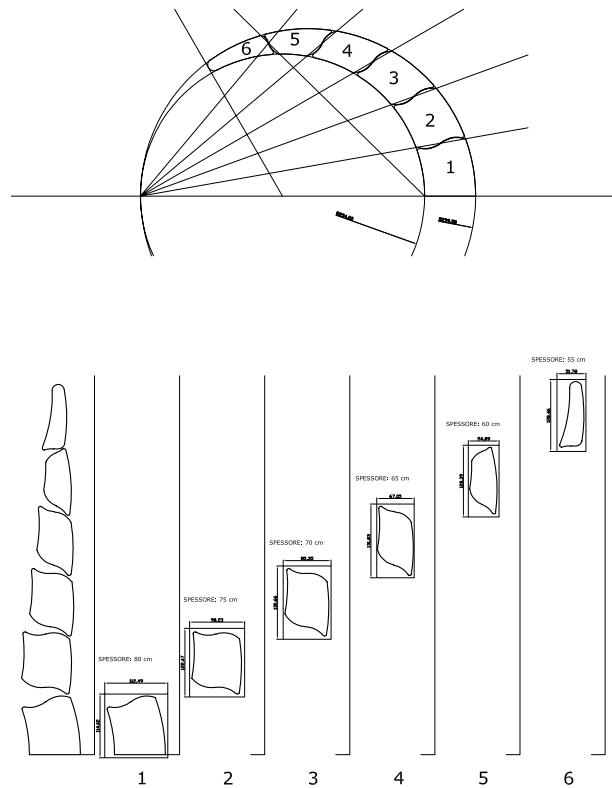
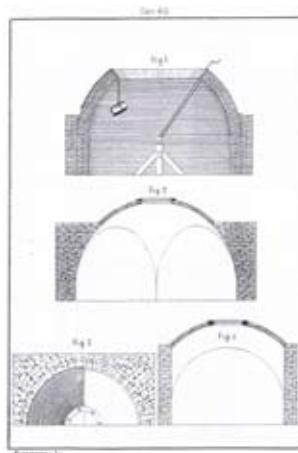
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993







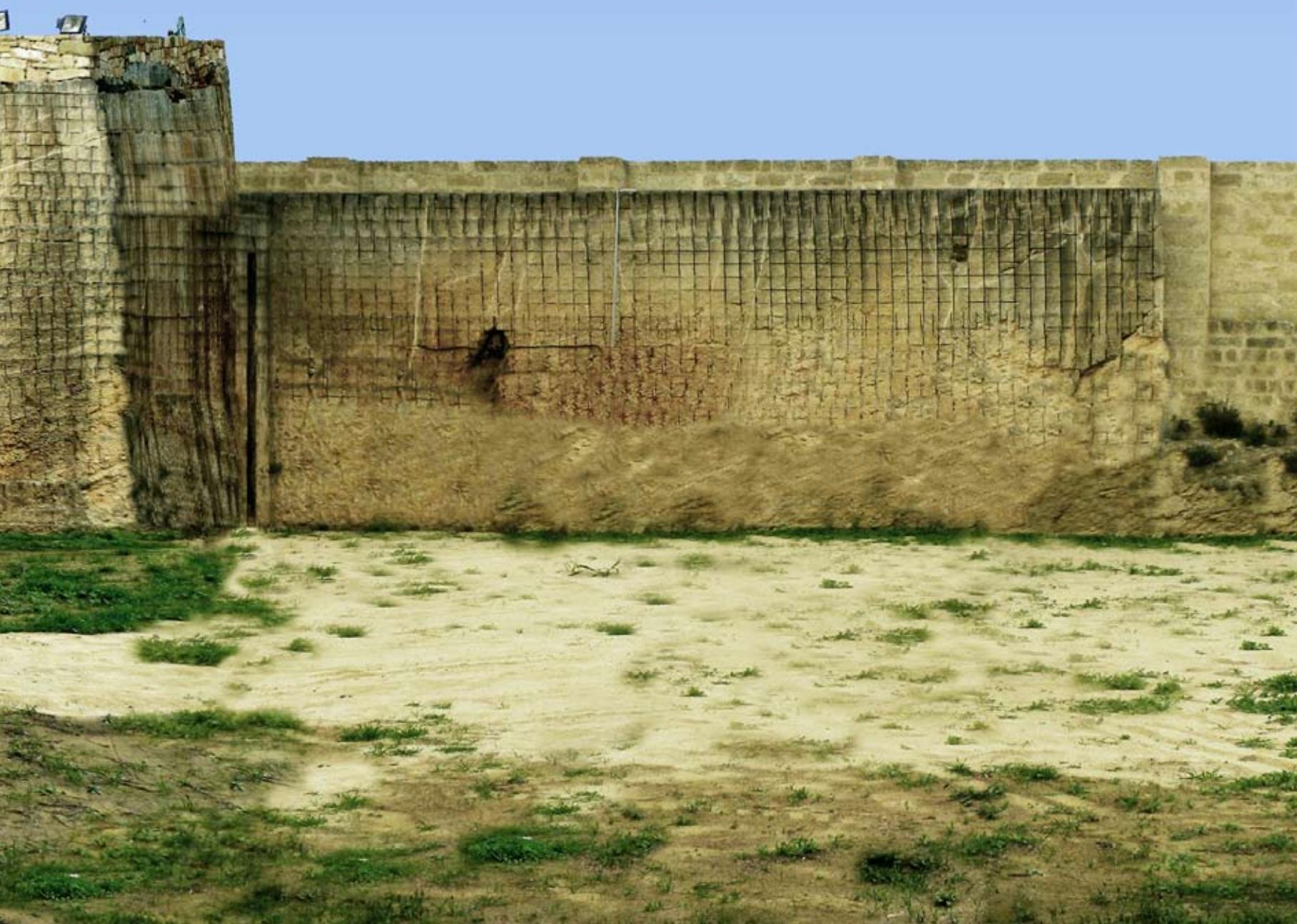
95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

In order to exemplify the notion of lightness that the name of the prototype implies, we thought of fixing a large metal leaf to the metal pillars of the stone extrados to increase the static performance of the work. The protruding stone structure measures 5 mt., 7mt. including the metal structure, the suspended ashlar weigh almost 4 tonnes. The paradoxical elasticity of the prototype gives ample space to reflections on the construction of earthquake proof structures that might counter weigh seismic activity. By reiterating the structure in sections, it is possible to create large roofing systems.





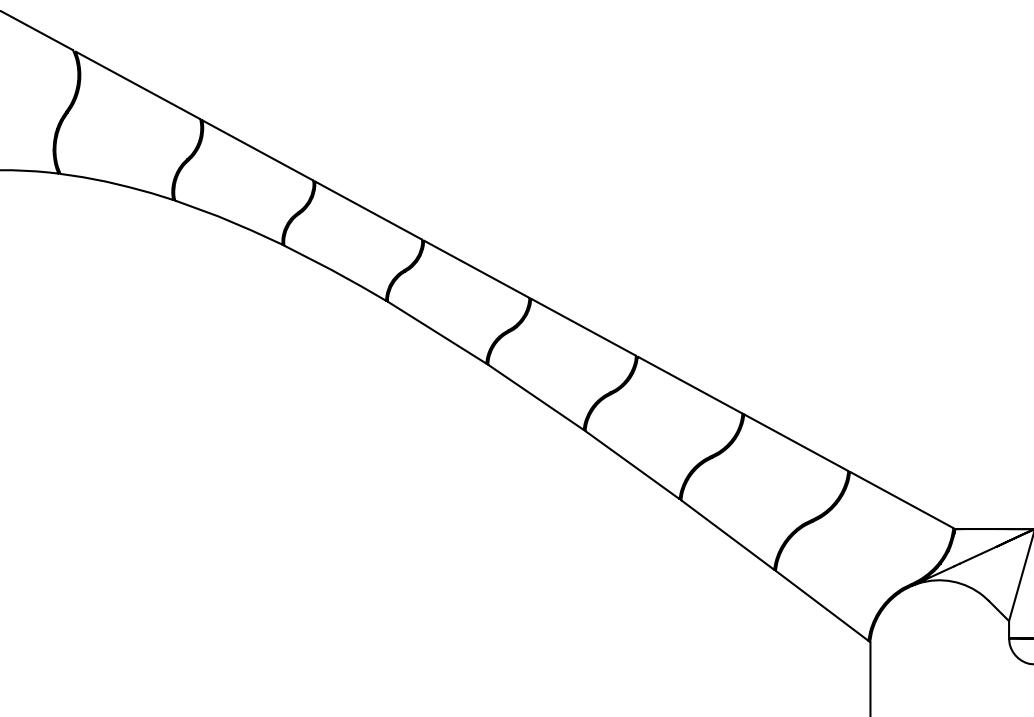


SNBR Arch [1] boureaux

Stage Stereotomy
Enterprise "S. N. B. R."
Brignoles, 2009

Taking its name from the company that designed it (S.N.B.R., Troyes) this arch was made for the first time to scale 1:2 at the APA (Atelier de la Pierre d'Angle) in Brignoles (TL). The aim was to verify directly on a real prototype the precision of the construction techniques regarding assembly and its static resistance. This was done in two ways: using a pre-stressed reinforced arch and in a naturally compressed arch. The arch was designed with a rectilinear extrados on which a wooden ceiling structure was positioned, and a parabolic intrados. The joints between the ashlar have a geometrical sinusoidal shape that increases the contact surface between the stone blocks, allowing greater friction between them, permitting at the same time micro-articulation during the assembly phase and afterwards. The intrados curve follows the catenary curve of the pressure the arch is subject to improving the mechanical behavior. The final shape of the curve is a perfect balance between geometry and the stone blocks designed to improve the performance of the structure, reducing the uses of stone to an essential minimum.

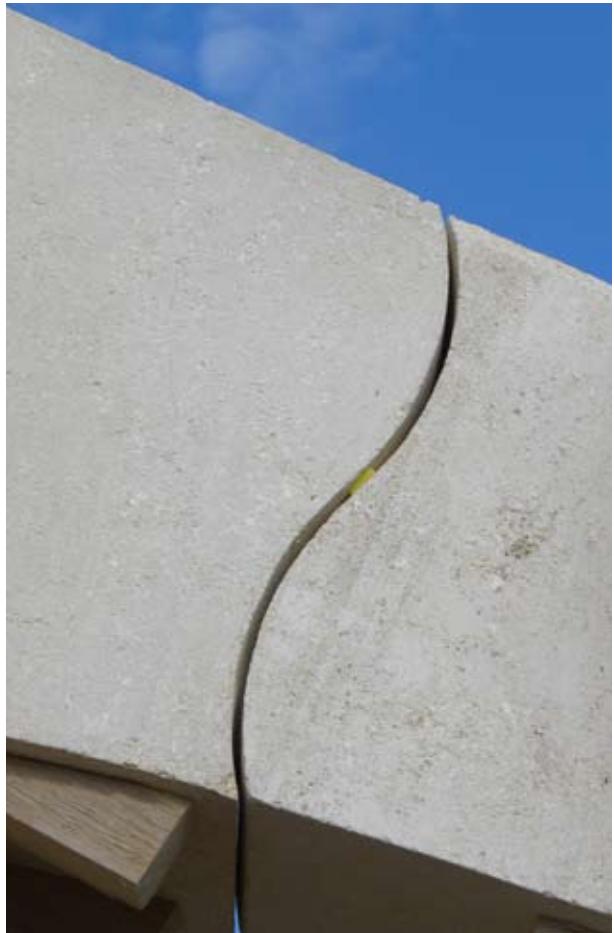
To improve the static behavior of the arch in an earthquake zone, a pre-compressed arch, using spring steel cables threaded through the masonry was also constructed.



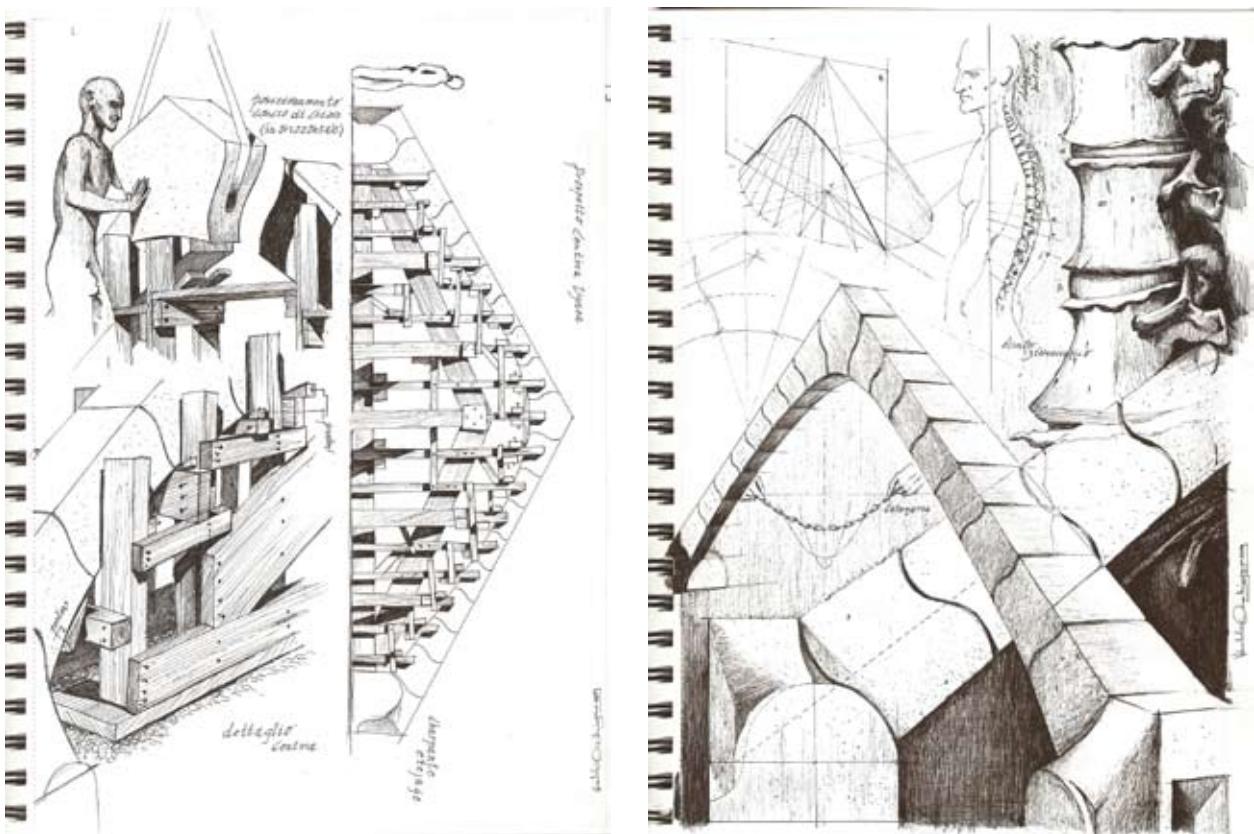


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



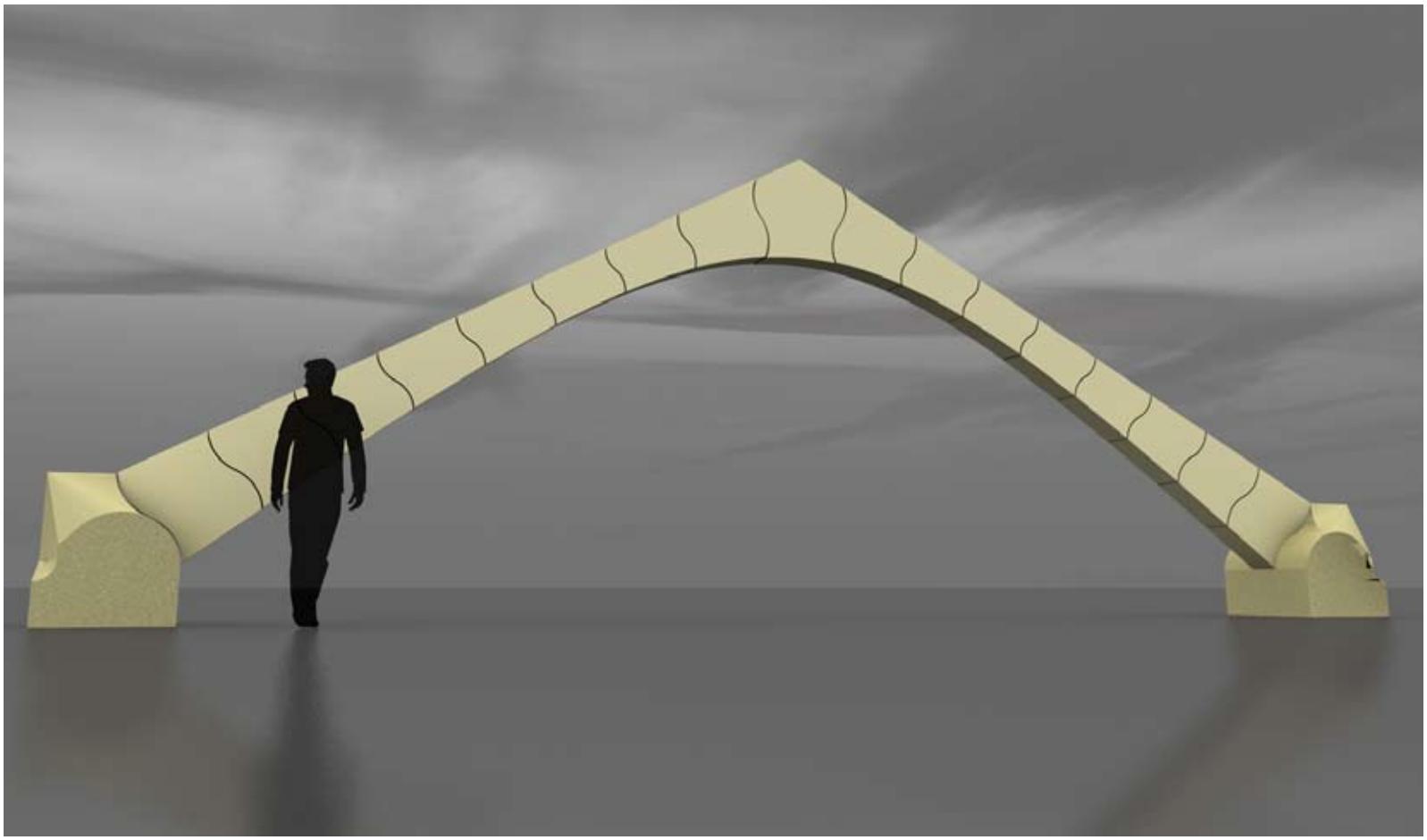




95. Utensili da lavoro, disegno di C. Gaul

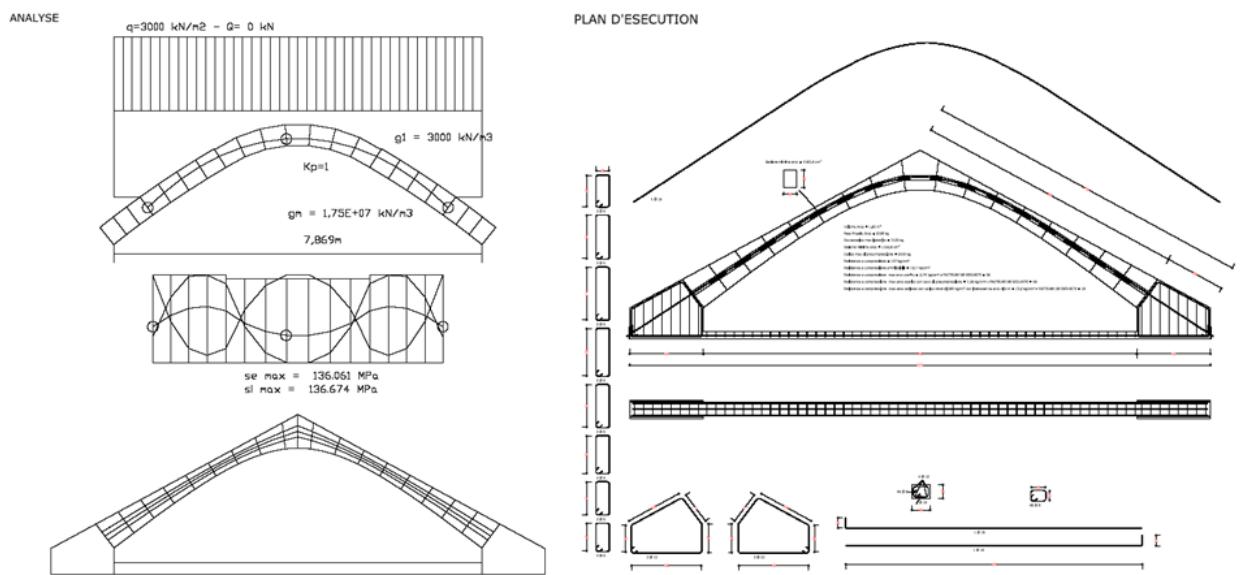
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

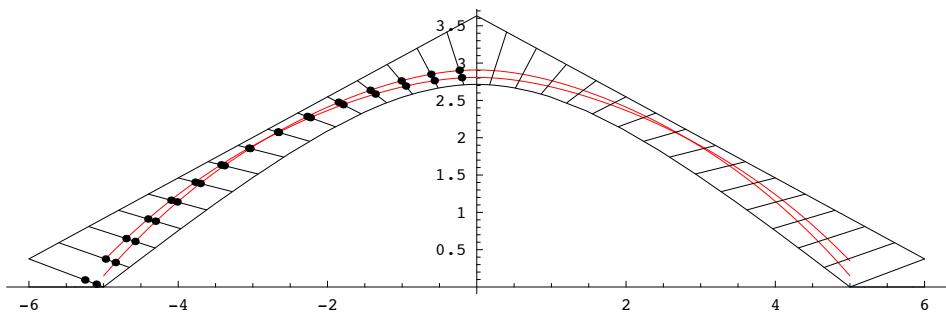




95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno di C. Gaul



96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993



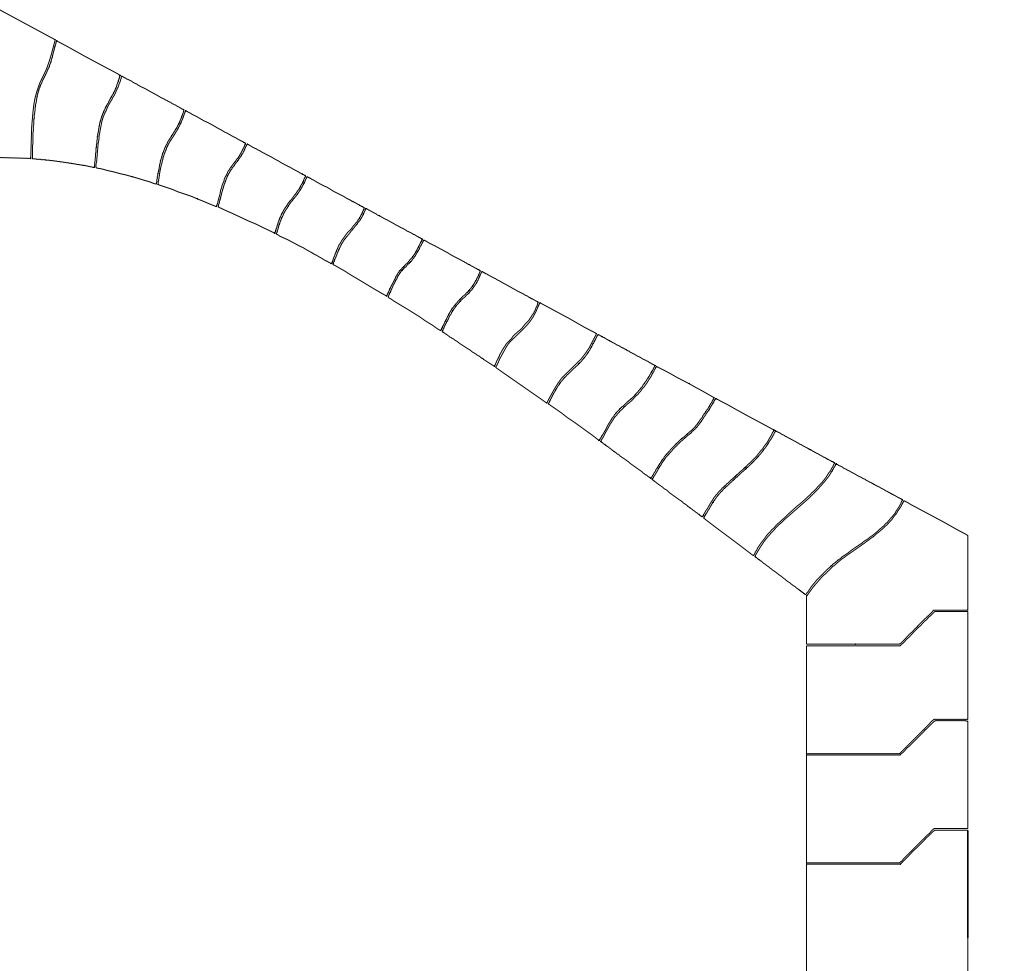


materiel



SNBR Arch [2] maison

Stage Arcs
Enterprise "S. N. B. R."
Brignoles, 2010



The portale composed of the SNBR arch built on linearly pre-stressed imposts, is the prototype that when reiterated , forms the structure of small ecological housing designs in stone and wood. The imposts are made of jointed interlocking blocks that undergo a linear pre-stress using the post-tension of a steel bar in the centre of the impost, about $1/3$ from the internal border of the base. This way, the impost counter-weights the horizontal thrust that the arch naturally exercises. The arch might also be reinforced internally and prestressed continually with the imposts in an earthquake risk area. During the development of the prototype, we decided to give the imposts spaces to insert wooden beams for any eventual decision to divide the space within the portale in two.

These beams, when anchored into the imposts, function as tie-beams counter-weighting the horizontal thrust of the arch together with the prestressed imposts. The aggregation of several portales, aligned linearly or in a circle, allows for a variety of formal building varieties.

95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



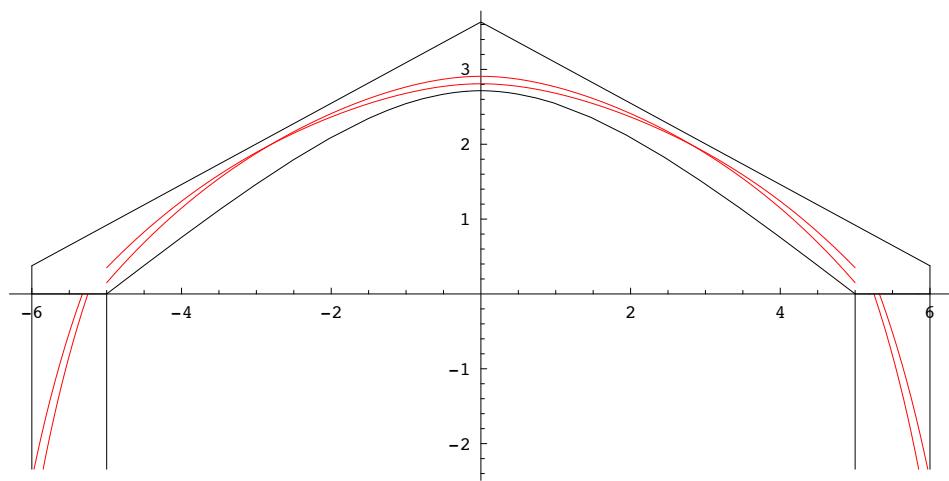
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



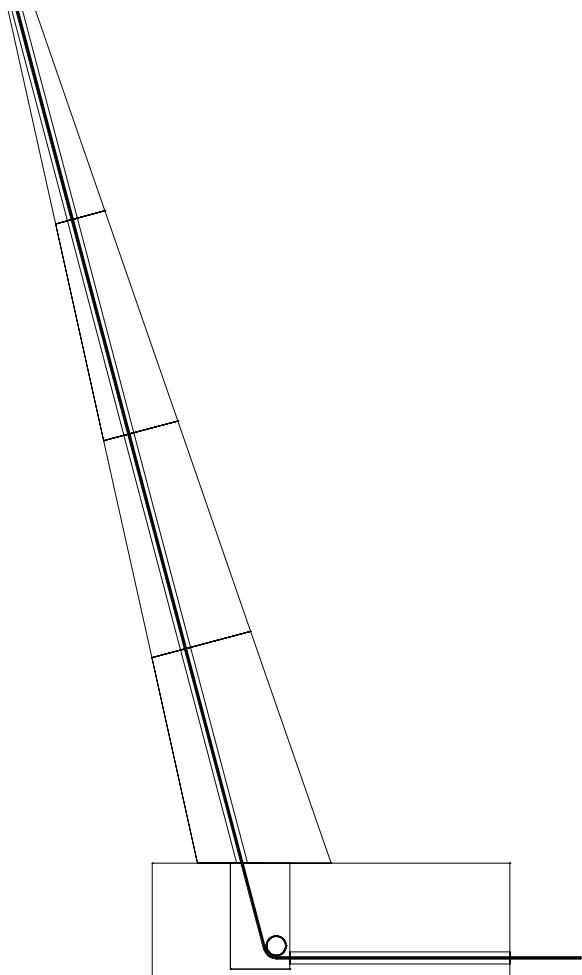






Oblique Obelisk

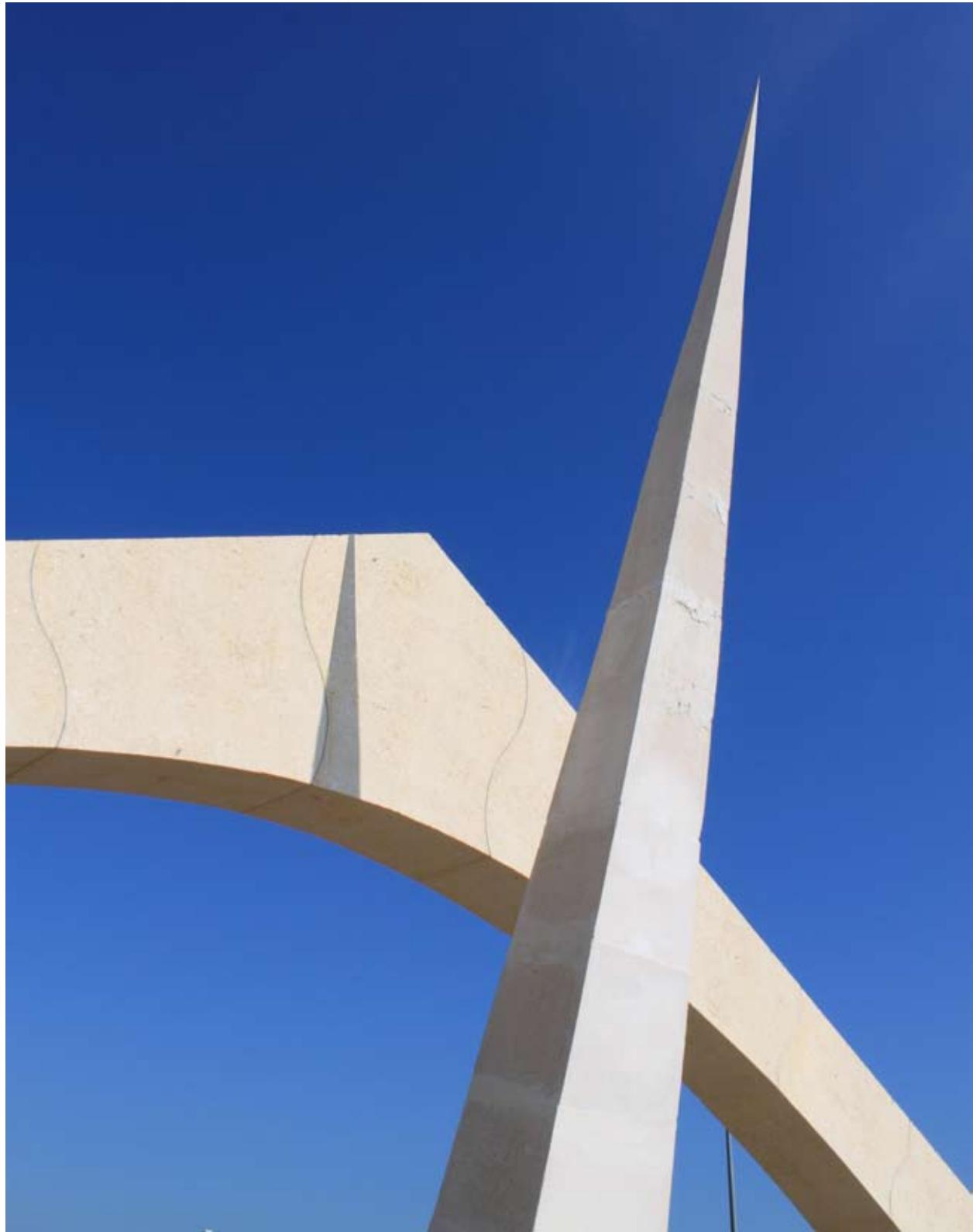
Stage obelisk
Enterprise "S. N. B. R."
Brignoles, 2010



The construction of this prototype was aimed at the study of stone architectural elements that, when positioned obliquely with respect to the horizontal lay out of the floor plan, lean outside the geometric centre of the construction. Traditional modern technology resolves this problem of equilibrium by utilizing reinforced stone or cement, especially by using carbon bars set in bi-component epoxy resin inserted through special holes drilled into the stone blocks. The gnomon sundial that in order to tell the exact time has to, geometrically, end in a pointed pyramid shape, is a good example of this morphological construction. The shadow cast by the gnomon functions as the hands of a clock, telling the exact time. The geometric shape of the obelisk is similar to a leaning pyramid or gnomon with its base an isosceles triangle and the ratio base-height 3:1. The carbon bars are positioned in such a way as to connect the vertex of the obelisk with a point in the triangular base about 2/3 from the cathetus. Each ashlar is then fixed in place using a dedicated product that prevents the seeping of epoxy resin into the axial bore of the ashlar or into the contact surface between blocks. The carbon bars were bonded into the foundations of the obelisk using a direct injection of epoxy resin from the top of the obelisk. The obelisk then assumed its monolithic structure, solid and permanent notwithstanding its apparent instable static appearance.

95. Utensili da lavoro, disegno
di C. Gaul

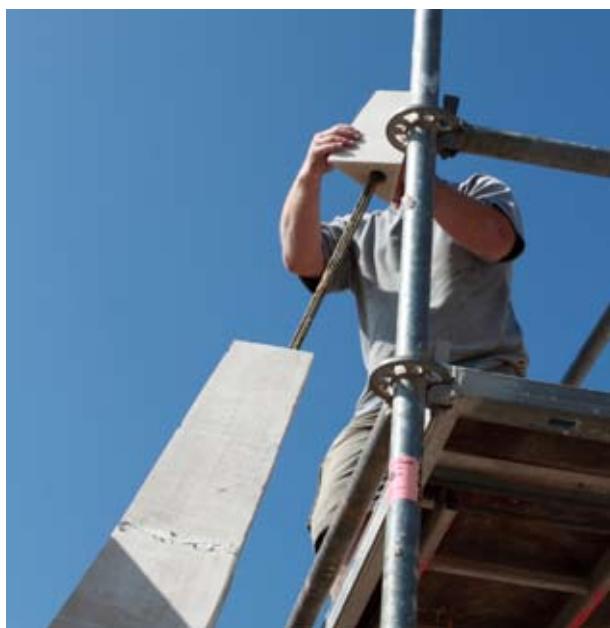
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



95. Utensili da lavoro, disegno di C. Gaul

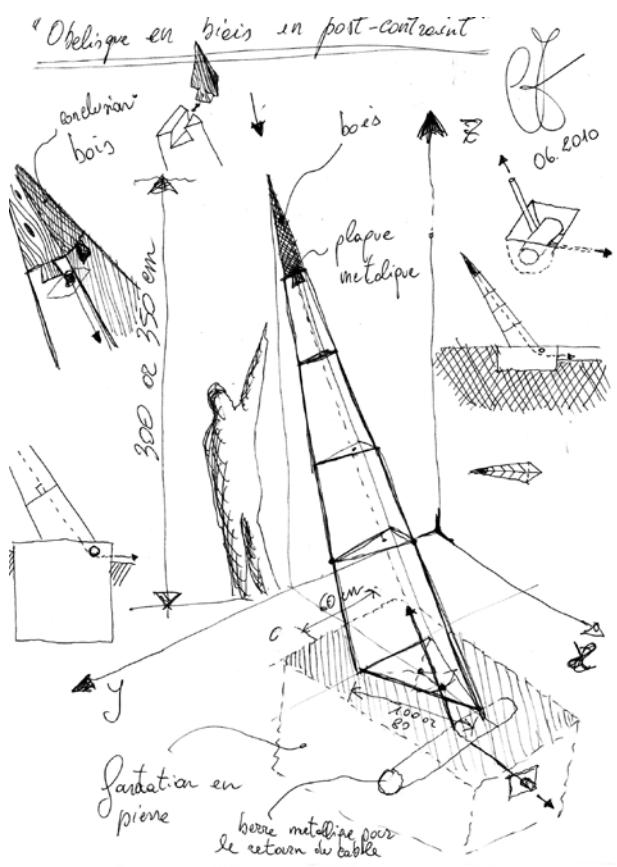
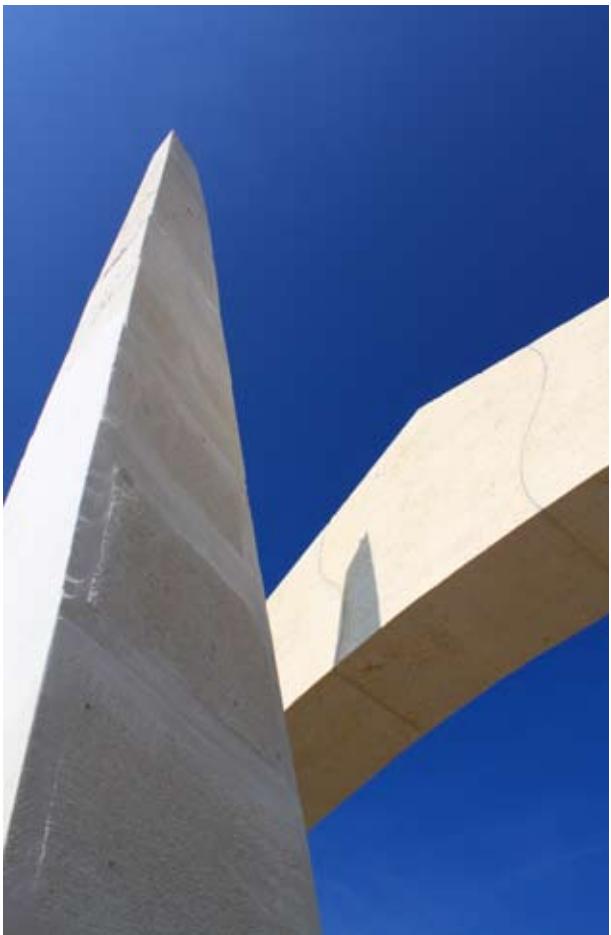
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno di C. Gaul

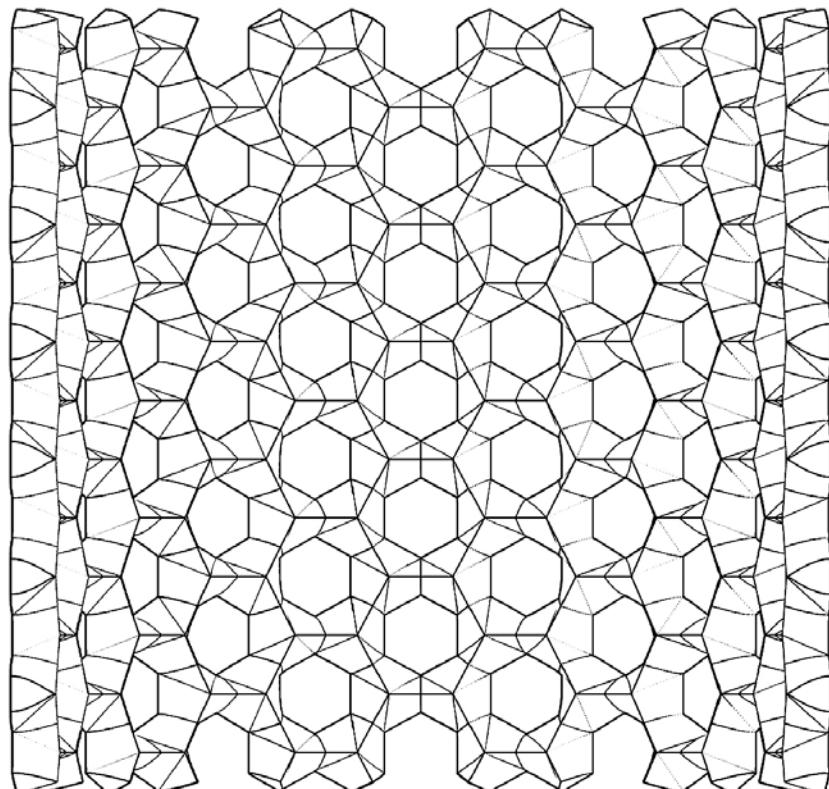
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





Alveare

Stand PIMAR srl
SAIE 2010, Bolognafiere
Bologna, 2010



Alveare 2010 is a complex decorated and perforated stone barrel vault that was assembled using a limited number of serial ashlar cut using a CAD-CAM and numerically controlled machine system. The specific conformation of the curved surface can also be used for modular wall systems and self supporting dividing walls. The serial ashlar is wedge-shaped and the constructive curve, like the whole construction, is parametric and can easily be applied to a wide range of construction and aesthetic requirements. The connection between ashlars is guaranteed by the natural compression between stone blocks in the barrel vault and, in walls by using a specific mortar with wooden plugs. After assembly, the notion of solidity is rendered by the exemplar interweaving of the blocks in the whole system.

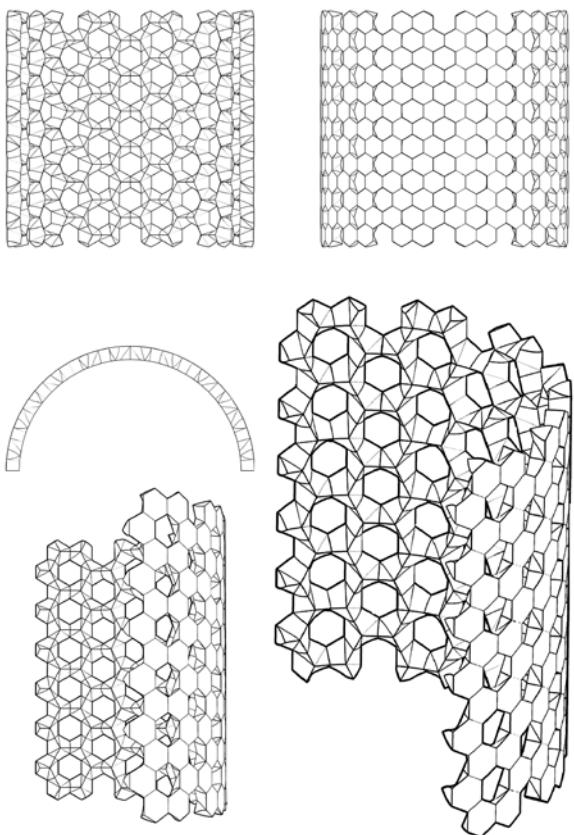
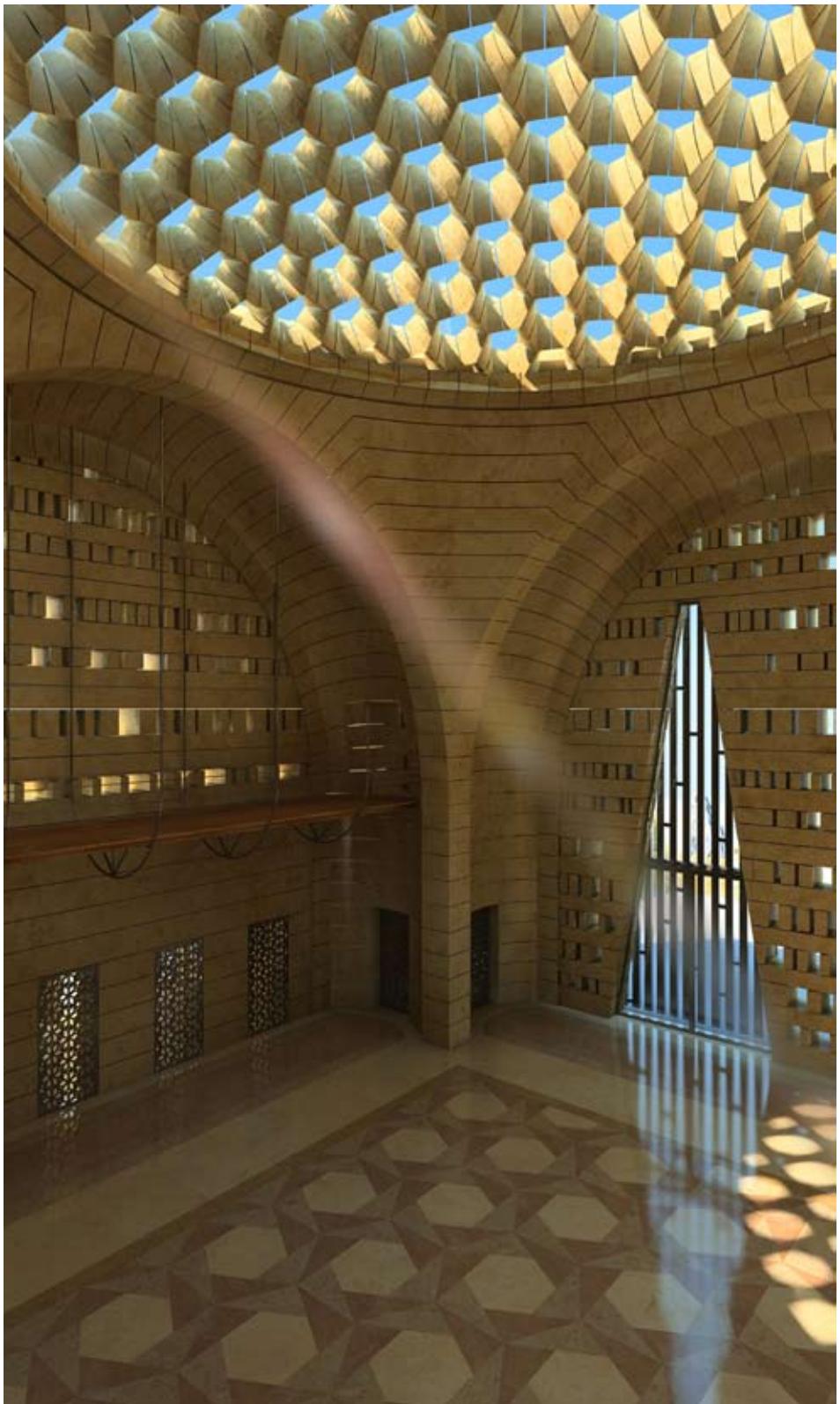




95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



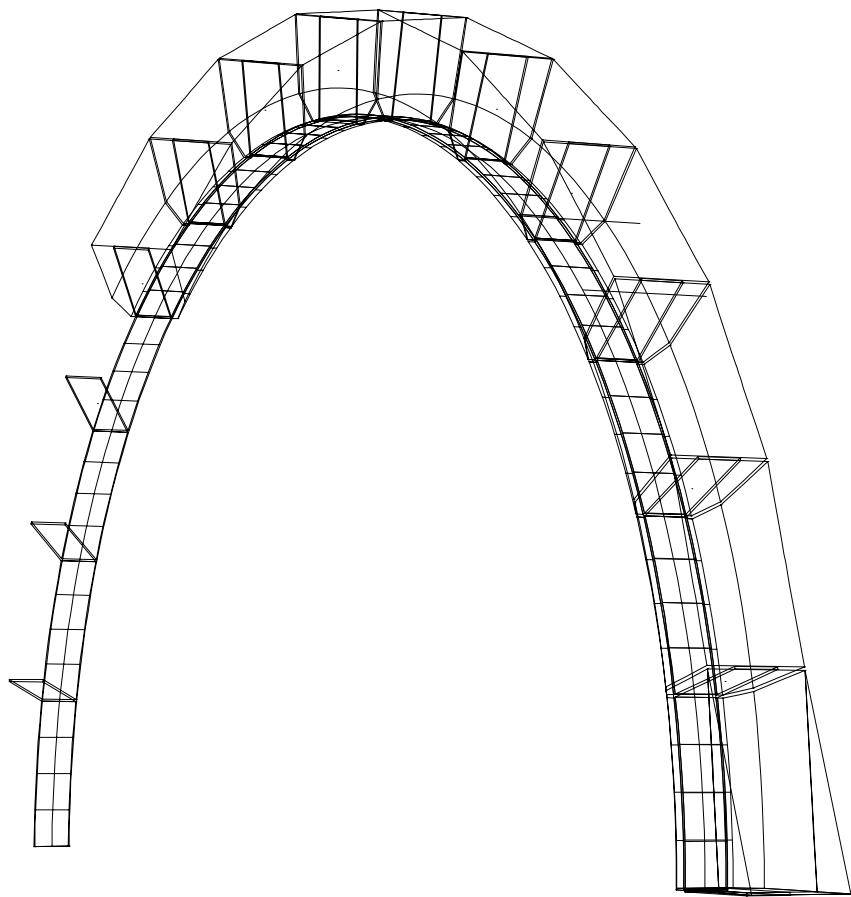


"Viollet le Duc" Arch

Stage

Sede "Société Nouvelle Batiment Regional"

Brignoles, 2010



Over the years, and within a continually changing cultural climate, the role of reinforcement in architecture has gone from being principally structural, something to be hidden within the structure, to assuming an integral and visible role in the aesthetics of the building. E. Viollet-le-Duc was one of the first to understand this tendency and to speculate on the possible future of forms.

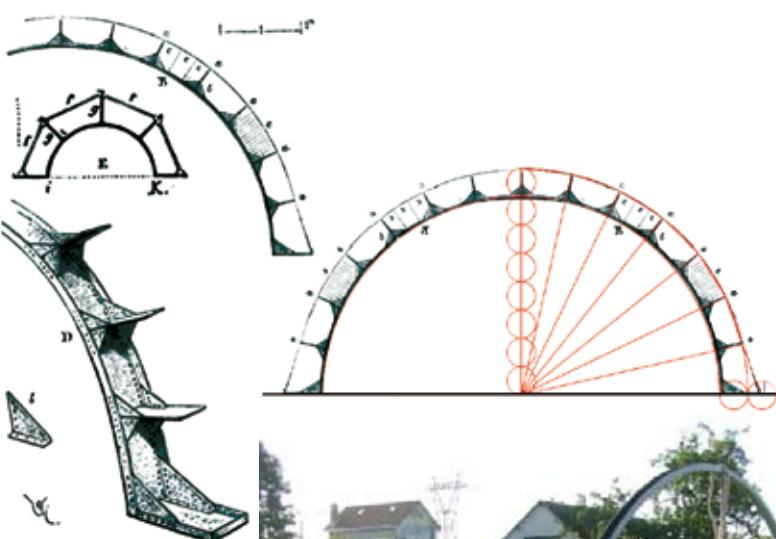
In his work *Entretiens sur Architecture* (1858-72) he proposed a prototype of an arch constructed partially in stone and partially in iron which we may consider the first example of a reinforced arch in history. His reinforced arch was a perfect example of the will to improve the performance of the architectural element by experimenting with the static/mechanical capacities and the morphology of both stone and iron. The great French monuments from the XVIII century, redolent of the desire to project huge stone constructions high into the sky, giving them the appearance of something magically suspended in space, utilized reinforce technologies both hidden within the masonry and revealed to the naked eye as worthy of praise as the most intricate stone mason's work.

Viollet-le-Duc's arch has an intrados made of riveted steel and lateral radial metal vanes.



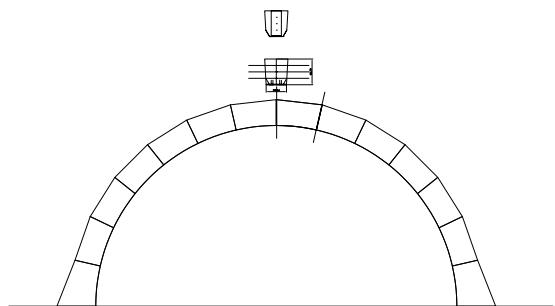
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



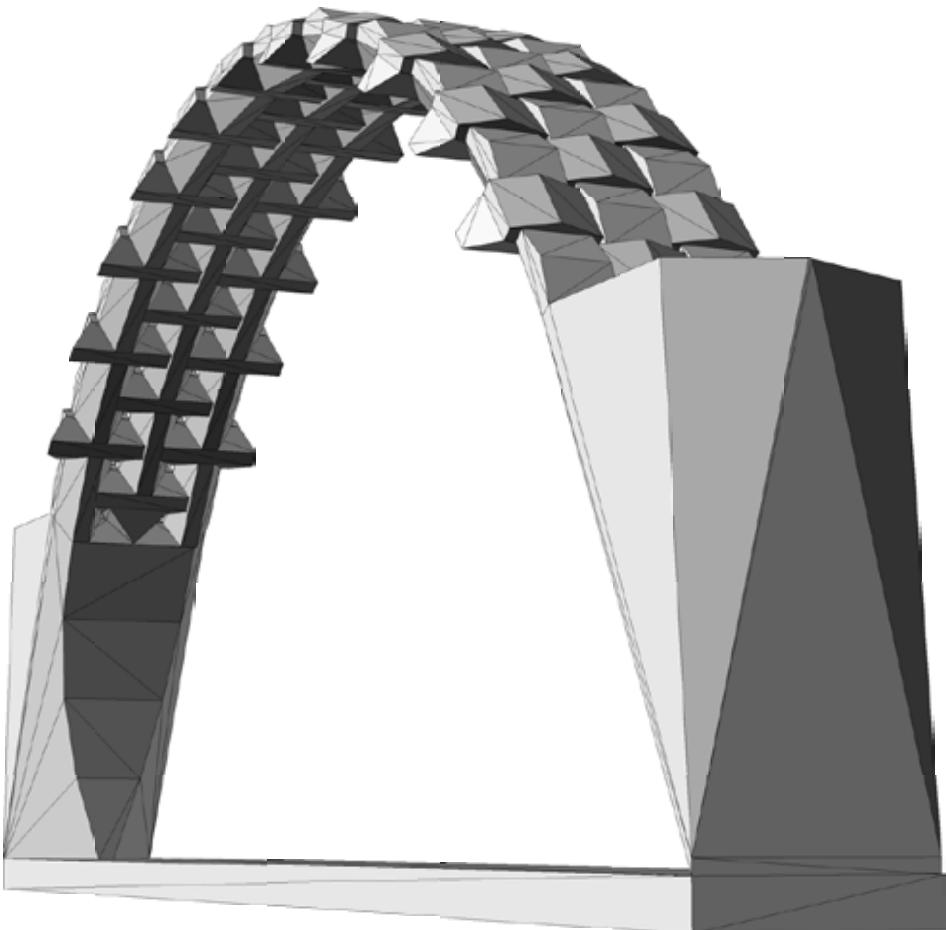


These function as the metal version of stone contact surfaces, and are sloped, with respect to the horizontal plane just like joints in an arch. The function of the steel bands is to keep the arch firm, preventing dilation of the joints and, as a consequence, guaranteeing the absolute stability of the whole structure.



Portale Murgia

Stage "Costruzioni in pietra"
Masseria Zucaro
Andria, 2011



This portale, conceived as a gateway into the Masseria Zucaro, is a variation on the theme of the Portale Abeille, made in local tufa, a much cheaper stone than Leccese limestone. But the biggest difference between this portale and Portale Abeille can be seen in the extrados where here the ashlar are rectangular not square, which during the assembly process generate gaps between the blocks in the vault. This allows the vault to filter in the sunlight from outside through the perforated vault while at the same time, due to the plastic conformation of the extrados, offering an external view of the perforated and interconnected ashlar.

Local tufa stone used carefully in architectural designs can assume great dignity notwithstanding its humble origins and its usual incompatibility with refined stone dressing techniques. The lateral sides of the arch are formed by three rows of ashlar. The perforated vault can also be used to house other materials, like coloured glass, which could also prevent rain from entering while allowing the light to pass.



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

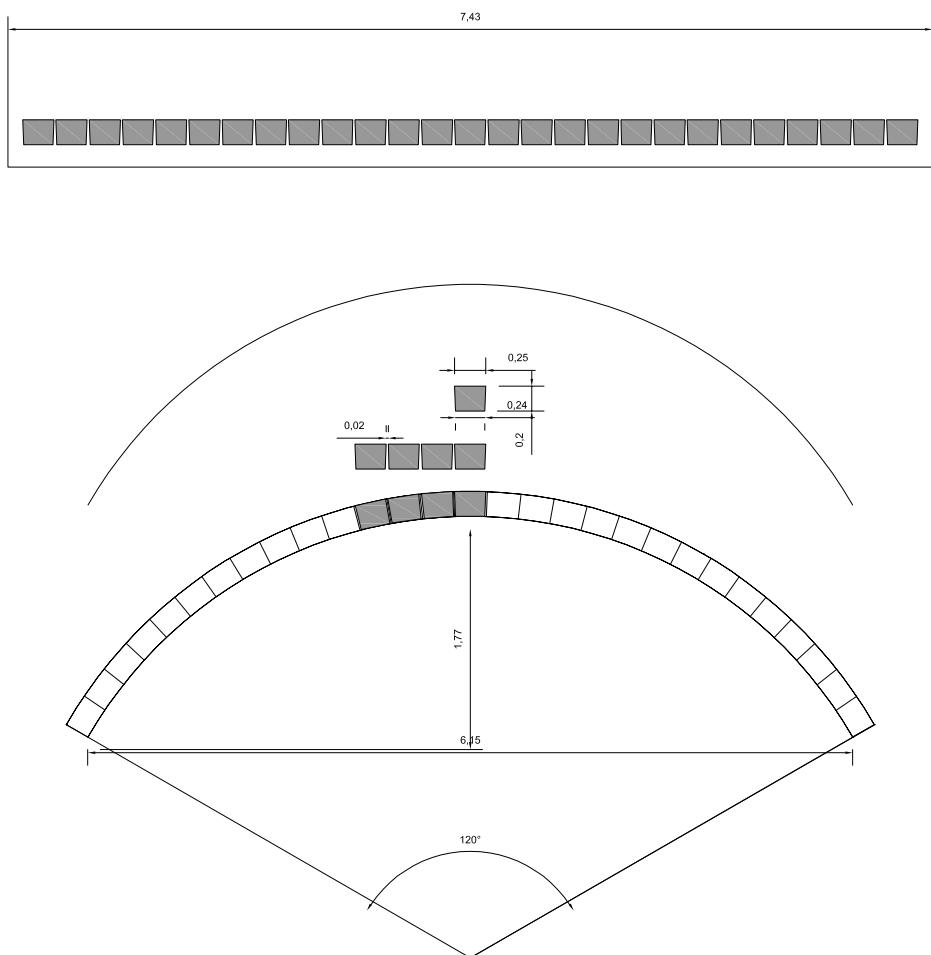
95. Utensili da lavoro, disegno
di C. Gaul





Flexi Arch

Stage "Le costruzioni in pietra"
Masseria Zucaro
Andria, 2011



Valuable insights into the use of reinforced extrados structures in arches have emerged from the research collaboration between Queen's University Belfast and Macrete Ltd, concluding in the patenting of an arch in Ireland named Flexi Arch. Flexi Arch is a unique architectural design that needs neither scaffolding during assembly nor steel reinforcements. Based on this patented design, in 2010 we developed a prototype in the workshop of a flexible arch in tufa with a 6 mt. span. The ashlars in tufa were cut to follow the right curve for the arch and were assembled on the ground before being lifted up. The extrados of the arch was then prepared using fibre glass fixed to the ashlars with bi-component epoxy resin and fibre glass ties. In order to lift the arch into position, a wooden beam (specific for lifting) anchored at three points was attached to a crane which then hoisted the arch onto the imposts. Once in position, the weight of the arch generates a natural compression between the ashlars that creates a flexible stone structure that has no need for reinforcing technologies.



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



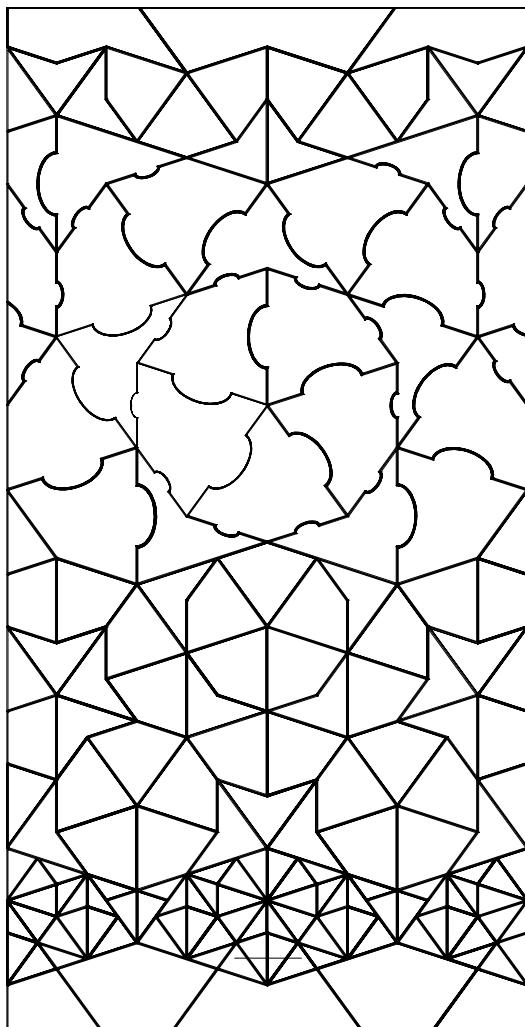
95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993



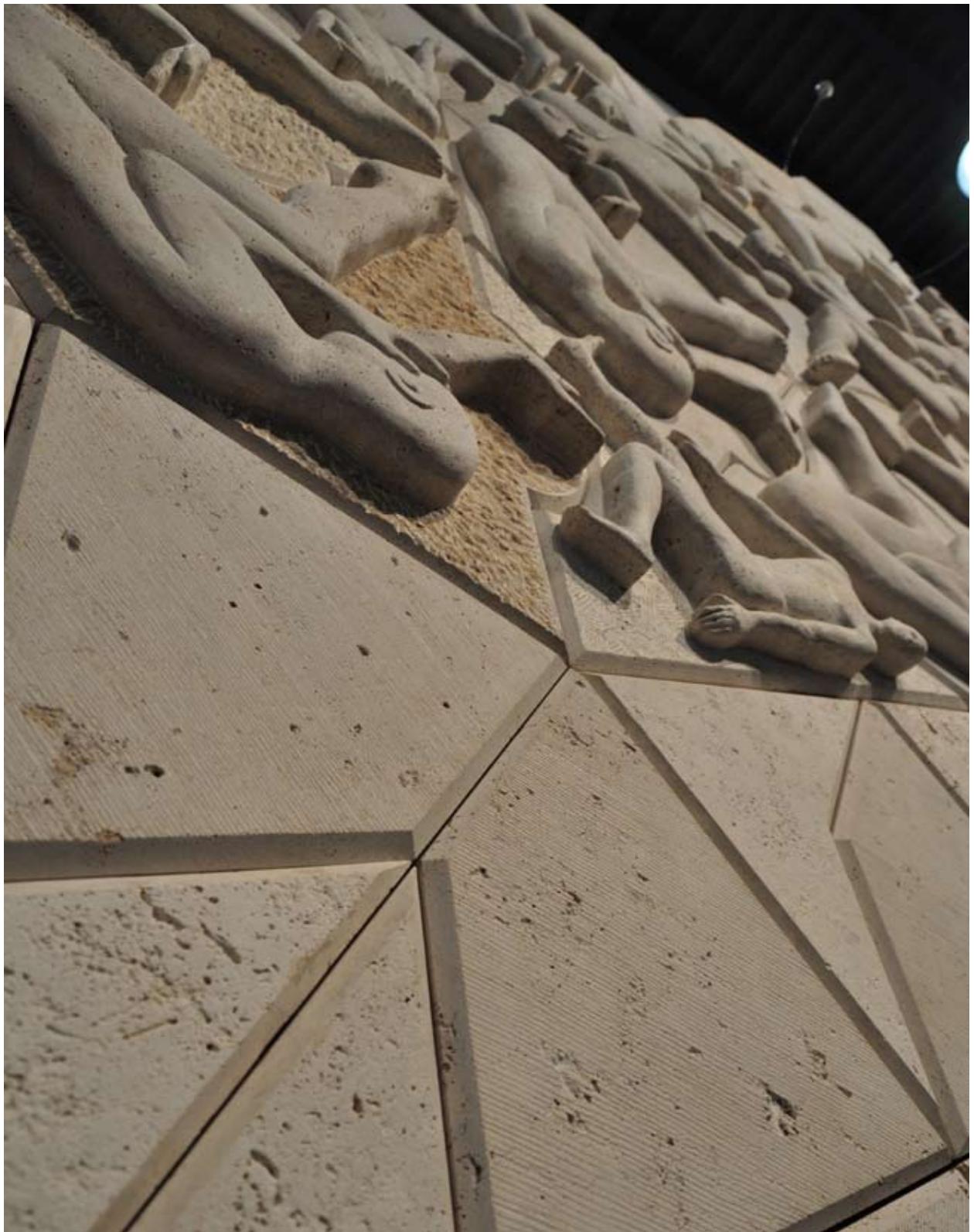
Deco_wall

Mock-up
Marmomacc Meets Design "Mutable Spirit"
Verona, 2011



DecoWall is a mock-up of a 5 mt. high stone wall inspired by the antique technique of polygonal masonry which due to the irregularity of the stone blocks makes the wall more solid and at the same time more interesting to look at. The stone blocks are arranged according to aperiodic tessellation patterns that according to Roger Penrose's definition of aperiodic tesselation (1931) is a design that is obtained by repeating periodically the same shape with no overlap or gap, along two, non-parallel directional planes, until the whole plane is covered. DecoWall utilizes aperiodic modalities by operating a 1/5 rotation of the primary geometrical figures (darts and kites). Both figures, deriving from the rhombus, can cover a surface without reforming a rhombus at all. They are assembled in patterns that may be round or in rows depending on the symmetry of the design and avoid problems of a possible collapse by creating an arch effect.

On the level of composition, the wall is divided into four horizontal bands to which are added a cornice and a basement. This division is reflected in the size progression of the tessellation: the number of tessellation elements double towards the top. The highest band is sculpted with low-relief figures.



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



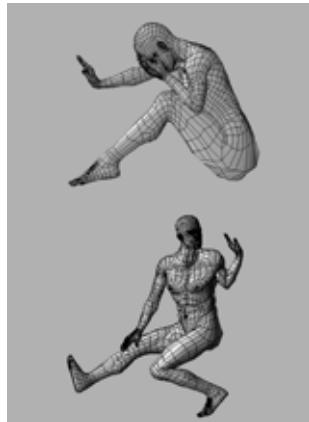
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

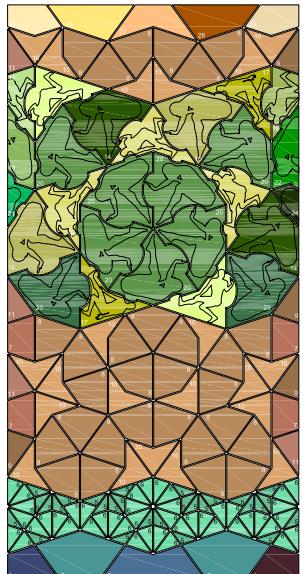


95. Utensili da lavoro, disegno
di C. Gaul

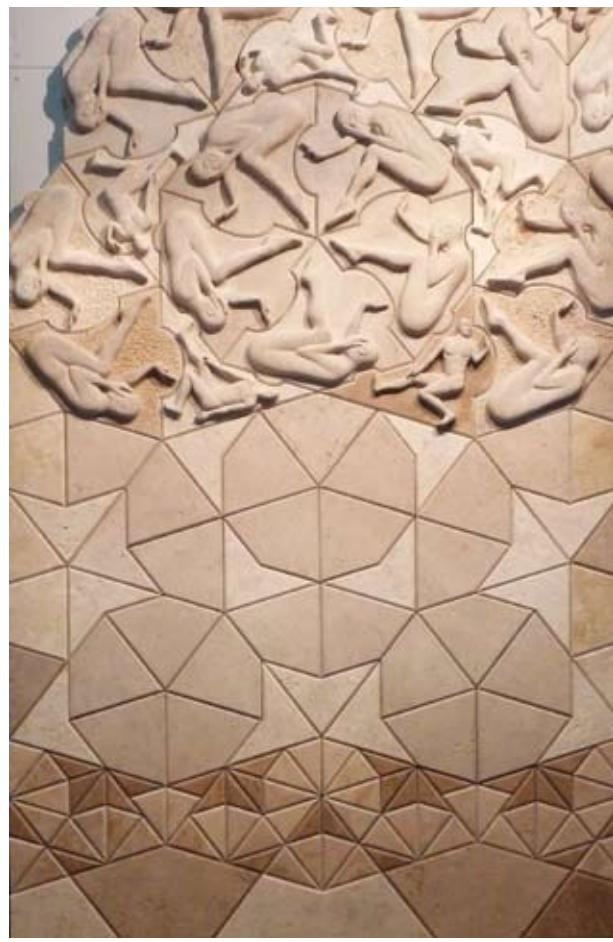
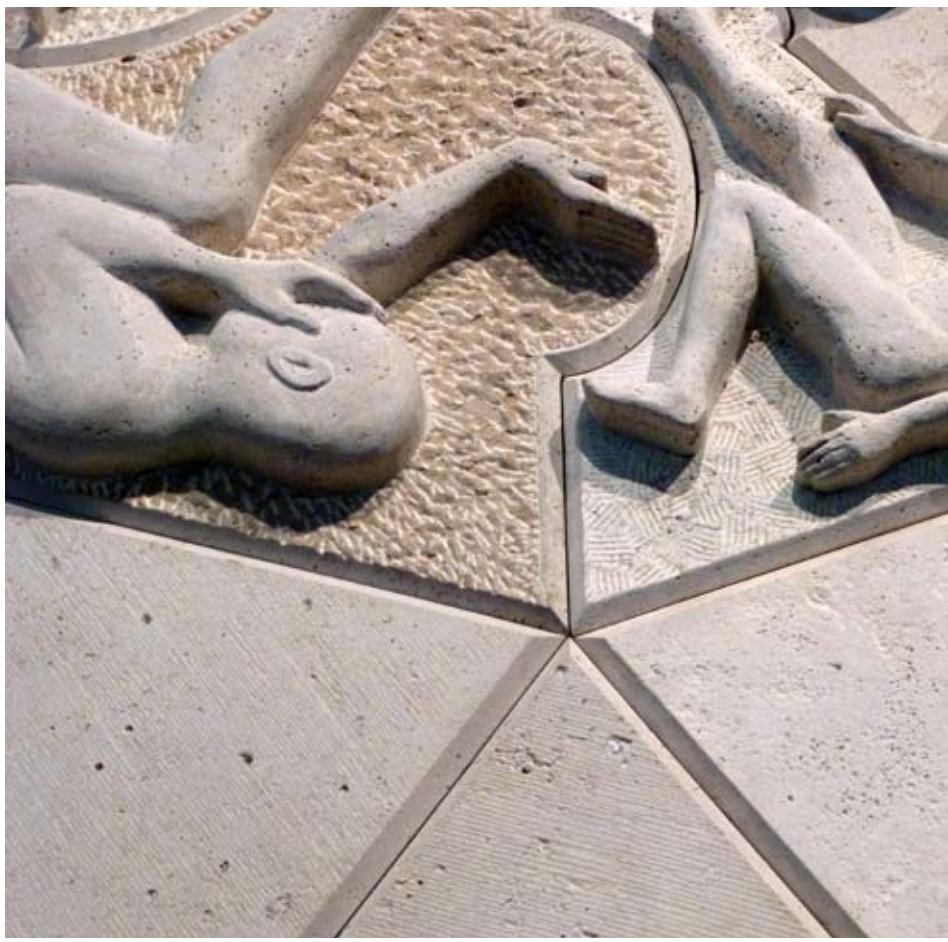
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



Here the stones reproduce a puzzle effect, fitting together perfectly by way of their reciprocal concavity/convexity. The mock-up was made using numerically controlled machines both for the sketch of the low-relief figures and for the shape and size of the blocks, and was then finished by hand by expert stone masons whose expertise gives value to the whole work. The wall was made using several different types of local stone, although the stone that responded best to this type of architectural project was Sutto Haraszti good for cross carving ('croce' or 'fleuri') and Sutto Gazdabànya , which can be carved along the veins.







95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993







Towards a sustainable design project

In 1925 Alvar Aalto suggested we "Build in a natural manner, don't exaggerate, don't do anything without having the possibility of doing it, in time everything that is useless is transformed into ugliness"

I like to think that Aalto's teaching consists in the notion of freeing elementary form from the superfluous, be that plastic, figurative, functional or historical, and to return to being a response to the genuine necessities of man, with simple, formal and tectonic gestures that can be located in natural and sustainable construction techniques.

Today's lack of a dominant architectonic theory, that history has taught us to look for, may well be interpreted as a loss of identity in our contemporary view of design, an incapacity to reflect on or interpret univocally the very future of our society, but may also be an important possibility (and it is this that I believe in) to bring a micro identity, one that is less conventional, to our designs, the quest for a new vitality in, for example, stone architecture.

The projects and the creations introduced in the following chapter all try to trace a future for architectonic research, based on logical precepts and rules of architectonic composition, through building designs conceived as and based on natural materials using innovative techniques. The examples are of houses or buildings, sites of human activity, conceived as paradigms through which architecture can be studied.

The house has been the principal object of experimentation for modern architects in search of formal experimentation, the site where modern theories of architecture can be tested. It is a site of destruction, discussion and reinvention, exasperating, and sometimes questioning of our very mode of living.

The idea of the house is the perfect medium for an organic engagement with the formal, constructive and functional notions of architecture. In particular, it reveals our desire to construct using natural materials, like stone, and allows us to explore the questions of both envelop and of structure, simplifying some themes (such as load bearing walls and enclosing walls, functional and structural bays), while complicating others (tectonic joints, stone dressing, language).

Stone architecture has remained one of the last 'artisan' fields of architecture and it thus remains closely connected to tradition. It is where the stonemason and the architect jealously exchange know-how, each with his own idea of who is the greater craftsman, each maintaining his own cultural autonomy in an age and in a discipline of fragmented knowledge.

At this point, I would like to express an opinion that is seldom agreed with by my friends and colleagues: the architectonic research that underpins these projects makes no attempt to reconstruct the epigenetic of stone architecture within a hypothetical moral continuity of architectural tradition, rather it seeks to 'adulterate' it, having first loved it, in the name of architectonic form.

In Puglia, that region where we live and work, the culture of stone, if we may call it thus, is paradigmatic of the relationship between material, form and order. The material is rock: it has no form and is not directly available, but it has a vocation to form and order. The first step is to recognize that vocation: in nature, rock is stratified, which presupposes the presence of layers in its use in the construction process. In this way, its intrinsic nature is maintained in its material role. Form derives from the choice of material,



95. (pagina precedente)
Le coperture a scaglie di
pietra scintosa dei Trulli di
Alberobello in Puglia

96-97. Modello "conservativo"
l'igloo e modello "interattivo"
il trullo



in other words, the possibility of quarrying huge blocks, slabs or pebbles; and from its mechanical quality, in other words, its resistance to compression, its hardness, durability and the extent to which it can be worked. Thus huge blocks of Trani stone, for example, built the vault and walls of the Romanesque Cathedral there. Stone from Trani indeed, is resistance to compression, it is durable and can be worked into large ashlar (masonry) with a complex geometry (special or decorative elements).

With the thin slabs of 'scintosa' stone from the Valle d'Itria, dry stone walls and Trulli are built. This is a hard stone and has to be split or broken and thus can never be reproduced identically. It is thin, waterproof and allows air to pass through it and thus perfect for roofing.

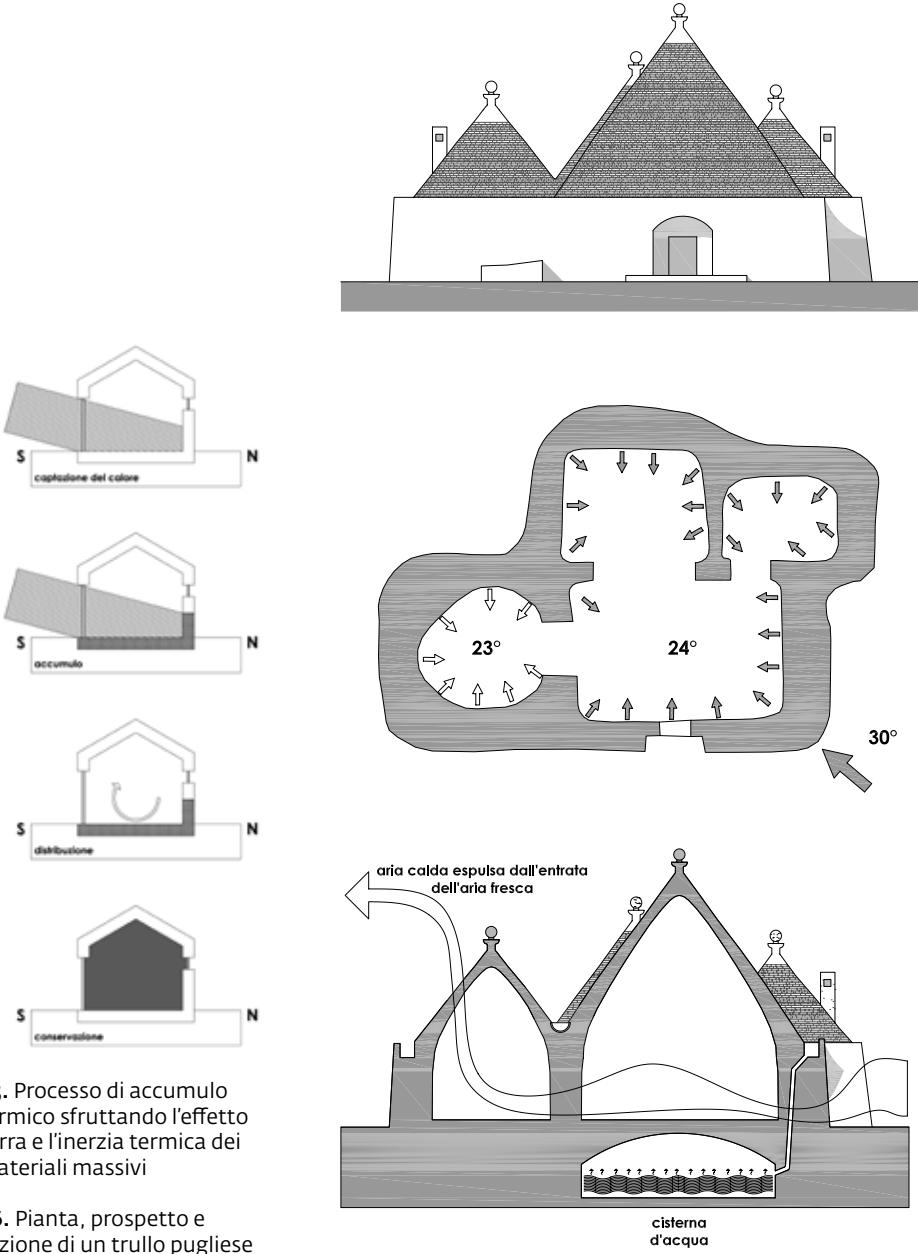
With the limestone from Lecce, the great masterpieces of Baroque architecture were made: a soft rock, it is easily worked and can be used for marquetry, sculpture and plastic designs of the highest quality.

Mediterranean stone architecture and environmental sustainability.

What does it mean today to construct a Mediterranean house?

The commonplace image of a Mediterranean house is of a structure whose forms are exalted by the bright light of the sun, deep shade and resonant colours – a picture postcard house by the sea.

But it is well-known that there is no 'single' Mediterranean culture and, consequently, that it is impossible to codify a Mediterranean style. The *mare nostrum* is nothing but a babble of languages connected by some perhaps homogenous characteristics that while they may seem to meet in a relationship of sharing, are never



95. Processo di accumulo termico sfruttando l'effetto serra e l'inerzia termica dei materiali massivi

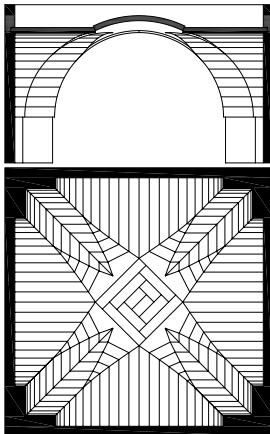
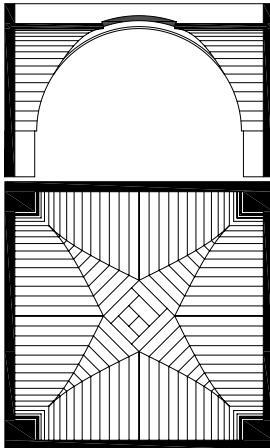
96. Pianta, prospetto e sezione di un trullo pugliese

identical and are often in contrast. The Mediterranean is in itself an expression of diverse cultures, of different and differing origins and histories, often irreconcilable, but that are, however, linked by the singularity of the land and by man's capacity to adapt to it, connected above all by a special relationship between the natural and the anthropic landscapes. It is perhaps this aspect, the relationship between the natural and the artificial, that unifies the cultures of the Mediterranean. Here architectonic and urban forms are diverse yet linked by the quest for an identity that manifests itself in a desire to weather the adversities of the external environment.

In the context of global consumerism, cultural differences tend to dissolve, to be simplified. As the need to communicate effectively increases, the result is a dumbing-down of difference, of specific identities, of traditions. The resultant homogenization of society, in which standardization and reproducibility (and saleability) become keywords, appears as the only way forward for modernity and sustainable development.

The success of the *Passivhaus*, of German design, is undoubtedly linked to this desire for a 'standard': a series of requirements and services in a model house offer practical solutions to issues regarding sustainability and a pre-established level of environmental quality that can be realistically achieved.

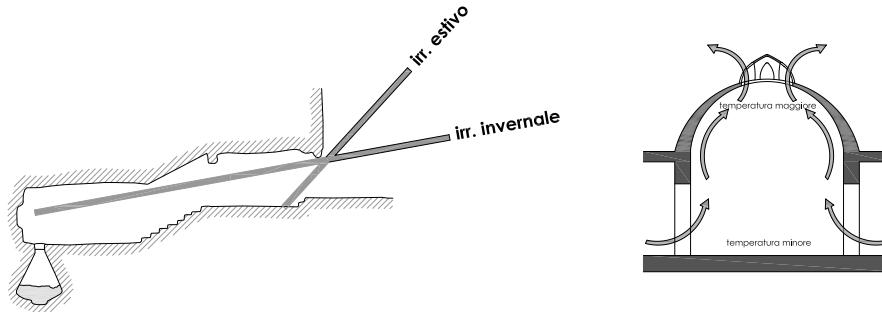
The basic principles of a passive design are: the regulation of natural light, heat and air within and without the dwelling through a careful orientation of the building, the correct position of doors and windows, shade, thermal mass and insulation.



96. Pianta e sezione di una volta leccese a "spigolo" e a "squadro"

96. Schema dello sfruttamento dell'illuminazione naturale nelle architetture ipogee

96. Scheme that represents the ventilation flows inside the vaulted space

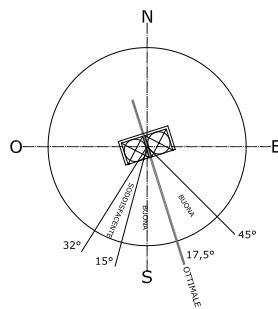


The standard *Passivhaus* was born, however, in a central-north European context, where its function is essentially 'conservative', that is, to protect the inside, as far as possible, from the outside. Taken to its logical conclusion, its archetypal model is the igloo. In the Mediterranean area, apart from guaranteeing comfort during the winter months, the summer months must be taken into consideration. Thus we must speak about an 'interactive' model utilizing cyclical processes of heat accumulation and elimination. Here the archetypal model is the *Trullo*. Recent studies have compared the two models and have shown how some of the requirements of the *Passivhaus* can be applied to a Mediterranean climate, such as air-flow through the roofing, the possibility of avoiding active ventilation systems beyond minor thermal transmittance from the roof.

From a tectonic point of view, two models are well-known: elastic-envelop and plastic-masonry. An analysis of the first model, from a tectonic-structural perspective, shows the need for a light roof that can be realized using an insulating membrane that preserves and protects (heat and air). The architectonic character of this typology is a repetitive- serial type. The second model necessitates a massive roof, using materials with an elevated thermal capability, that functions according to the principle of accumulation and elimination (heat) and a naturally regulated ventilation system. The character of this type is unique and organic.

Vernacular Mediterranean architecture is a tried and tested model that has for centuries functioned well and that offers us today sustainable contemporary solutions to the excesses of energy consumption, the waste of primary

resources and the destruction of the natural landscape. This model has always been based on the use of stone as a primary building material, which along with being a natural defense against heat and endowed of a natural ventilation system, also permits us to create comfortable living conditions both in the Summer and the Winter. Vernacular architectural forms, however, differ from place to place, and even within the same region: depending on the specific microclimate, building designs differ radically, thus we must avoid over simplifications when describing phenomena. For this reason too, it is difficult to compile a standard list of passive requirements and techniques for the whole Mediterranean area , for Italy Spain, and Morocco, for example. It is more useful to develop a standard 'strategy' for the creation and manufacture of sustainable buildings, utilizing the ideas of passive design while interpreting the strategic elements that characterize traditional architecture, rediscovering construction techniques more in sympathy with the surrounding landscape, with its morpho-typological character and natural materials. Mediterranean architecture has always been a collective art form, involving everyone, it is connected to the principles of handing-down knowledge from generation to generation and where the connection with tradition means first of all accepting it as a point of departure, of following traditions in order to innovate and transmit knowledge to the next generation. It is the basis of the social development of a community.



The Trulli.

The *Trullo* is a widespread building typology found across the Apulian area, from the highlands of the *Murgia* to the *Valle d'Itria* and in the more northern areas around Bari. The region is characterized by a temperate Mediterranean climate. The *Trullo* itself manages to maintain a stable temperature, indeed with respect to the outside temperature, the temperature inside the *Trullo* is on average 6-7°C cooler. This is in part due to the fact that the Trulli are usually built over an underground water cistern, and to the nature of the conical roof. Trulli were originally constructed in dry stone and only later used lime-mortar. Even in the Summer, the *trullo* guarantees cool air thanks to the natural ventilation from holes in the pseudo-dome and the white colour of the lime-mortar on the outside of the cone (slabs of *scistosa* stone).

The compact floor-plan, almost square, together with the conical roof, offer a perfect compromise between an attachment to the ground and the use of the sun's rays. In Winter time the heat accumulated in the dome during the day is released during the night into the living areas. The original trulli were made of thick, dry stone walls (1-2 mt.), while the roof, in the form of a pseudo-dome, was lighter and of decreasing thickness towards the top, where it ended with a closing stone or keystone and a pinnacle. Ventilation holes are restricted to the area around the chimney and permit a system of transversal ventilation at night, expelling hot air through fissures beneath the door.

96. Schema dell'orientamento ottimale per la latitudine pugliese

Hypogea type (excavated architecture)

In the area of *Gravine* (the small canyon, on the border between Puglia and Basilicata) a form of excavated architecture or "hypogea" can be found that has prehistoric origins. Following the natural *Gravine*, caves were excavated into the rock and then dug out to create complex living spaces: the result is a constructed fabric that extends over several levels of the cliff edge of the *Gravine*, invisible from outside, it is an original urban complex that exist in symbiosis with the landscape.

An underground system allows water to be collected through a network of canals, cisterns and caves that keeps the earth stable and avoids erosion of the sloping surface. The artificial terracing made of dry stone walls open onto cave dwellings whose openings face onto a flat, horse-shoe shaped space called "*vicinato*" or "neighbourhood".

The need for light is what determines the shape of the excavated dwelling (that follow the line of the calcareous layer) and the manner in which water is to be drained off determines the degree of slope that is required. The slope increases the further back the cave is excavated. The cavity is excavated deep and at a more oblique angle also as a way to protect the dwelling from the sun. The iterative pattern of this model is both horizontal and vertical, one construction on top of the other, so that the courtyard of one becomes the roof of another and so on, both dwellings sharing an underground cistern. Water running off the roof collects in the cisterns following steps or sloping canals cut into the rock.

The whole forms a complex urban labyrinth. In this type of model, due to the difference of temperature between the external walls that are heated by the sun and the cooler, internal walls,



convective heat transfer occurs that contributes to maintaining the internal spaces cool.

Lecce Vault type

In the southern area of Puglia, the climate is more humid and somewhat hotter than the *Murgia*, especially along the coast. Historically, the most common architectural domestic typology was the terraced house with one or two floors, both in rural areas ('Masseria' or farm houses built around a courtyard) and in urban areas. It has a compact floor plan, square or rectangular, and is normally north-facing although in urban areas the front door does not always open to the north.

The house is built with a double wall in tufo (limestone) with a central cavity. The roof is made of traditional limestone from Lecce without wooden frame, wood being a material that is not readily available in this area and is expensive. The thickness of the wall modulates the temperature inside the house.

The system of keeping the roof from leaking is particularly interesting. By using thin Cursi stone tiles, the spaces between the tiles encourage the growth of lichen which acts as a protective film resistant to the summer heat and guaranteeing the protection against the water in the winter.

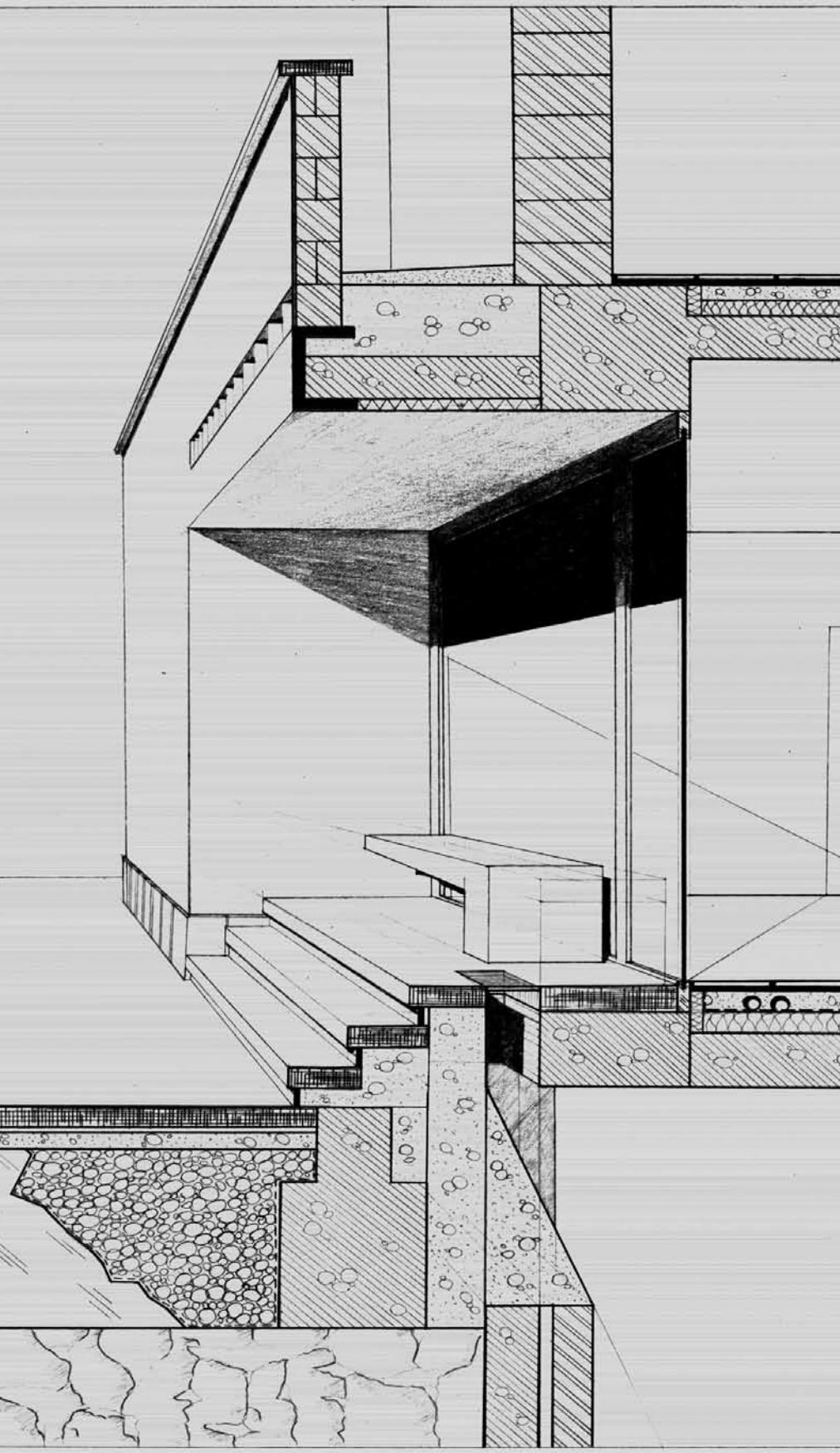
The temperature is controlled in a very similar way to the '*dammuso*', (traditional rural dwellings on the island of Pantelleria); convective cooling through air flow at night (with the door closed) and in the early morning (opening the north facing door).

In the light of these models, it is clear how the term 'passive' here does not signify a system that passively submits to the environment but one that reveals the capacity of the system to interact with the environment, using its intrinsic qualities to regulate the environment without relying on technological systems.

Environmental sustainability challenges those models that are reliant on low cost energy. If we add to that the transformation of the landscape, the discomfort of contemporary urban spaces and even of domestic spaces, the need for a construction ethics becomes clear, one that is careful not to consume those resources that nature cannot replace or reproduce naturally. The materials used in construction and an awareness of the processes of production and processing of those materials (including the energy cost for production or extraction of materials, transport, construction, assemblage, recycling and waste management) are all essential to such an ethical approach.

Some materials that are generally considered to be ecological, like wood, when transported thousands of miles, are no longer ecological in that the atmospheric pollution deriving from the transportation outweighs all other concerns.

In the case of stone architecture that is based on the principle of utmost simplicity in the process of construction and sustainability, choices can be made of how to make the most of solar energy and how to use thermal mass from the stone itself, as a way of using free forms of energy and thus reducing technical systems in the house.



The following paragraphs report some of the principles behind sustainable housing design in the form of synthetic proposals for the design and construction of houses.

Typology and Morphology.

The form and typology of the architectonic organism have a decisive influence on its energy efficiency. The history of construction has produced typologies and forms that still today can be considered perfectly 'appropriate' and that can be used as models for an experimentation of form and innovative technological solutions. In the Mediterranean area we can recover those elements that have been successfully consolidated over time, like the single block house running on an East-West axis for single family homes, the terrace house with a back garden, the open courtyard house, all facing South or South South East (20° East).

The energy exchange between inside and outside occurs through the surface of the building envelope so apart from the conformation of the envelope itself, the size of the surface from which energy may be lost is also key, in other words we must study the ratio surface to volume S/V.

It is also important to moderate the depth of the building in order to guarantee a sufficient standard of lighting and ventilation in all the rooms. The distribution of the internal spaces should depend on their use during the day. Those spaces used more during the daytime should be positioned facing South, in order to make the most of the sunlight and warmth during the Winter. Service spaces (bathrooms, garage, storerooms and corridors) should be North facing, that is the coldest part of the house, thus acting as a 'cushion' between the cold wall and the rest

of the house. Bedrooms should be positioned facing East: its best to avoid a West facing bedroom which during the Summer months and in the late afternoons can become too hot.

Orientation.

The position of the sun varies according to latitude. A suitable orientation in the Mediterranean climate , depending on the type of building of course, varies between 0° South and 20° to the East of South. Firstly the house should be positioned along an East-West axis, moving it slightly to get the maximum benefit from solar energy during the Winter, as the sun's rays, being lower can enter directly while in the Summer, with the rays higher, they will beat on a portico or some other system of protection, creating shade. The building should have few openings to the North as that is the wall that threatens the most heat dispersion during the Winter. The wall should ideally be used for corridors or services. In Puglia, for example, south facing walls are the sunniest all day and all year. East facing walls are sunny in the mornings, the sun being more intense in the Summer, but remain sunny for longer in the Winter. West facing walls are averagely sunny in the afternoons, with intense sun in the Summer and remain sunnier for longer in the Winter. North facing walls get the sun only at dawn and dusk, with the rays striking the lower part of the wall.

Use of Greenery.

Apart from the sun, wind, should also be taken into consideration, as this can cause heat dispersion from the building envelope in the Winter as wind favours thermal convection. It is best to minimize the surface area affected by the wind. In the Domus Benedictae project and in

Villa Korch, the prevalent wind in the Winter is the 'maestral' and to placate it, a wind barrier of evergreen trees planted on the North-East side of the house was used. On the opposite side, South-East, a row of deciduous trees were planted that allowed the winter sunshine to pass once the leaves had fallen and that acted as a barrier to the hot 'scirocco' wind in the Summer.

Ventilation in the building.

Ventilation systems ensure a good supply of cool air and the expulsion of heat from inside through physiological cooling and fresh air. Natural ventilation allows cooling through air currents generated by natural phenomena like the wind and the chimney effect. The aim is to encourage transversal ventilation in the Summer, particularly at night, that helps to cool the house in the hot periods, while conserving the inside temperature during the day (absence of ventilation) and to make the most of the breeze. In the Winter a 'conservative' approach is necessary, limiting ventilation where possible to the warmest hours of the day.

The use of vaulted roofs in the projects presented here allow natural ventilation to occur according to the combined Bernoulli-Venturi effect: air flows up a curved surface, its speed increases and pressure diminishes towards the apex, which induces the warm air inside to escape from openings situated high up.

The tapered vault structure creates a chimney effect due to the difference in temperature of the several sections: the higher parts are warmer because they are horizontal and thinner and they stimulate convection because of the difference in temperature.

96. Domus benedictae, executive design draw. The large overhang protects the windows from the sun radiation

Ventilation processes initiated in this way are able to suck in cooler air from the underground level of the building (the ground temperature all year round can be measured at a constant 15°C) and during the Summer months to increase the efficacy of the natural ventilation system, controllable air-vent grates can be put in to aid cooler air from underground to circulate in the above-ground rooms.

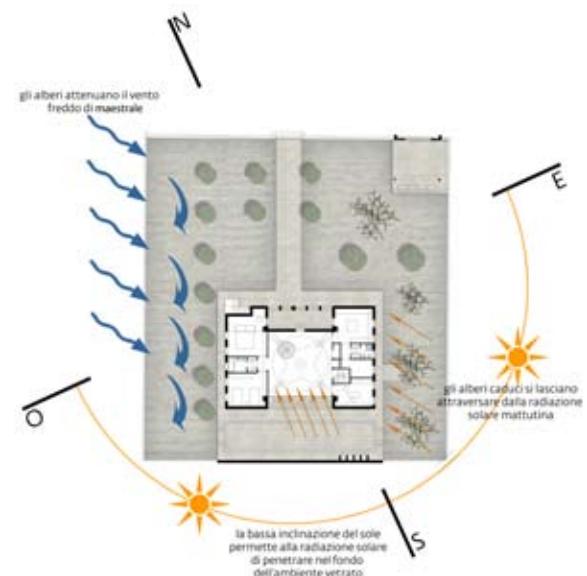
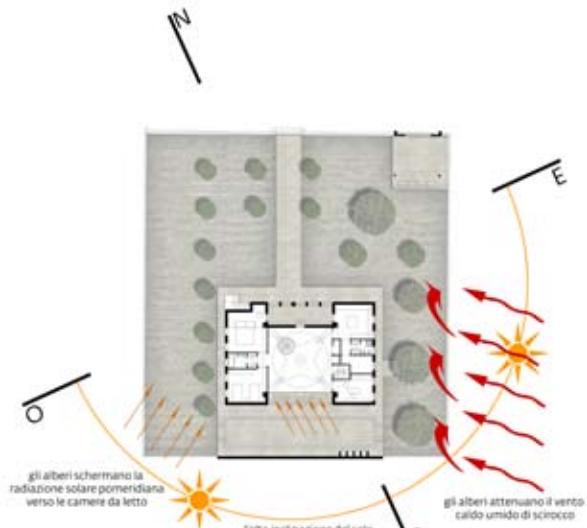
Relationship with the earth.

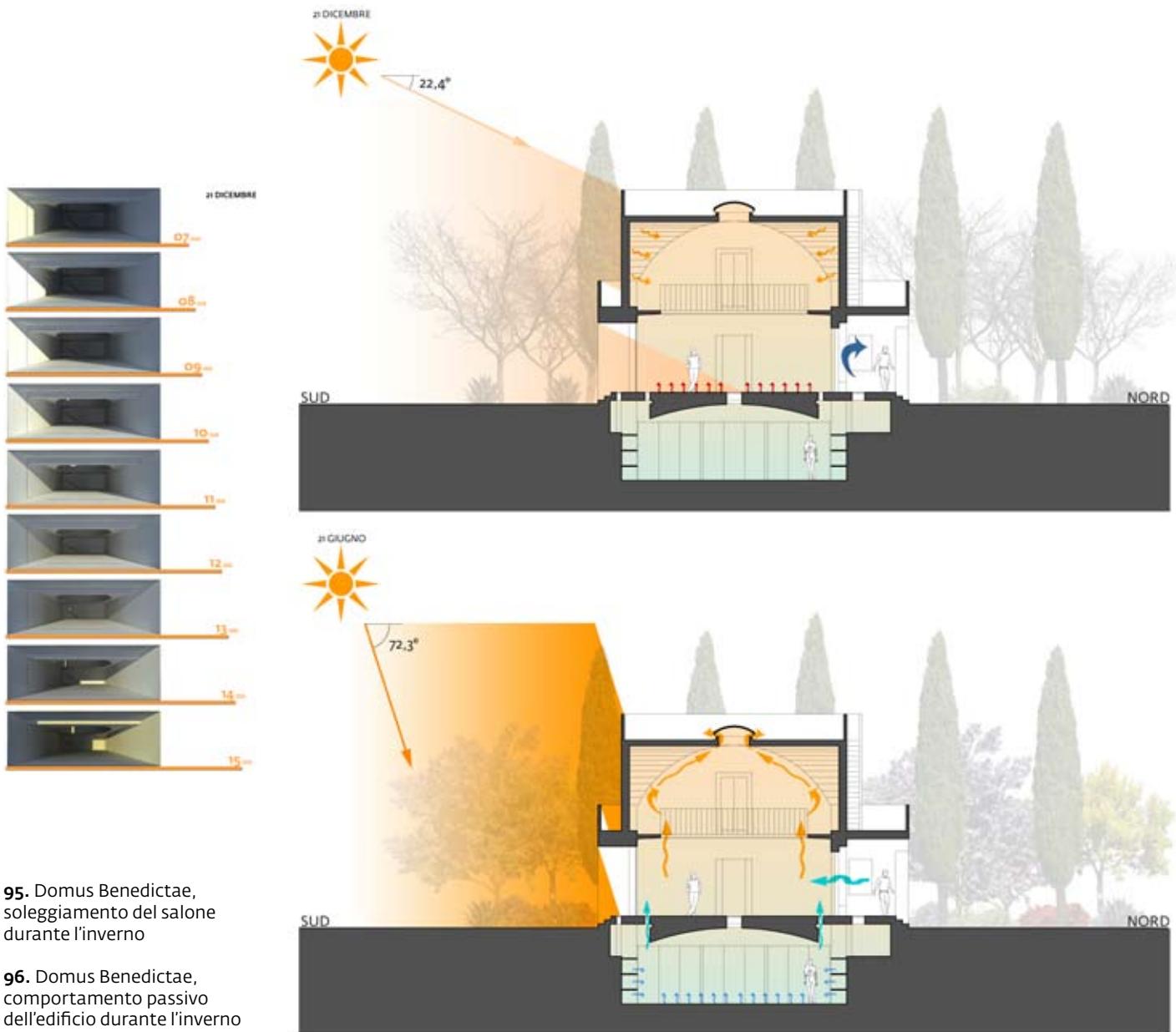
The earth is a thermo-regulator in the Summer and in the Winter. By adapting to the morphology of the earth, semi-underground spaces can be used to create a cooling effect in the house and by utilizing the rock walls as structural support , thus integrating the building structure with the earth. Terraced houses dug out of the sides of rock formations, for example, can use the vertical rock surface as one or more walls of the house, guaranteeing a constant cooler temperature as well as a resistant load surface. From the floor to the roof, and from the walls in contact with the rock towards external walls, convection is generated which can be augmented by placing air vents high up in the building allowing hotter air to escape. The earth can also be used by utilizing a reversible heat pump connected to a geothermal system that absorbs heat from the earth and transfers it to heat the house or the water during the winter. In the Summer it can transfer the heat from the house into the earth.

Walls.

How we choose to build walls depends on several factors: construction simplicity, the degree to which material can be worked, thermal inertia, thermal and acoustic resistance

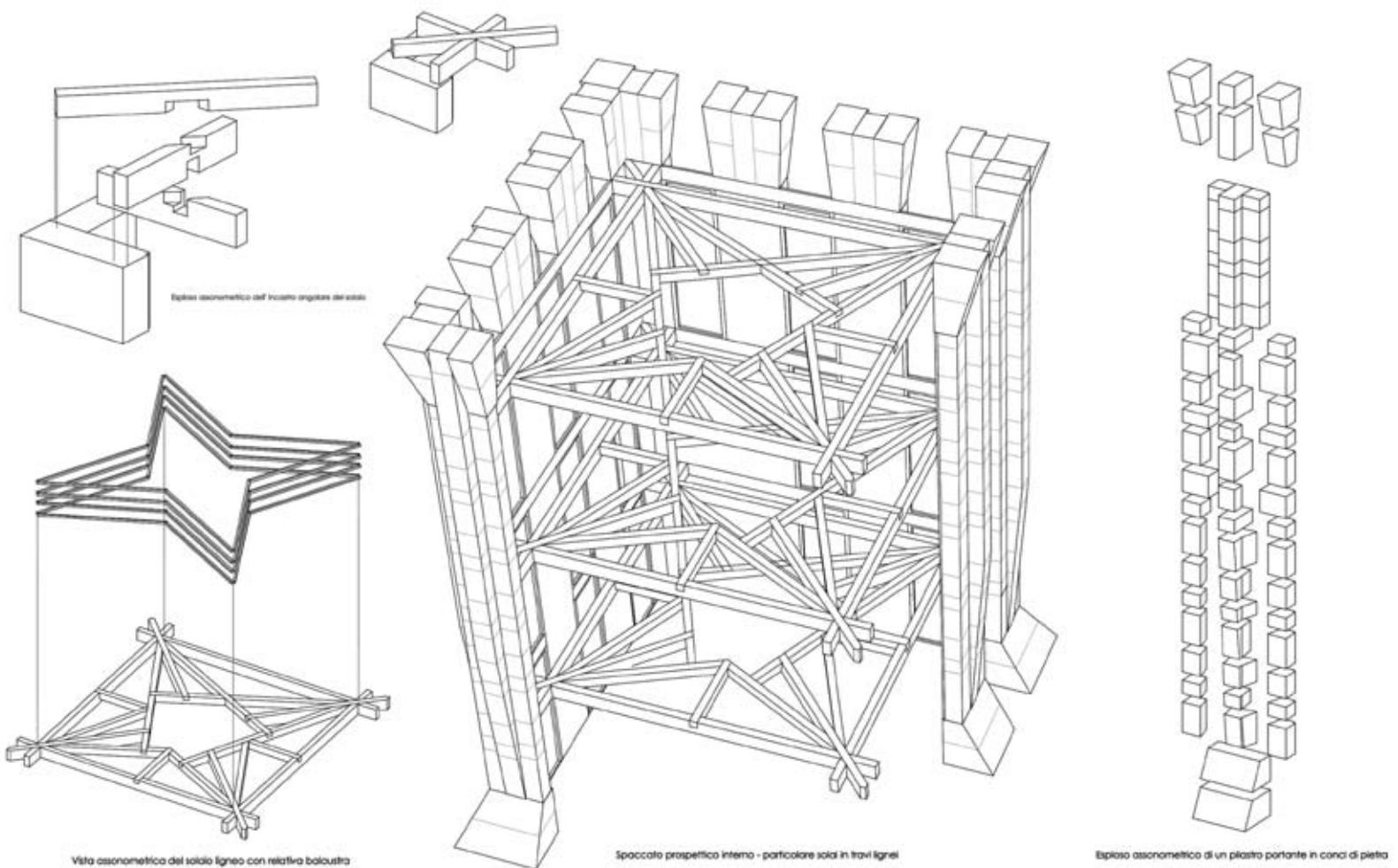
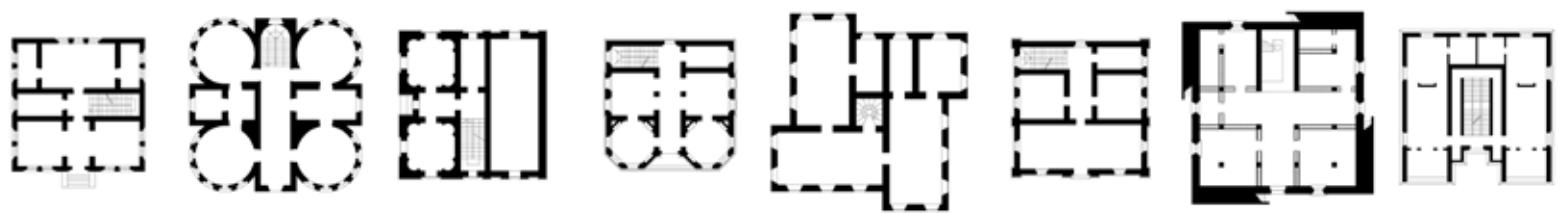
95-96. Domus Benedictae, orientation and vegetated outdoor space in summer (up) and in winter (down)

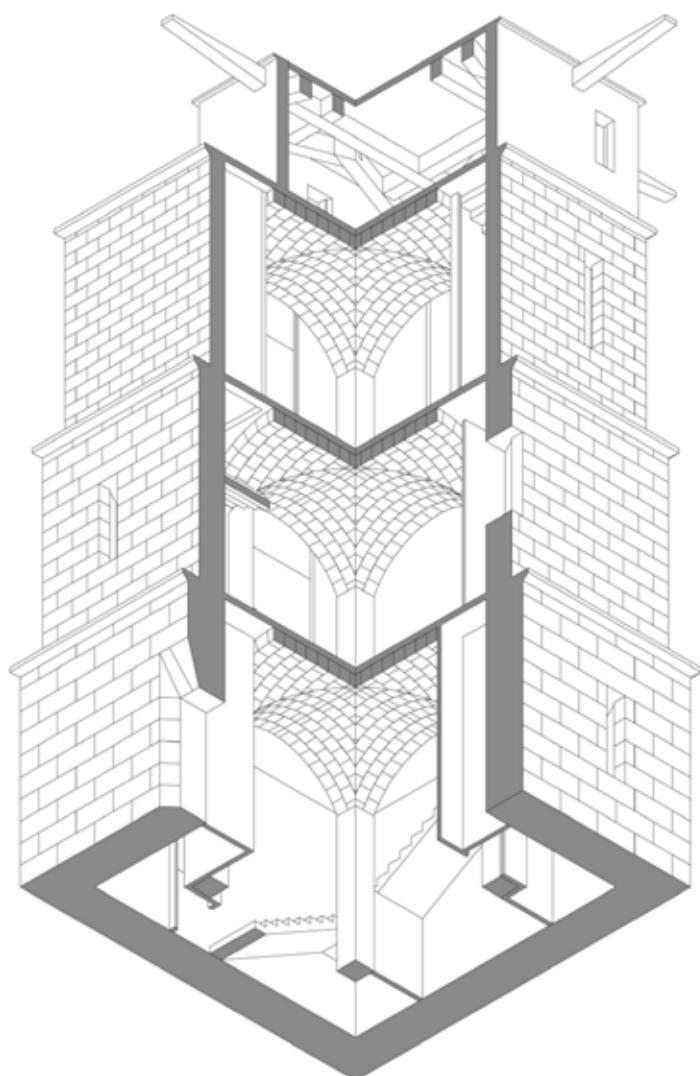
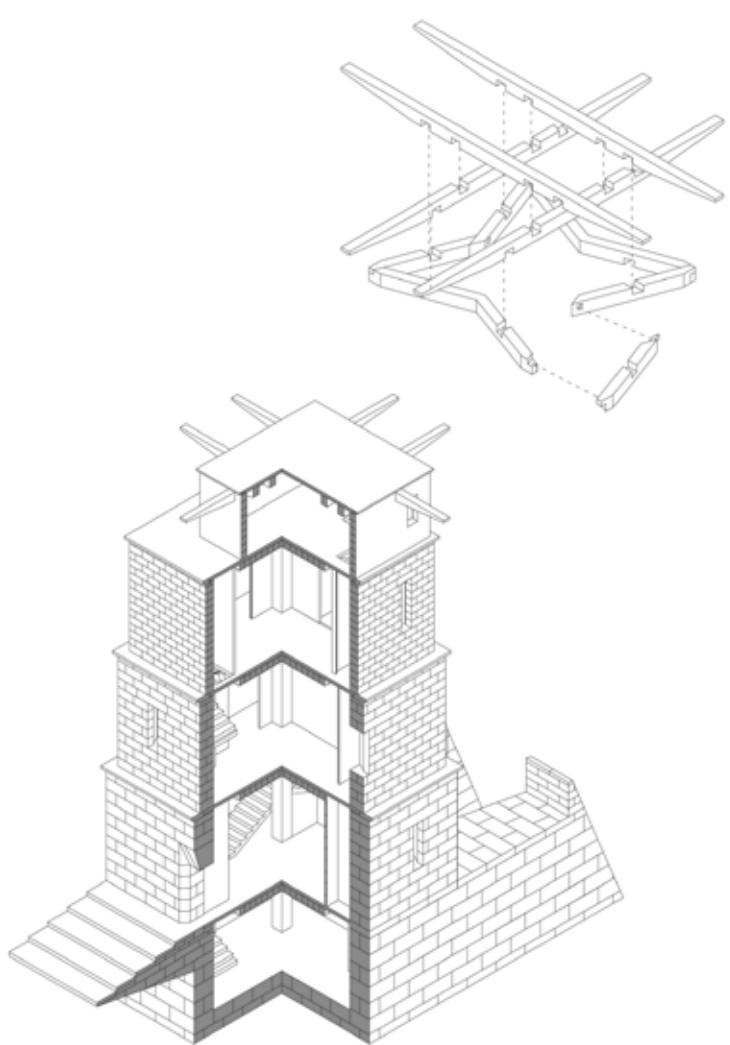
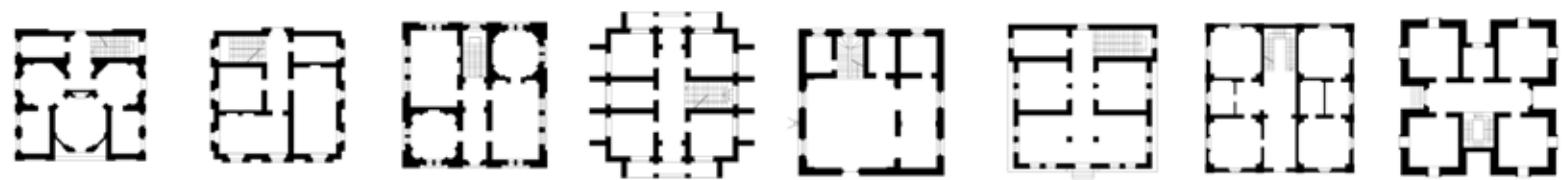


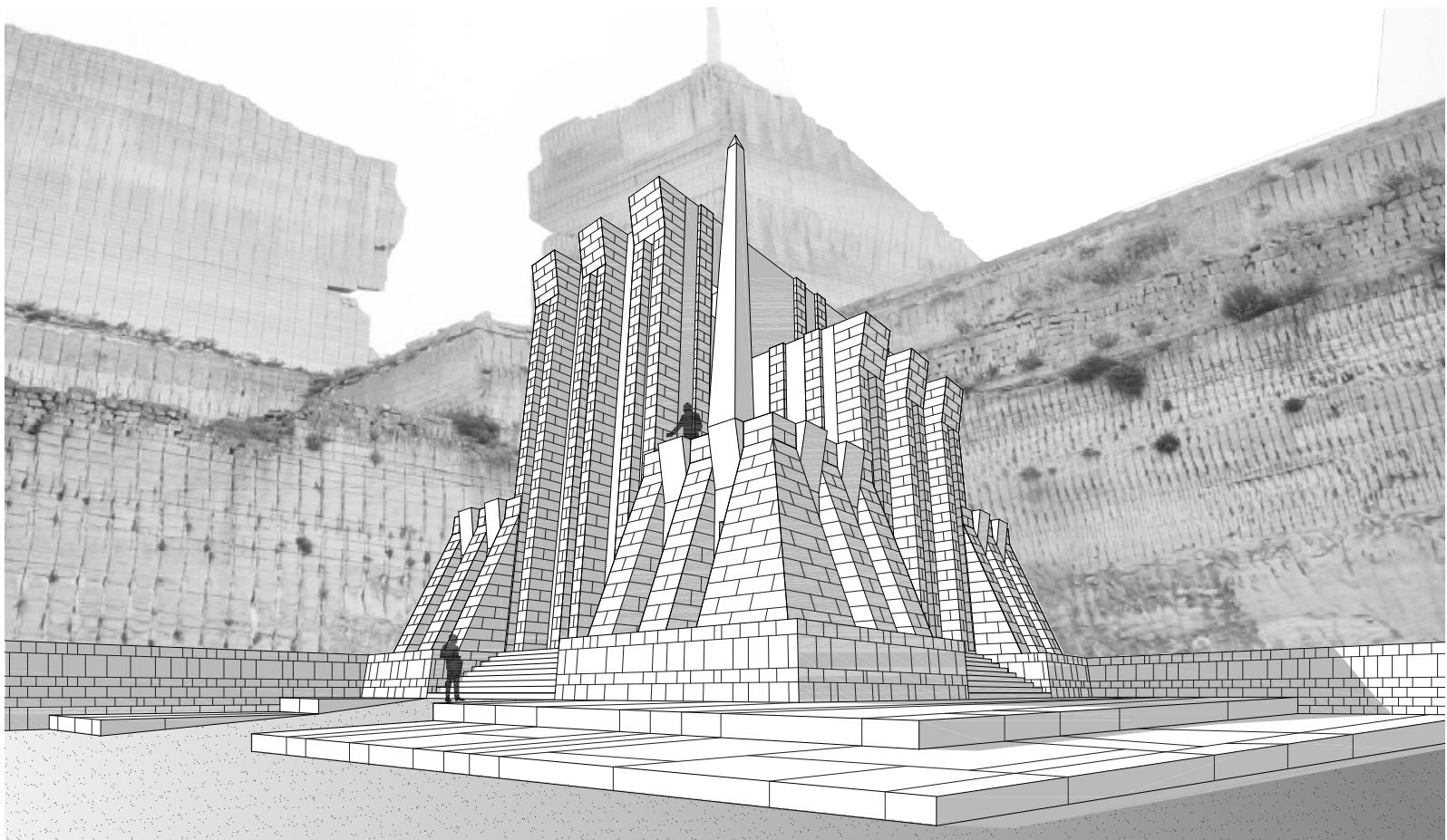


95. Domus Benedictae,
soleggiamento del salone
durante l'inverno

96. Domus Benedictae,
comportamento passivo
dell'edificio durante l'inverno
(in alto) e l'estate (in basso)

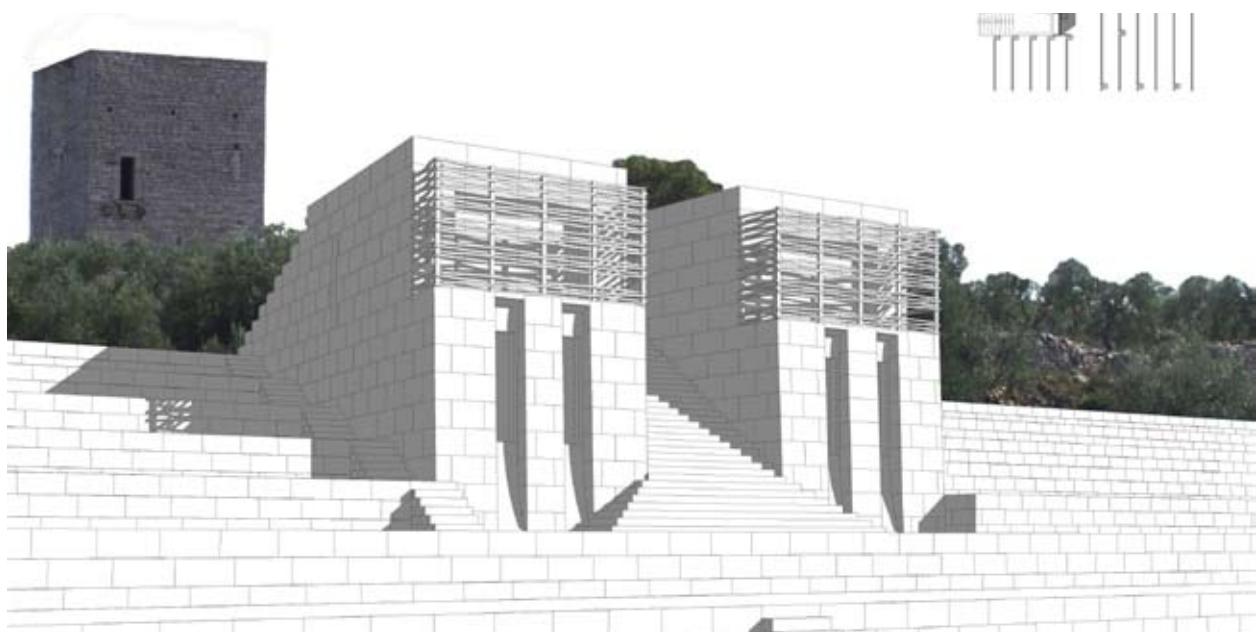




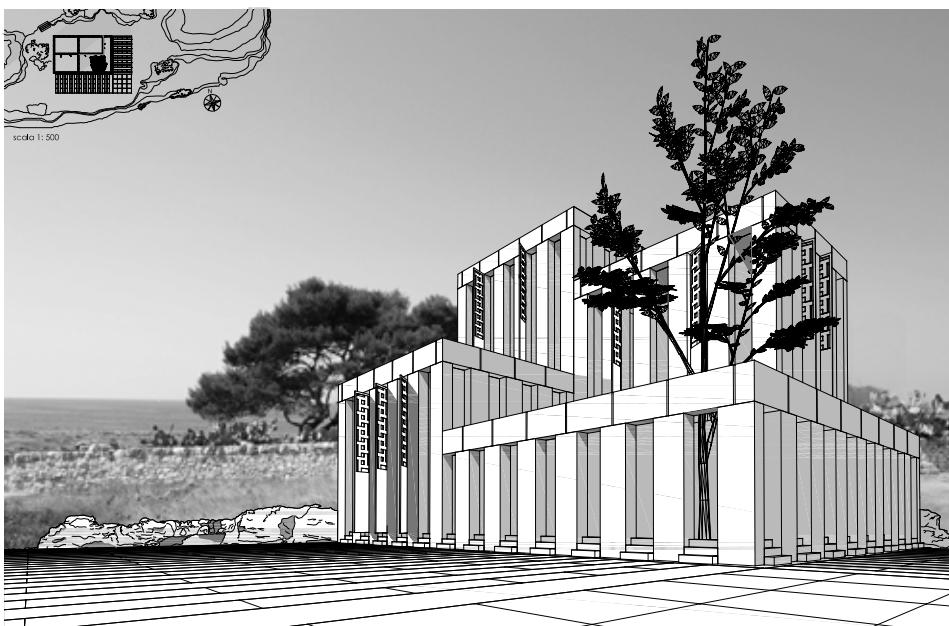
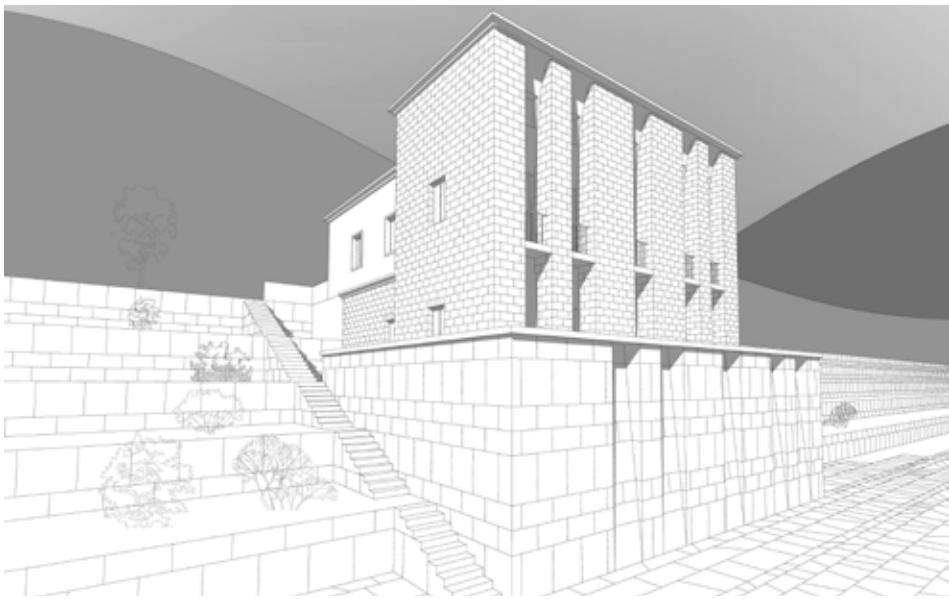


95-96. (pagine precedenti)
Laboratory of Architectural
Design I, Faculty of
Architecture of Bari. Students:
Francesco Lorusso (left),
Giulia Mellano (right)

96-97. Laboratory of
Architectural Design I, Faculty
of Architecture of Bari.
Students: Cosimo Chiancone
(up), Gianluca Landriscina
(down)



96-97. Laboratory of Architectural Design I, Faculty of Architecture of Bari.
Students: Luca Attardi (up),
Gianluca Berardi (down)



and transpiration. The use of stone to build thick walls guarantees thermal insulation both in the Summer and in the Winter with a consequent energy saving (both for heating and cooling). 50-70 cm wall material guarantees thermal inertia (internal slowing down and attenuation of the effects produced from the external atmospheric conditions).

Thick walls combined with large south-facing openings, can during the Winter capitalize on solar heating in three ways:

1. By trapping solar energy and transforming it into heat using a greenhouse effect
2. Thermal accumulation, in which the heat trapped during the day in the thick walls is released later;
3. The distribution and the conservation of heat released (through systems of convection and radiancy) during the night into the house for as long as possible.

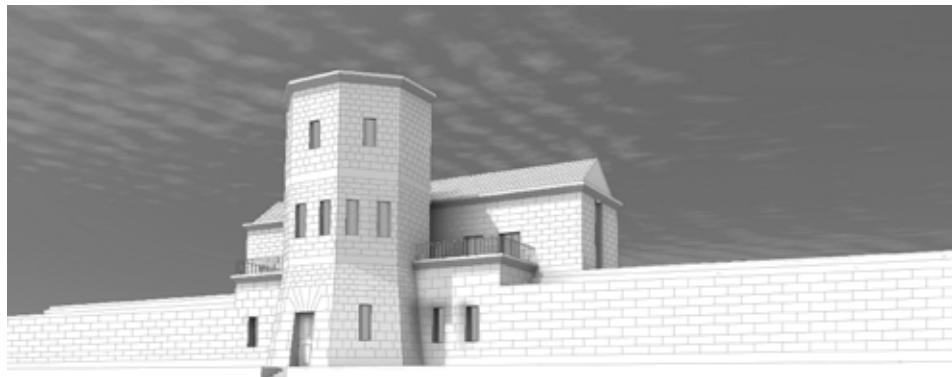
The house should be plastered with natural waterproof lime plaster without cement or chemical additives, this has good mechanical resistance and excellent degree of transpiration. This is important particularly for north-facing walls, rendering them dry and in good condition, guaranteeing comfort and good thermo-hygrometric conditions.

Openings.

The most important openings (windows and doors) should be located on the south-facing front of the house (allowing for cold month thermal gain).

Smaller openings can appear on the East and West sides of the house where the sun shines for several hours in the Winter, but less so than on the South-facing walls. Here the openings are mainly useful for light and ventilation rather

96-97. Laboratory of
Architectural Design I, Faculty
of Architecture of Bari.
Students: Serena Mallardi
(up), Marco Mittica
(down)



than for heat. The North-facing wall should be predominantly closed to the elements, because of the lack of sun, apart from the door (double door with a cavity between them) with air vents for ventilation purposes.

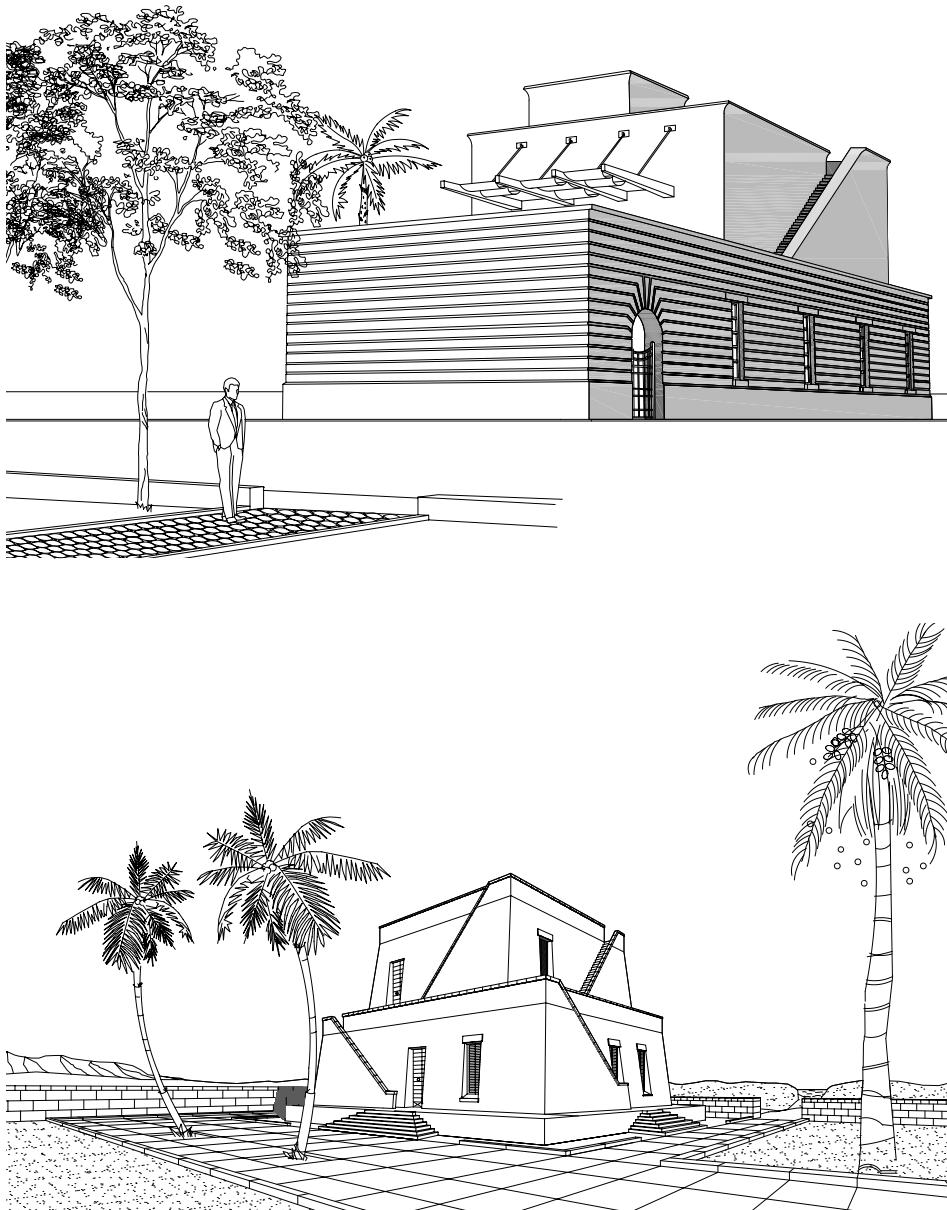
Big windows on the South-facing wall are to be screened to allow internal thermal comfort during the Summer, blocking the sun from penetrating the house directly and heating up the rooms excessively while allowing the sun's rays to enter during the winter.

A large vaulted central space is the most important means of passive solar energy use. In Winter, the greenhouse effect caused by the windows, accumulates heat in the thick stone walls of the vault, in the internal walls and in the stone floors. After several hours, heat is released in the central space through a system of natural convection and warms the other areas of the house. The use of thermal inertia is calculated to provide 25% heat necessary to cover the whole house in the Winter.

Thermal mass is also utilized for Summer cooling, when the external temperature rises. Internal temperature is calibrated by the structure's capacity to absorb heat during the day, keeping the rooms cool; during the night, the natural circulation of fresh air coming from the underground level, cools the insides.

One other consideration to be made regards the colour of the external surfaces of the building. White lime putty reflects more than 90% of visible radiation (wavelength 0,3-0,7 micron). The combined agency of thermal mass, natural ventilation and South-facing screening significantly reduces internal temperature by 6-8°C during the day.

96-97. Laboratory of Architectural Design I, Faculty of Architecture of Bari.
Students: Lucia Muscogiuri (up), Pietro Palumbo (down)



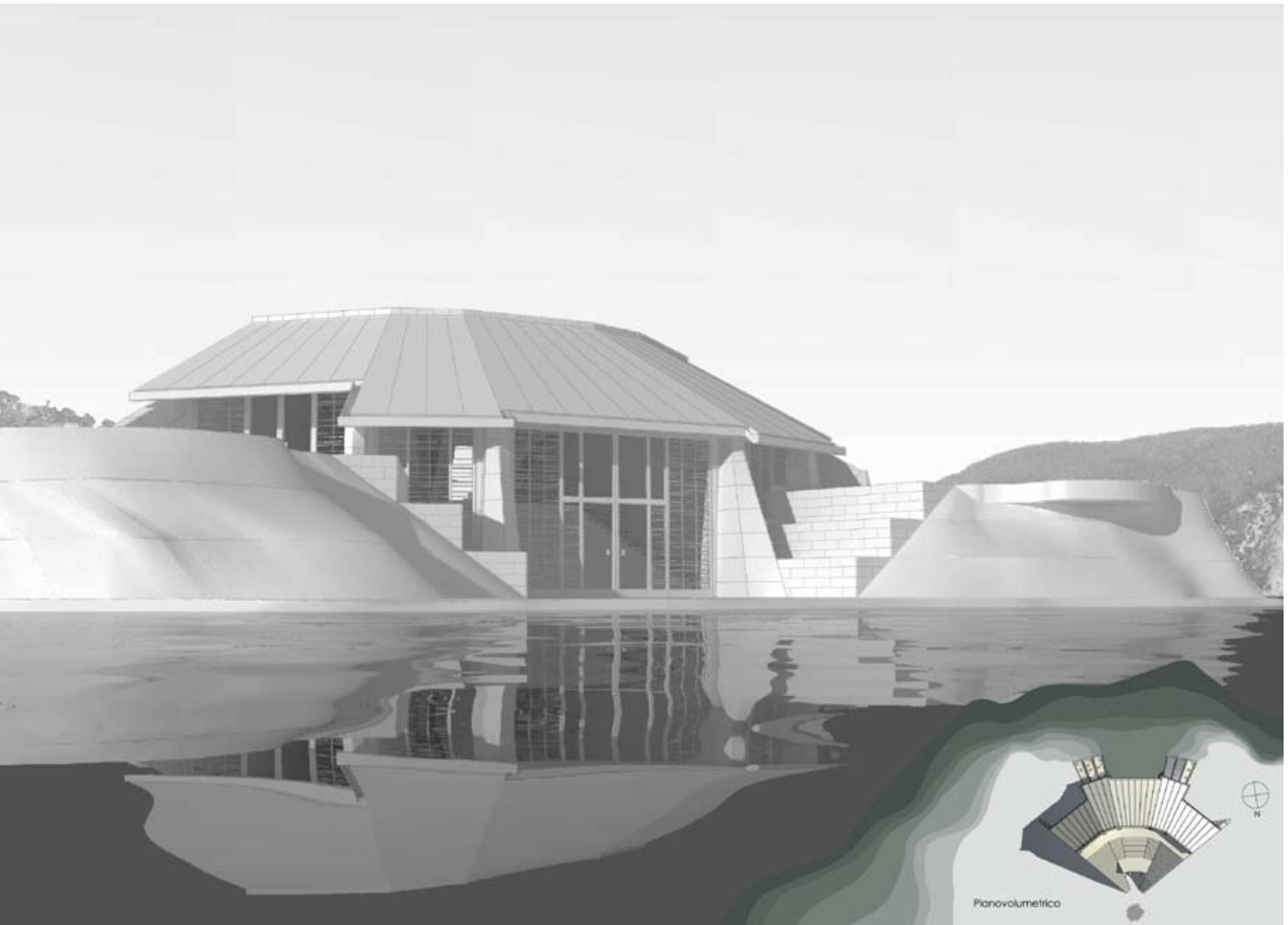
Porticoes, Loggia and Screens.

In the context of Mediterranean latitudes, porticoes and loggia should be constructed on the South-facing front of the building; the highest part of the portico should be positioned in such a way as to prevent sun from entering during the Summer (72° inclination). If the portico forms an external casing that runs around the house, screens and other removable structures can be used to regulate light, heat and air around the building.

In the projects presented here sun screens similar to the Arab musharabiya have been used. This system, apart from screening sunlight, also creates two ventilation systems: draft-creation through the acceleration of the speed of the air passing through a small section of the screen, and humidity control due to the hygroscopic properties of the material used for the screen. Loggias are positioned along a South-South-East axis, in such a way as to catch the breeze. The loggia also functions as a 'cushion' between the walls of the building and the elements, forming air currents by creating thermal movement through air vents high up in the structure. A loggia can also function as a heat storage unit if double-glazing is installed in the Winter months, creating a greenhouse effect: the sun's rays penetrate the glass and are absorbed and then released later. Generally, thick walls, as they heat up release warmer air than that of the original sun's rays. In the Winter, the windows that are opened during the day are closed at night, permitting the thick walls to release the heat accumulated during the day. In a Mediterranean climate, at least $2/3$ of the glass surface should be openable to allow ventilation in the Summer.

96-97. Laboratory of
Architectural Design I, Faculty
of Architecture of Bari.
Students: Ilenia Di Gennaro
(left), Domenico Monopoli
(right)





Pianovolumetrico

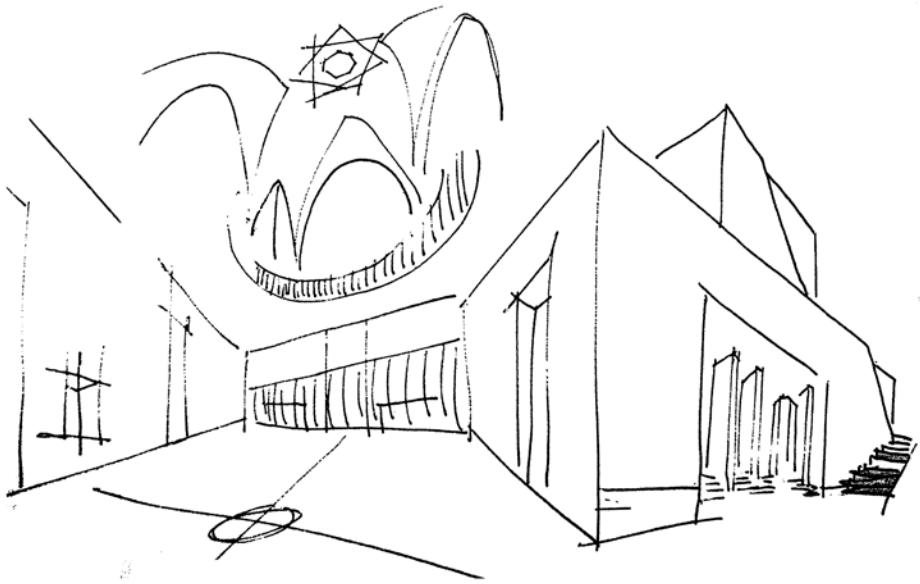
7

SUSTAINABLE STONE ARCHITECTURE

2007	Domus Benedictae
2008	Bureaux SNBR
2009	EcoMaison a Villy de Marechal
2010	Ardito House
2010	Zucaro Winery
2011	Korch Turturo House
2012	Astonyshine

Domus Benedictae

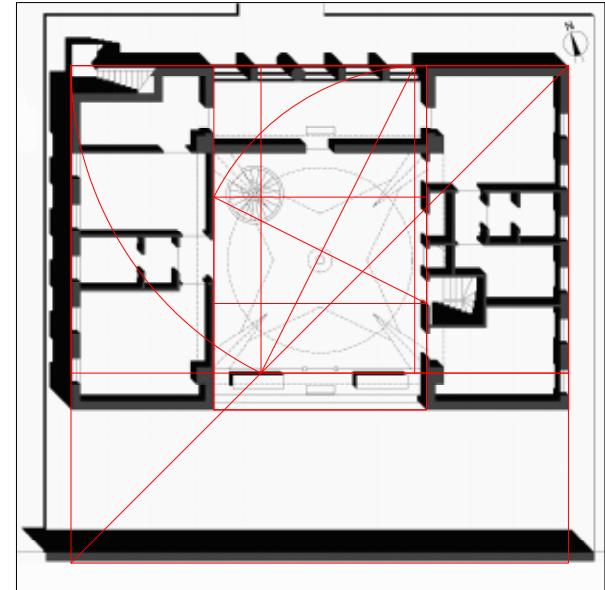
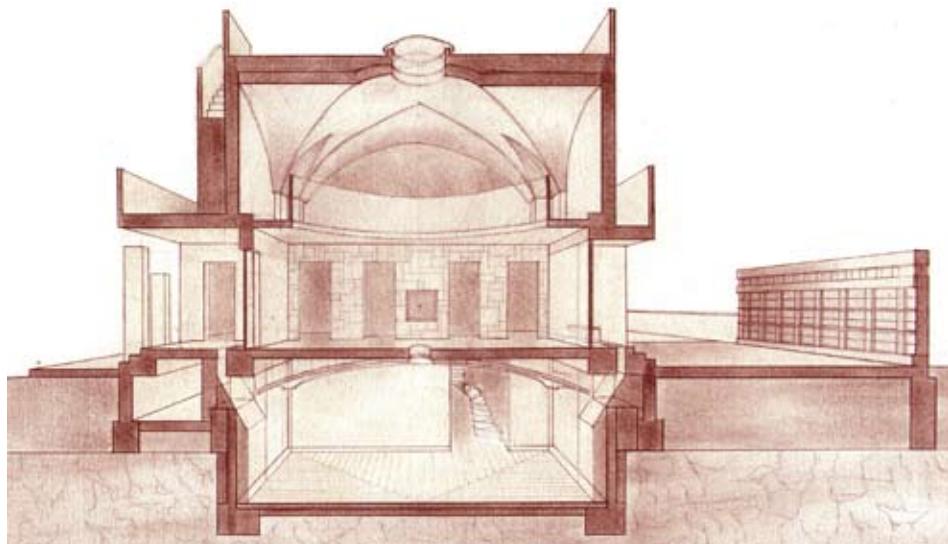
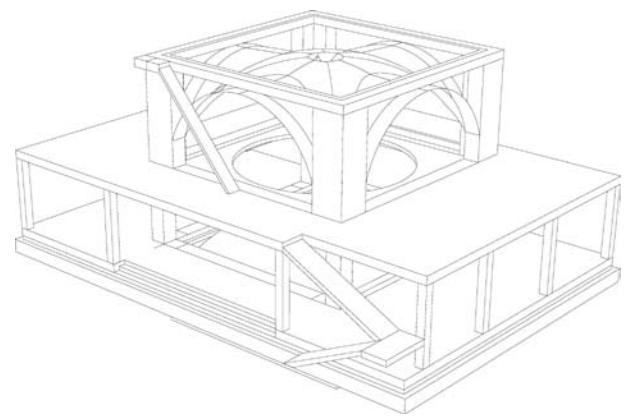
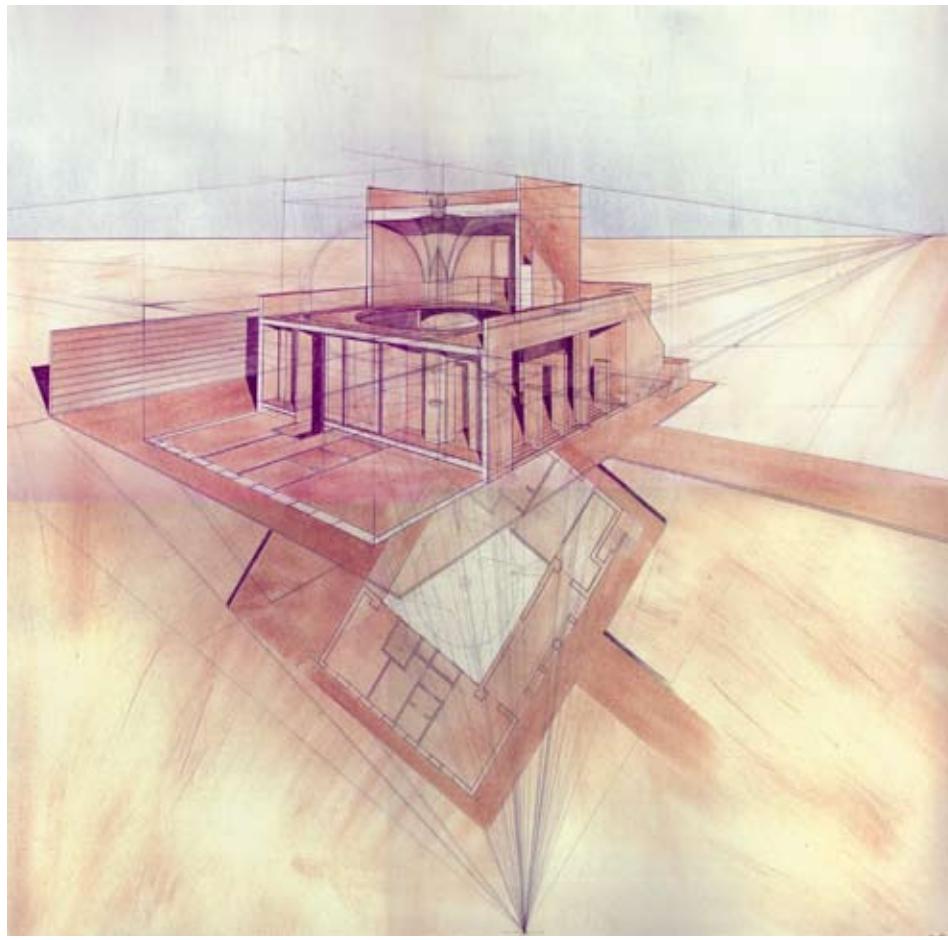
Corato, 2007 | 2009

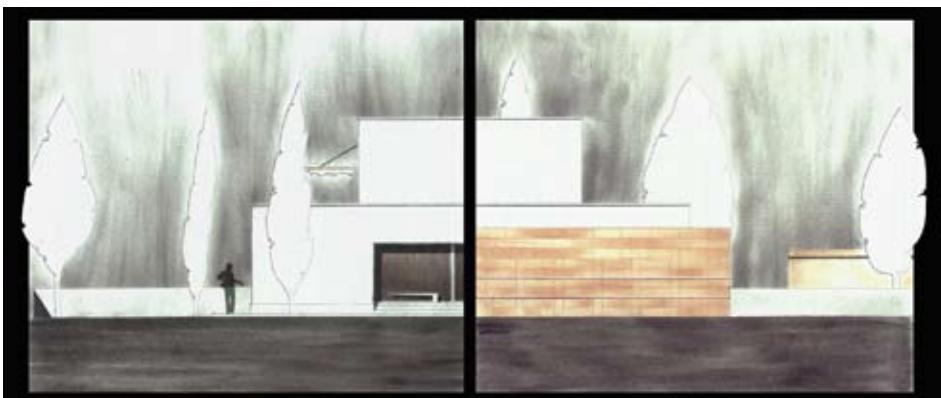
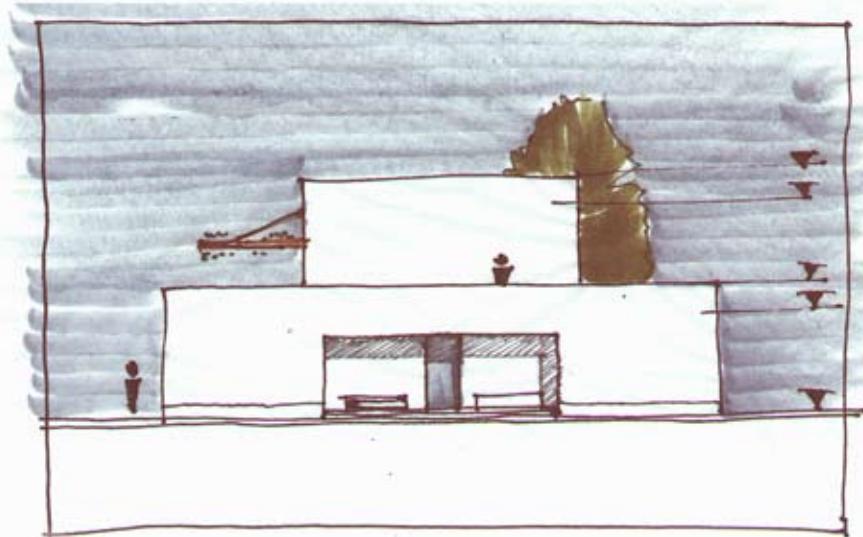
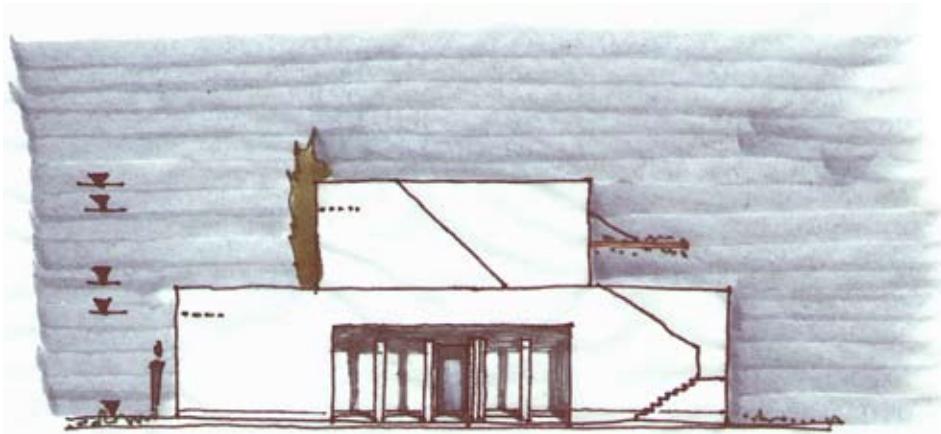


Situated along the ancient route Barletta-Grumo, in the countryside near Corato (Bari) half-way along the axis that joins Castel del Monte with the Cathedral of Trani, Domus Benedictae is a single-family house set in the countryside typical of the Murge that reflects the charm of typically Mediterranean construction forms. The house is modern and yet based on traditional building traditions. This tension between the ancient and the modern informs the entire structure, emerging as two poles in a complex design dialectic. The house re-reads and re-interprets the main themes of traditional Apulian construction: simple and compact spaces, white lime plaster, external staircase "*a proferulum*", vaults, local stone, window frames and blinds in wood, climbing- plant covered pergola etc.

One of the most significant aspects of the house is the construction technique used, decidedly hybrid in nature , which allows the design project to experiment with new expressions of space and structure. Based on a skeleton structure of reinforced concrete that supports a large vault in tufa that functions according to a thrust system, the perimeter walls are continuous weight-bearing stone walls integrated with a steel framework.

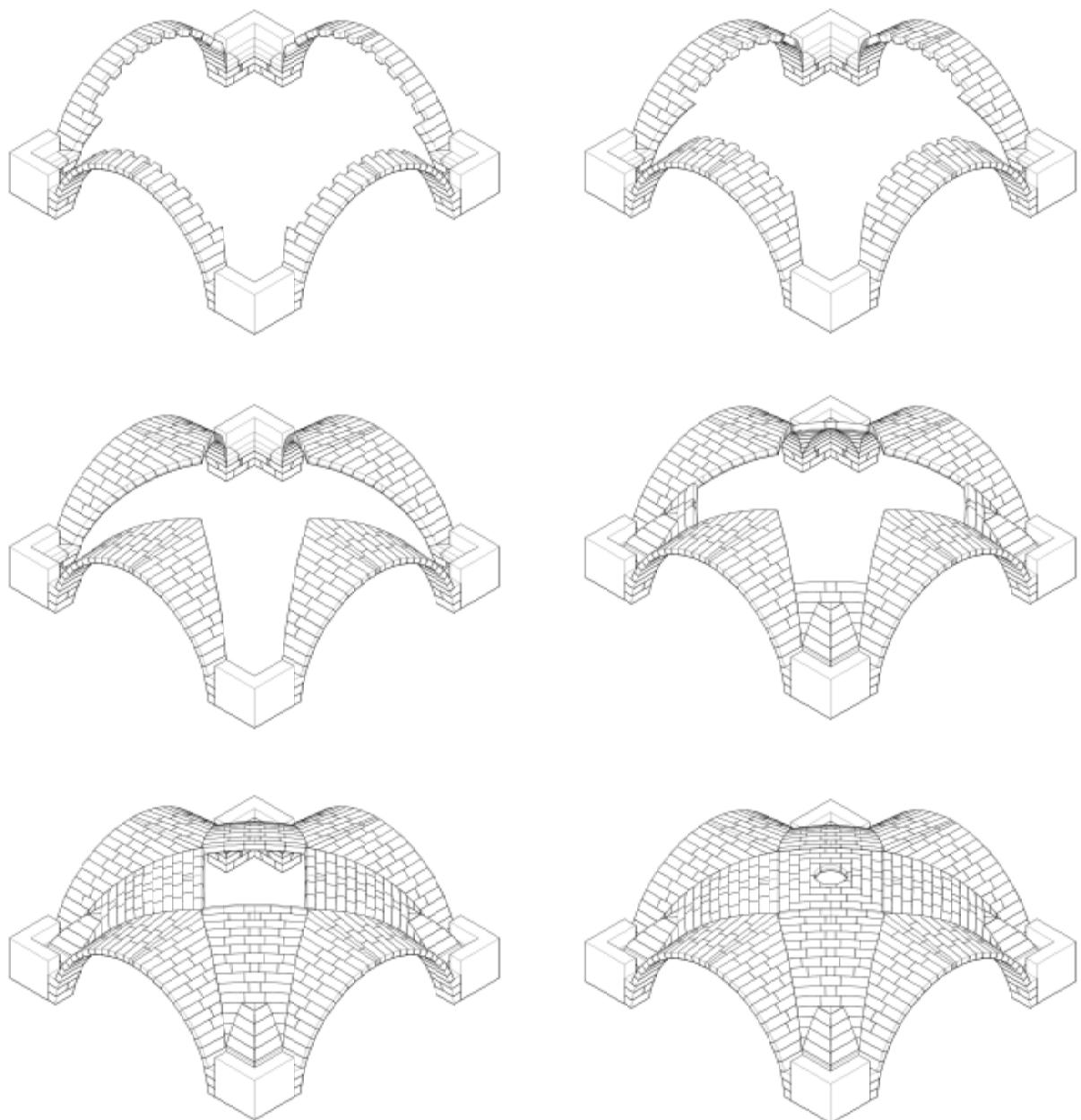






This is a mixed system that utilizes both the elastic-framework and the load-bearing thrust system of the masonry. The reinforced framework permits the construction of ample bays and horizontal openings for glass windows and the living space is characterized by a high vault. These eclectic structural choices are all functional to the creation of a living-space organism that revels in its hybrid nature: formal 'caprices' through which the house expresses its very nature with a series of architectonic choices made from an eclectic repertoire of Mediterranean possibilities: the vaulted space of Salentine houses, Turkish majolica, blown-glass lamps, Moroccan muqarnas, Catalan stairs and French helicoidal staircases, doorways with Arab engraving, back-lit onyx, thick stone walls with splaying at the windows, English wallpaper, large windows and Nordic-style conservatories, suspended vault ceiling in the cellar, wooden boiserie etc. The compositional logic that unites the harmonious silence of the forms, allows for a myriad of formal expressions within the architectural organism. Harmony becomes chaos. By decontextualizing specific construction forms and aligning them with others, the value of each singular architectonic element is amplified.





95. Utensili da lavoro, disegno
di C. Gaul

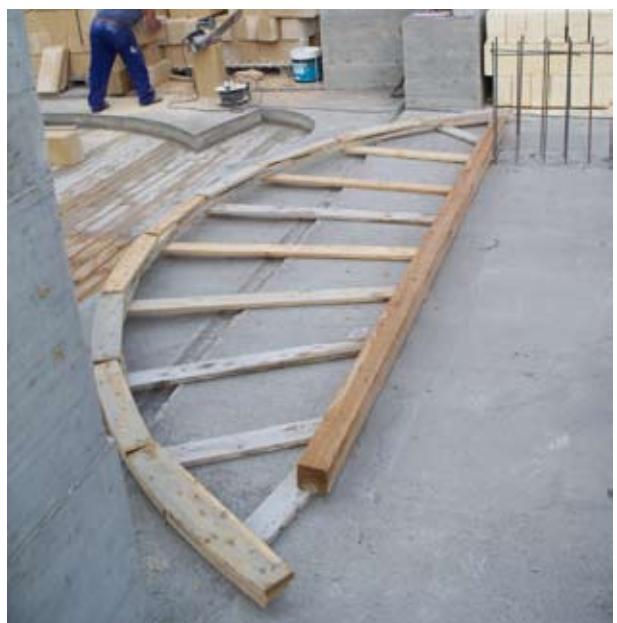
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



The floor plan is based on geometric patterns that clearly define the separate domestic spaces: the house is a harmonically proportioned rectangle within which there is a large central square. Here, a tufa vault (8,5 mt. x 8,5 mt.) forms the living-room ceiling, which is divided hierarchically into two levels, separating and simultaneously joining the day-time from the night-time areas. The vault itself, built according to traditional precepts, pays homage to Salentine architecture generally, which even when revisited in a more romantic key, has lost its status as the defining emblem of stone architecture in an architectural landscape that is becoming increasingly flat. The vault is of the type commonly referred to as "lamia a squadro", or square vault, with a central skylight and is part of that general category called "stella" vault, the term deriving from the ribs making a star-shape. Its morphological specificity encloses within it all common vaults; cross vault, fan vault, pavilion vault. The construction techniques that underpin such a structure are the sum of the knowledge of a few remaining master-artisans who try to pass their secrets on to a younger generation increasingly intolerant of similar slow-process architectures.

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993

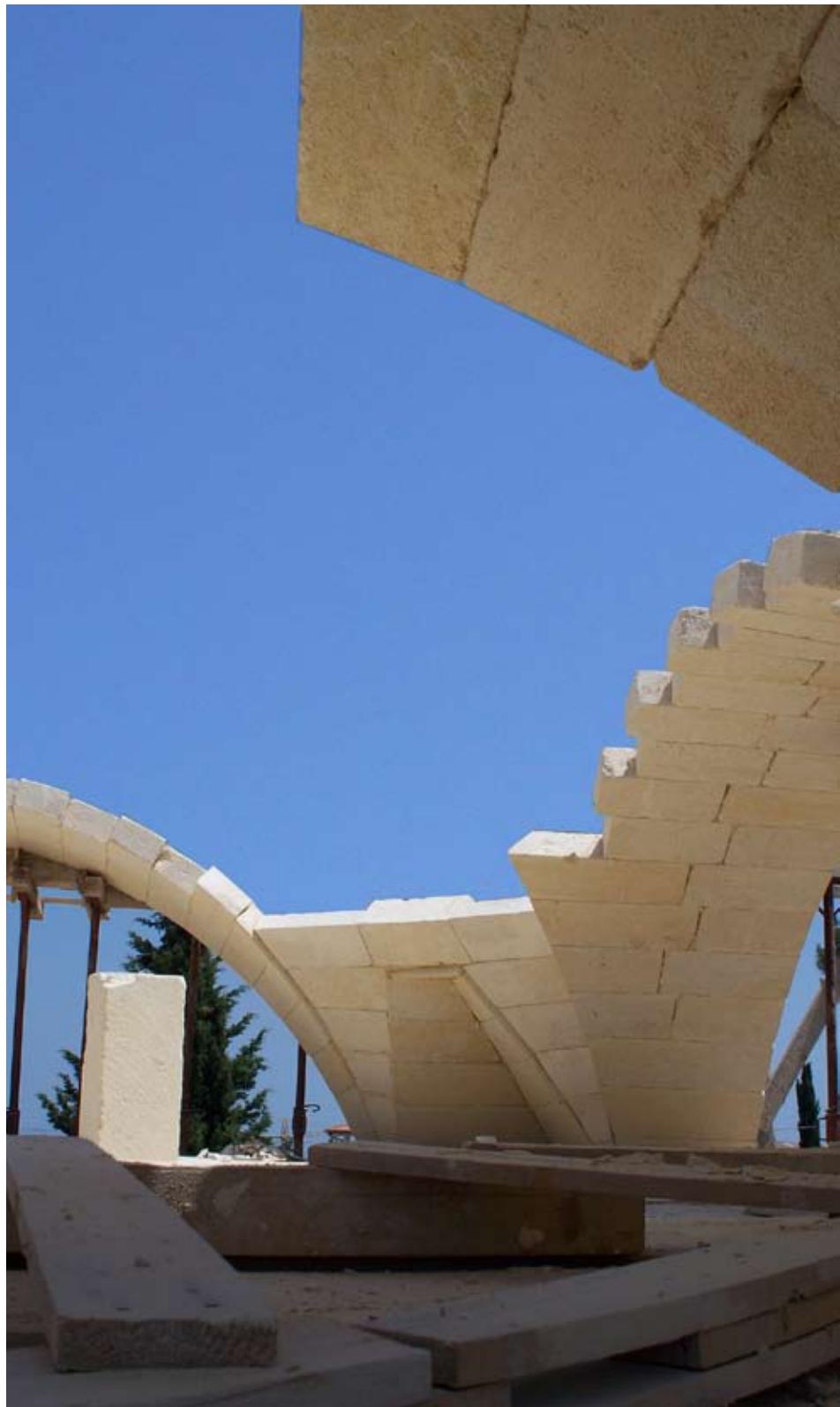


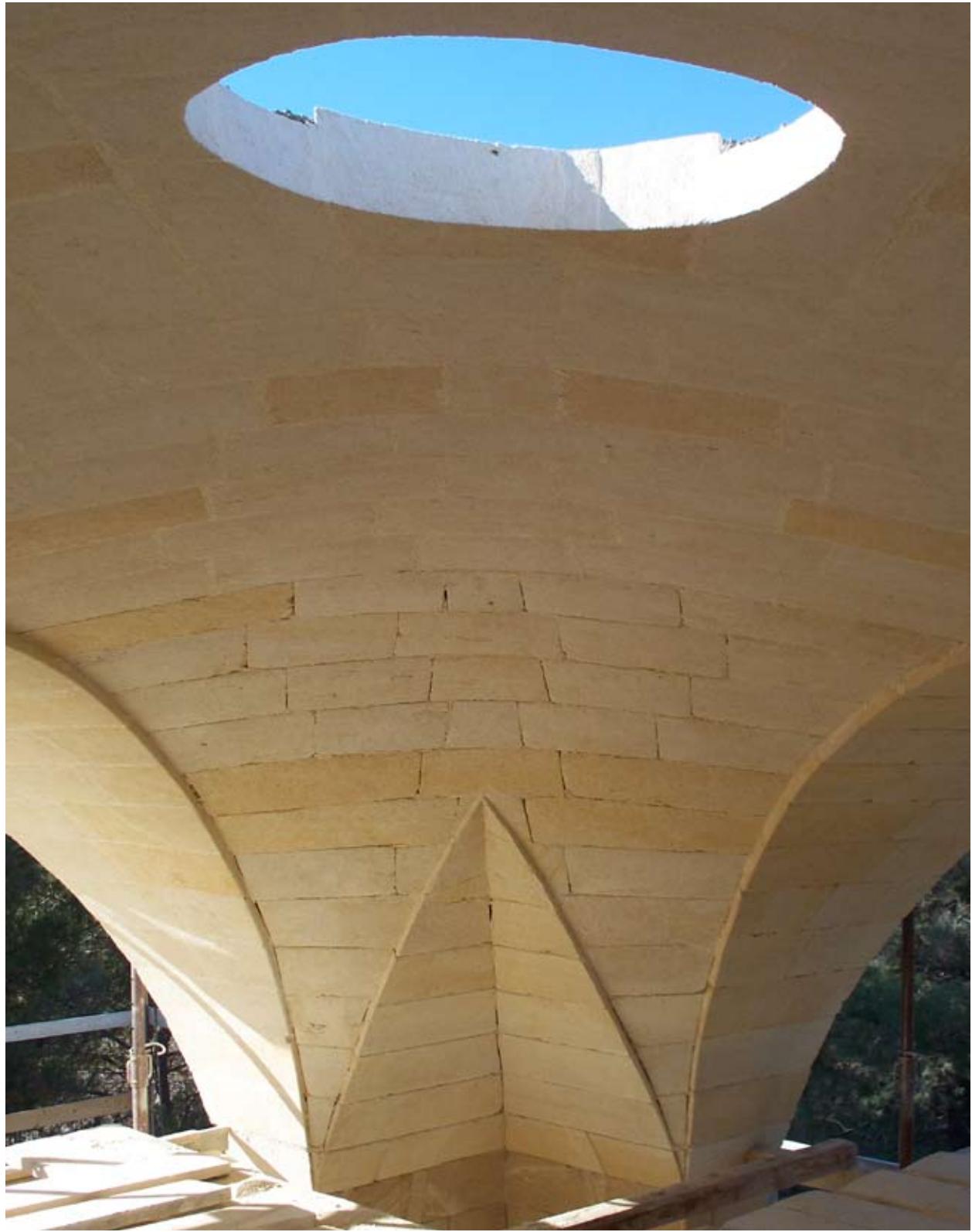


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993







95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

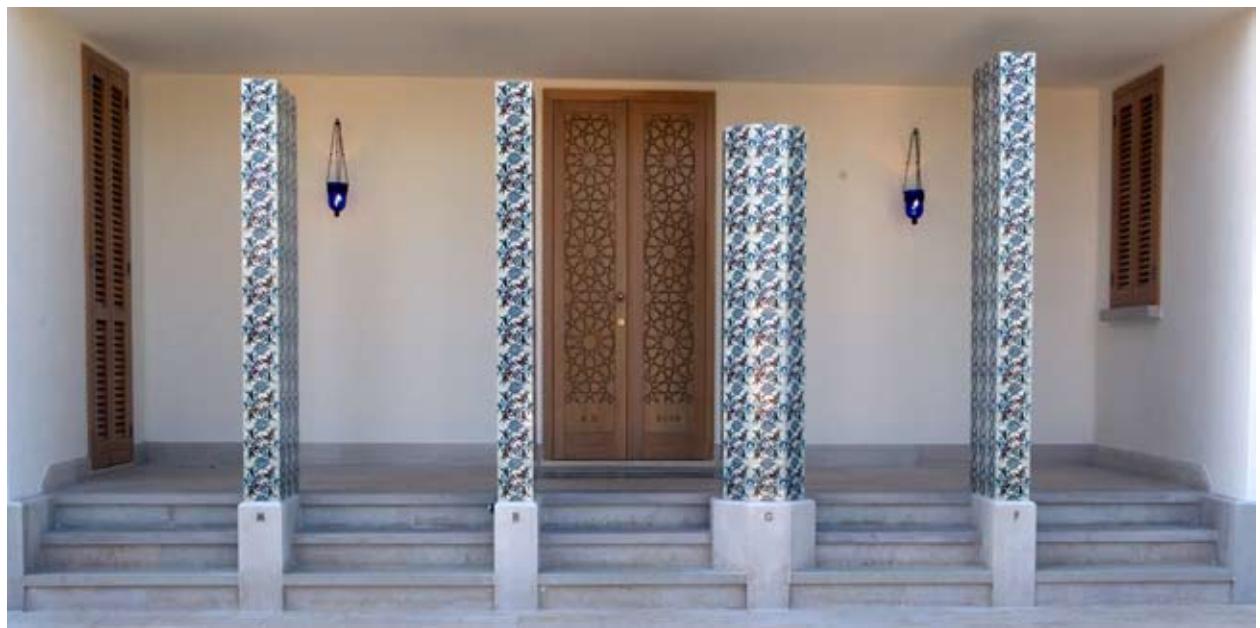




This project emerges as a desire to demonstrate the harmonious possibilities of expressing ancient building logic in a contemporary architectural language , showing beyond any doubt, that tradition is always a fertile and essentially modern field within which to work, because it is timeless.







95. Utensili da lavoro, disegno
di C. Gaul

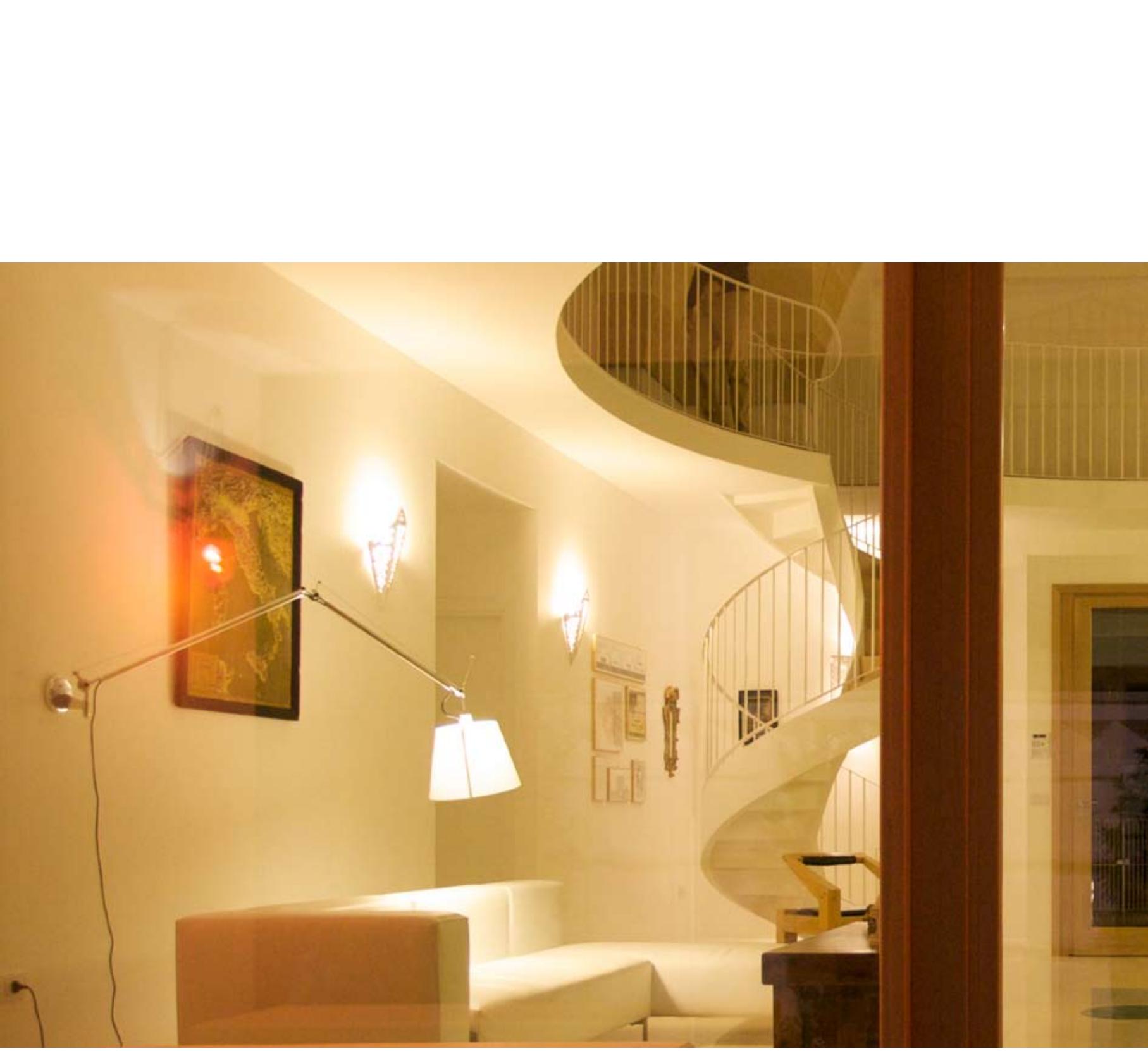
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993









SNBR bureaux

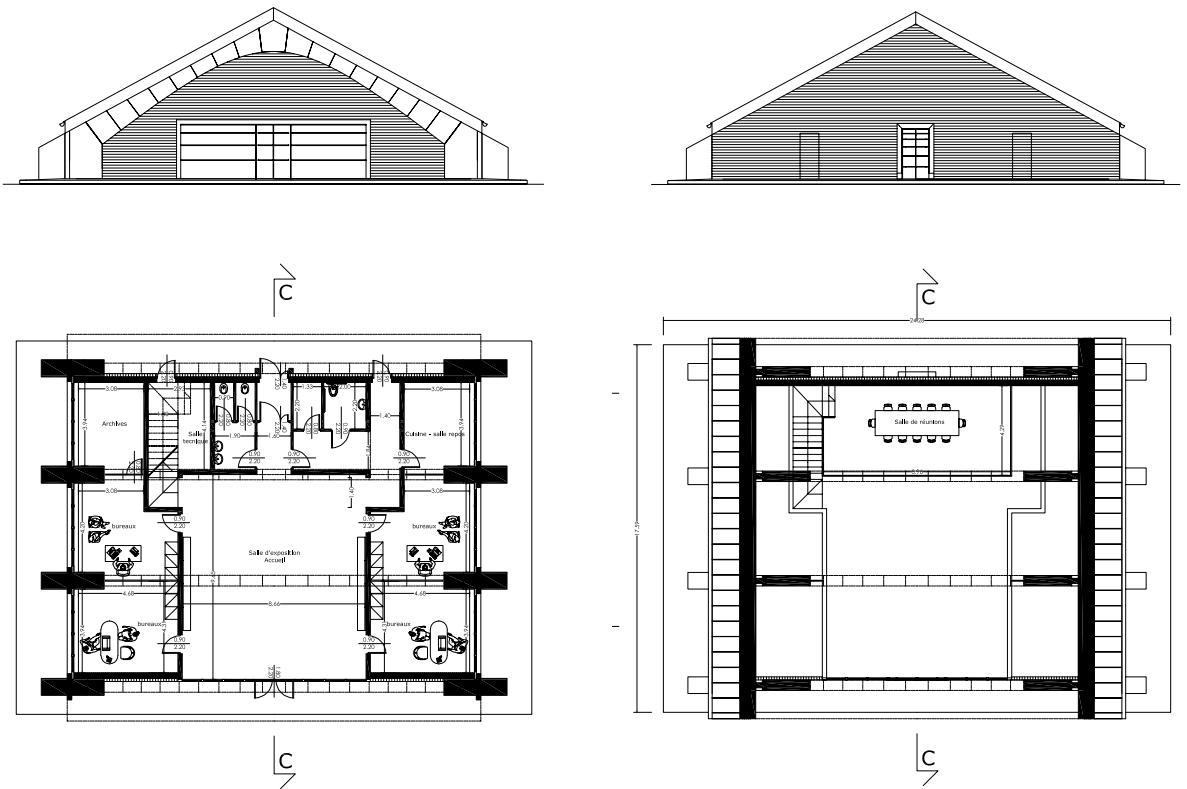
Troyes, 2008 | 2012

The diaphragm arch is part of a research program related to new stone architectures developed in collaboration with the French society SNBR, Troyes, specializing in stone masonry with numerically controlled machinery. The principle aim of the project was to create a HQE building (Haute Qualité Environmentale) according to French energy standards, in stone and wood. The HQE methodology which has been used in France since 1994, is different from other European approaches because of its implementation of four essential criteria: eco-construction, eco-project management, comfort and health. Another important feature of the HQE approach is the manner in which criteria are adopted according to the varying climatic zones of France, privileging in this way certain aspects connected to thermal comfort and the use of materials local to the site.

The commissioners specified the construction of a building redolent and representative of the company's image, one that works with stone, by using stone, an ancient material , applying absolutely up-to-date technologies.

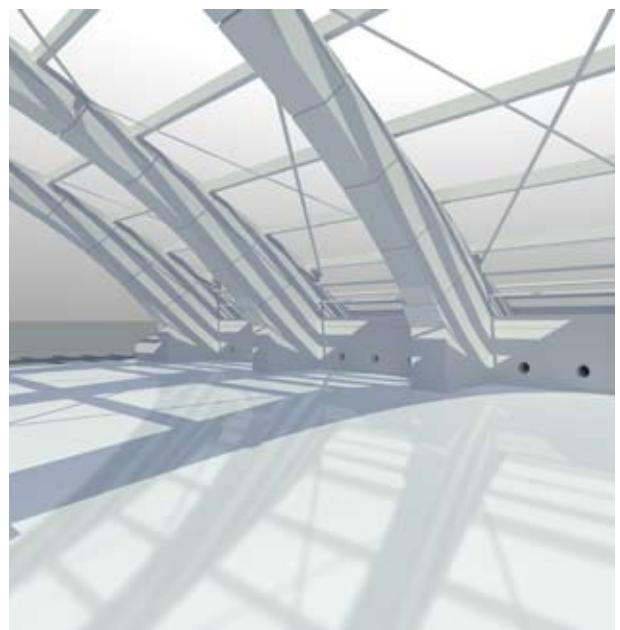
The design foresaw the construction of a large roof under which a functional plan could be freely interpreted, existing in total harmony with the genius loci of the French

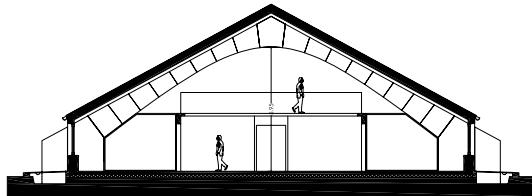




95. Utensili da lavoro, disegno di C. Gaul

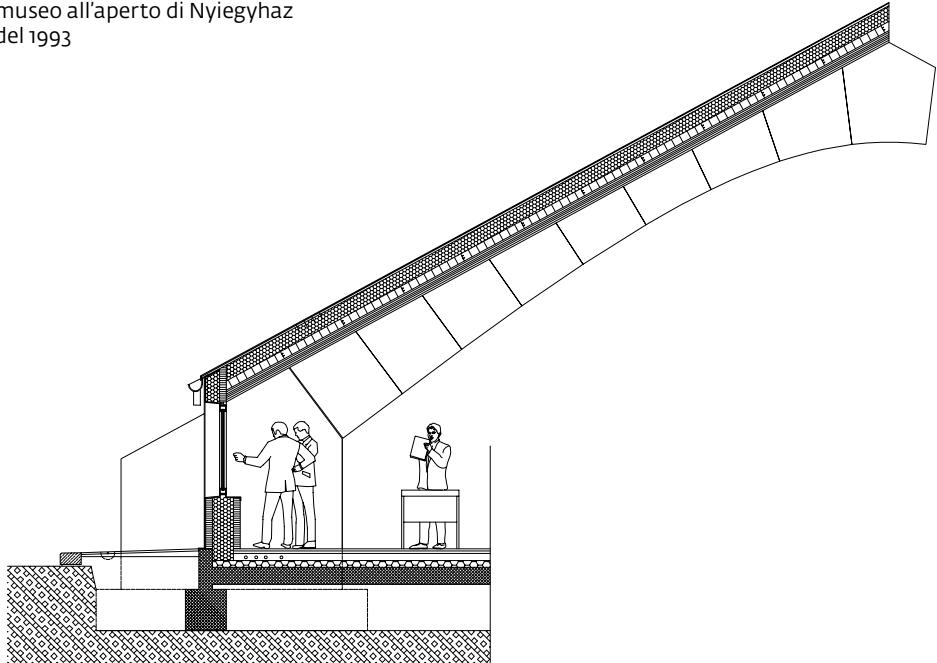
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

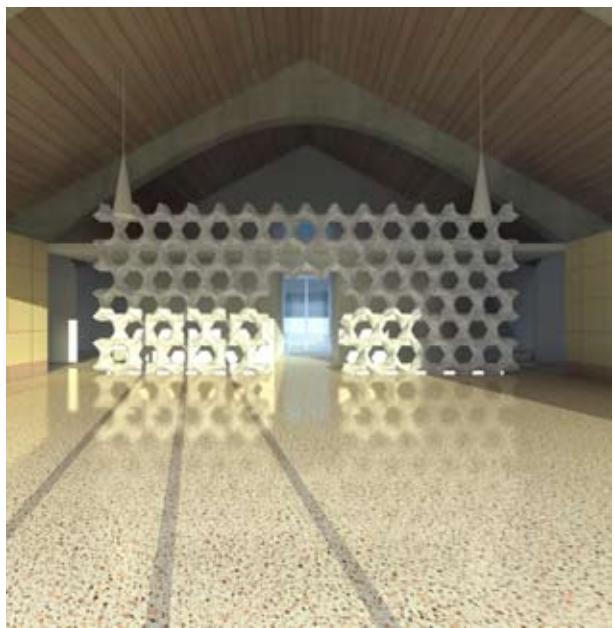
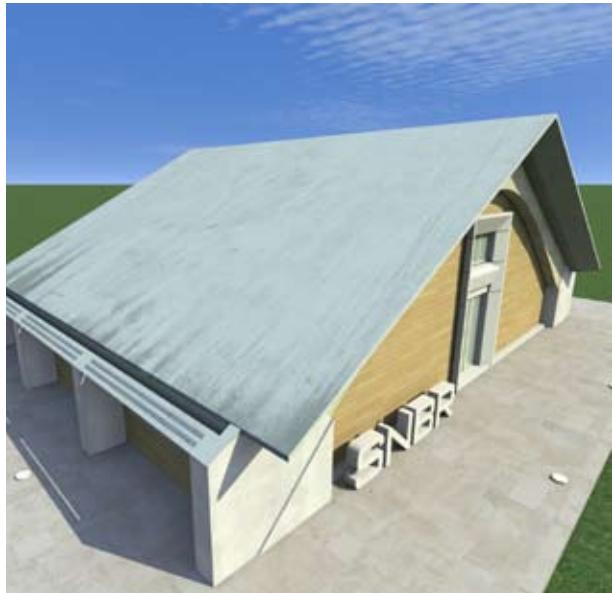


countryside, characterized by double pitched sloping roofs, using the logic of the diaphragm arch positioned on parallel planes.

The design of the arch initiated from the optimization of structure in order to reduce the thickness of the stone material to a minimum, for both economic and, above all, aesthetic reasons and connected to the idea of a concerted experimentation into the potential of the material.

The arches were constructed in Beaulieu limestone with a span of 20mt. The line of the intrados/archway is parabolic while that of the extrados is straight. The joints form sinusoidal curves. The parabolic curve of the archway 'follows' the stress-strain curve to which the arch is subjected; the superior straight lines , double sloping, were designed to support the wooden roof structure. Finally, the shape of the articulated curved joints increases the contact surface between the quoins and consequently, friction, while at the same time, avoiding any damage to the stone.

The arch is repeated four times in a parallel pattern (4 mt.) , until it covers a total space of c.300mq. The wooden structure of the roof functions as a static support for the arches below that would otherwise overturn/collapse onto the octagonal





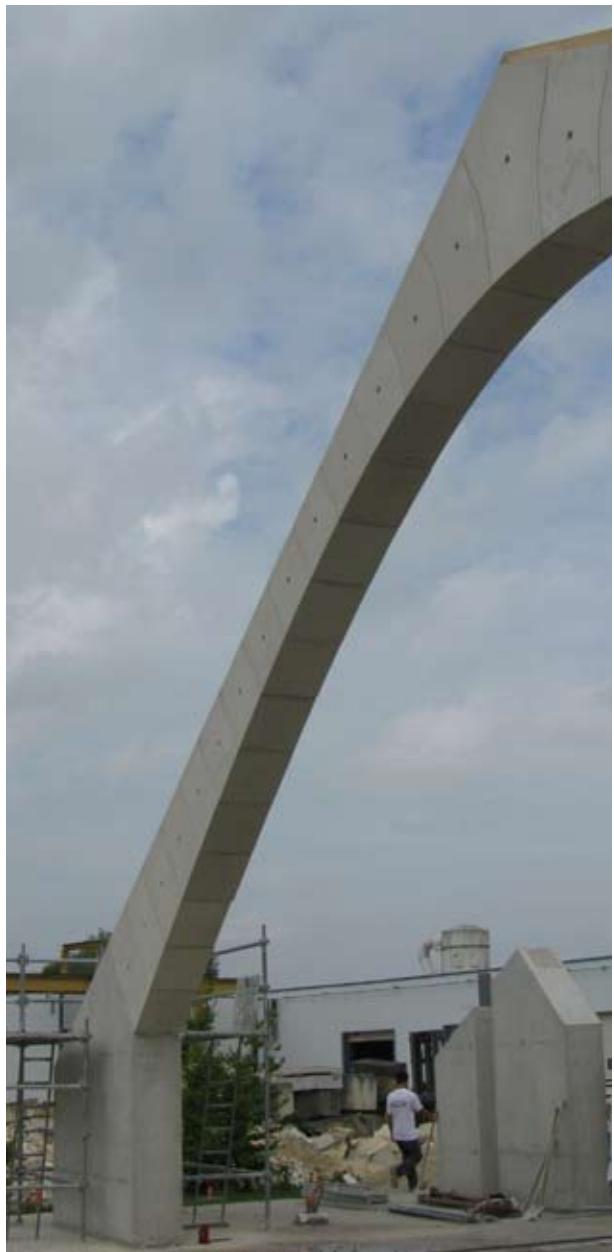


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993











95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



surface of the lying plane due to horizontal thrust.

The structure of the arch allowed for the possibility to utilize pre-compression techniques, using a steel cable threaded into the stone through drilled holes. This technique offered an interesting solution to problems concerning the use of stone structures in contemporary architecture, allowing us to reject prejudices regarding the technological possibilities for such materials used in large constructions.

The absence of seismic activity in the Troyes area indicated the choice of a 'traditional' type of structure with the arches transferring their weight into horizontal thrust. The experiment was tried first on a prototype.



95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





ECOmaison

Villy de Marechal, 2009 | 2013

This project was conceived during our experimental work on the SNBR bureaux project, as an adaptation of the diaphragm arch system to a residential family house. The construction principle utilized was similar to that of the SNBR 'older brother': here each arch has a span of 10 mt., half the size of the SNBR arch, and the load rests on a vertical masonry structure in pre-compressed stone (the SNBR arches were supported by reinforced concrete structures), with added blocks to increase the lateral thrust of the arches. The house itself is composed around the repetition of the four diaphragm arches with a centre-to-centre distance of 5 mt. below which the internal living spaces are devised.

The choice of a sloping roof was made according to the guidelines relative to urban architecture in the area, which is characterized by antique dwellings with formal characteristics.

The South-facing front of the house is characterized by a large glass window, set back from the wall of the first arch, useful for capturing indirect sunlight. The North-facing side of the house, on the contrary, englobes the arch itself into the structural casing of the house.

95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



95. Utensili da lavoro, disegno di C. Gaul



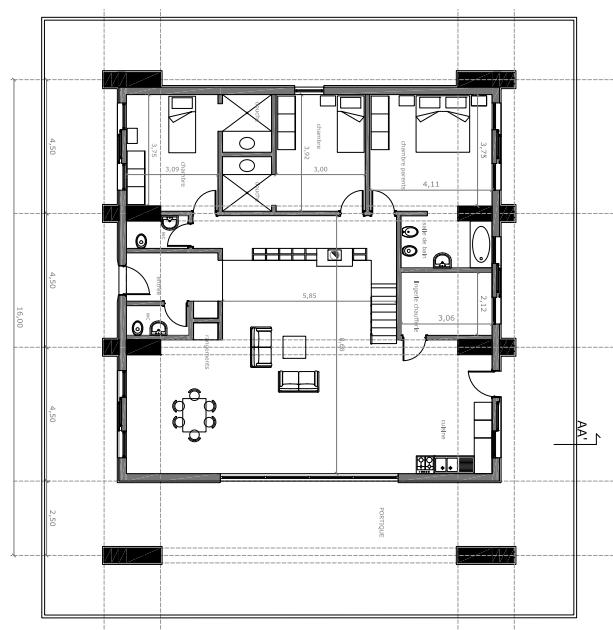
96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

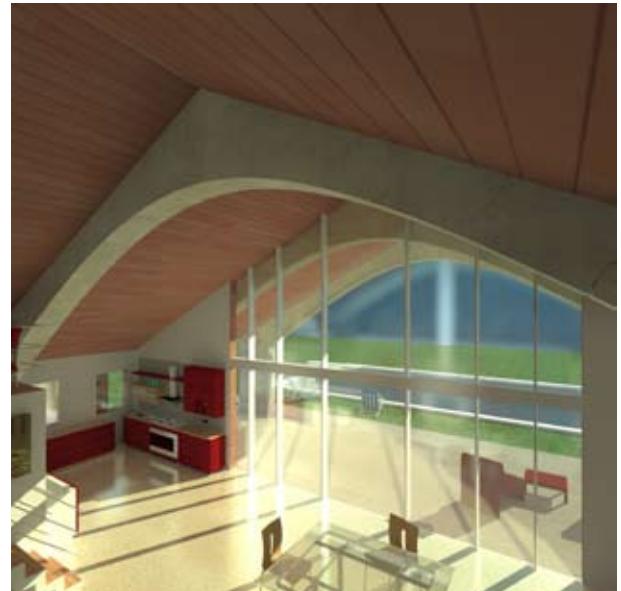


The East and West-facing sides of the house are characterized by the rhythmical spacing of the heavy stone vertical structures that support the arches, creating a monolithic effect.

The masonry mass guarantees a good use of thermal inertia both in the Summer and the Winter.

Inside, the house is divided into two large functional zones: on the South side a large living space that extends over two levels, this leads into the second, north-facing zone constituted by bedrooms and a wooden mezzanine, designed as a study or play area, built above.



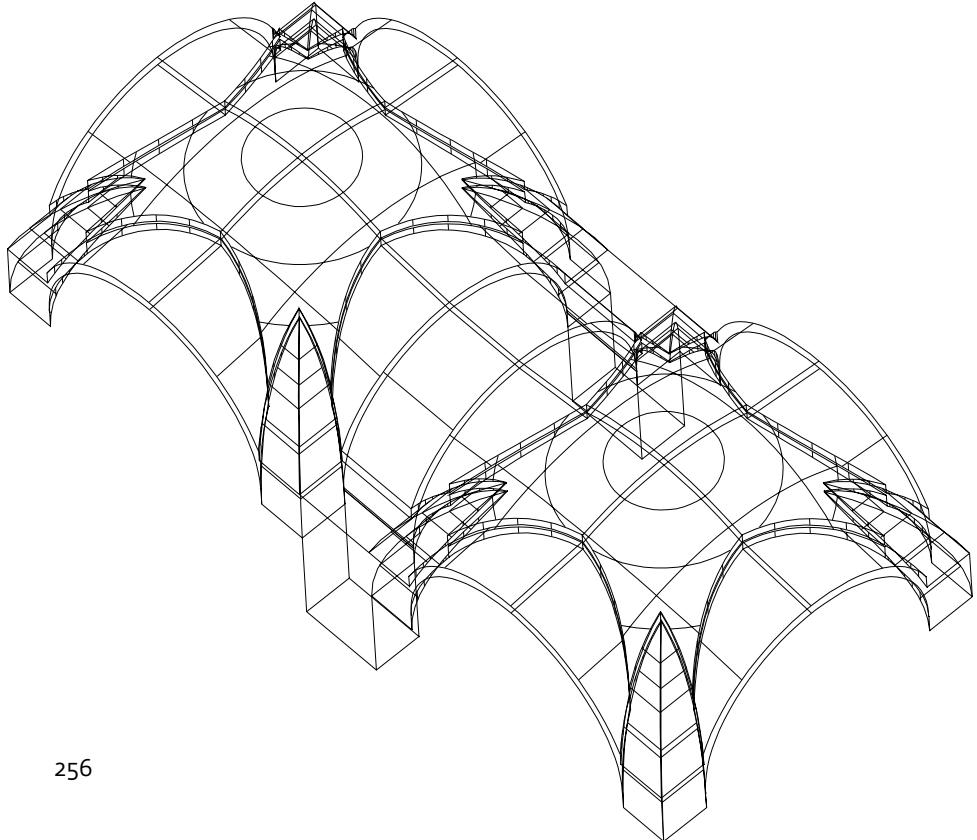


SOLEIL, 21.06: da 8h a 16h (avancement de 2h)



Ardito House

Corato, 2010 | 2012



A house is always a response to personal exigencies, it is never objective. This project came from the request of the commissioner to construct a domestic space that was recognizably a home and in which the owners could see themselves living and belonging to an autochthonal culture. The project design aimed at firmly rooting the building in the landscape, not making it stand out, but at the same time offering a determinedly modern response to the vernacular spirit inherent in the idea. The design of a single-family dwelling might not seem as challenging as other more complex building typologies, but is nevertheless not just a series of pragmatic steps made to resolve the physiological issues concerned with creating a living space. The complexity of such a project lies in the responsibility implicit in giving form and structure to a space for man to be born, live and die in. The aim of the project, to give a Mediterranean identity to a building, led us to engage with those intimate connections between nature, implied by the landscape in which the site was located, and the climate. We searched for a perfect equilibrium between the structural and the geometrical simplicity of the space. In this small rural house, the vaulted unity of the structure

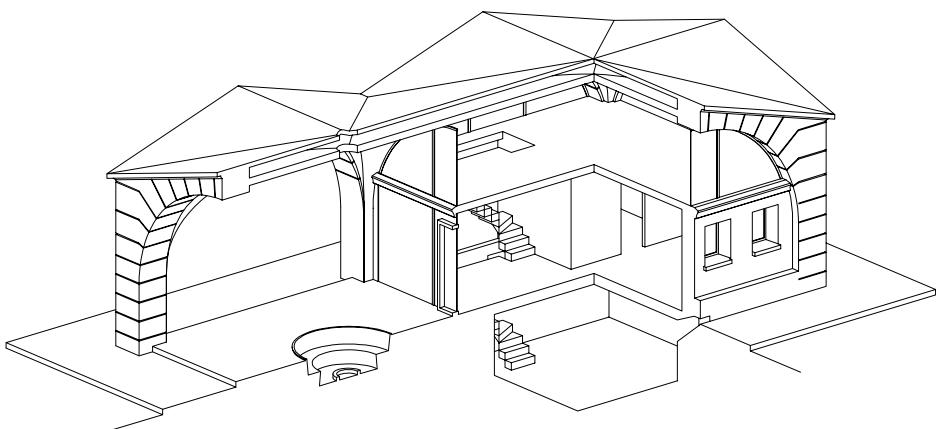
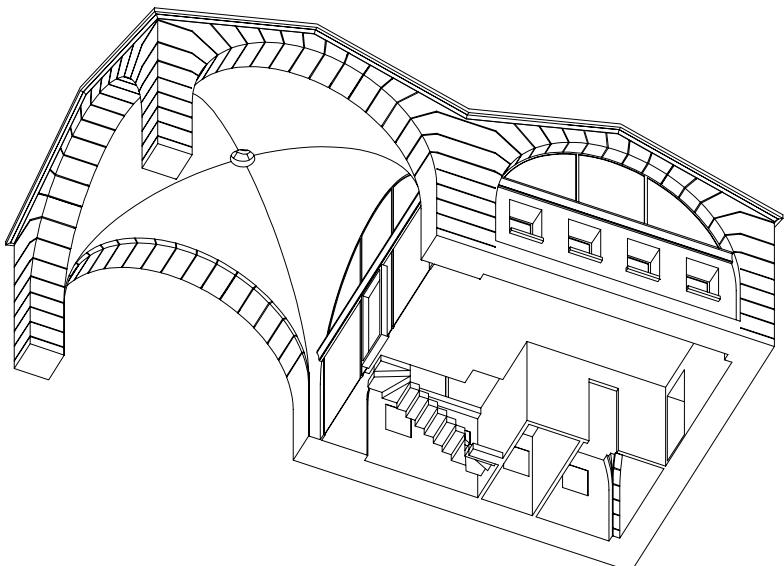
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993



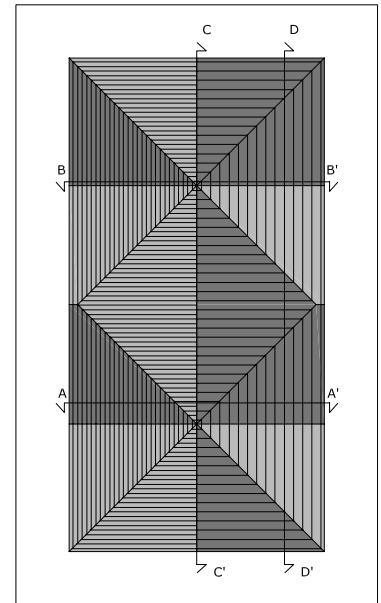
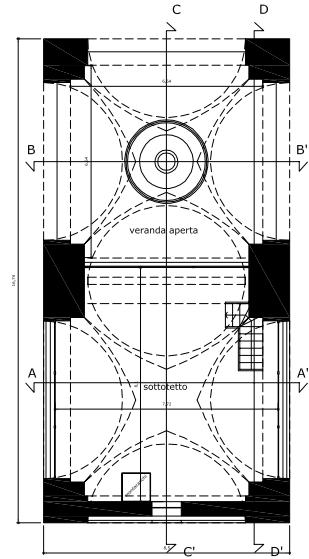
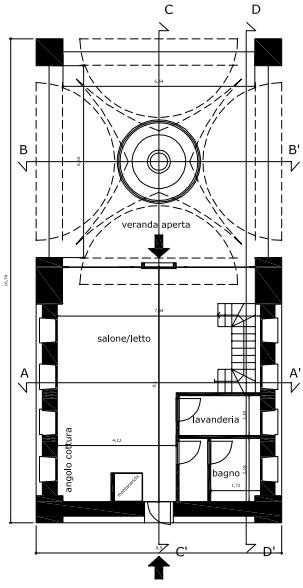
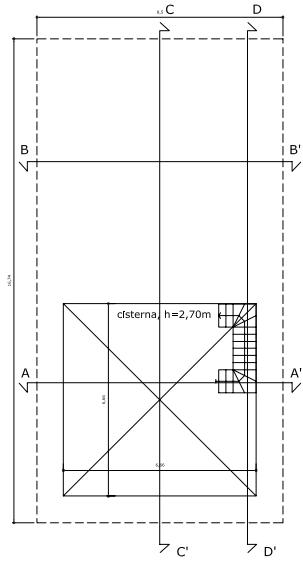
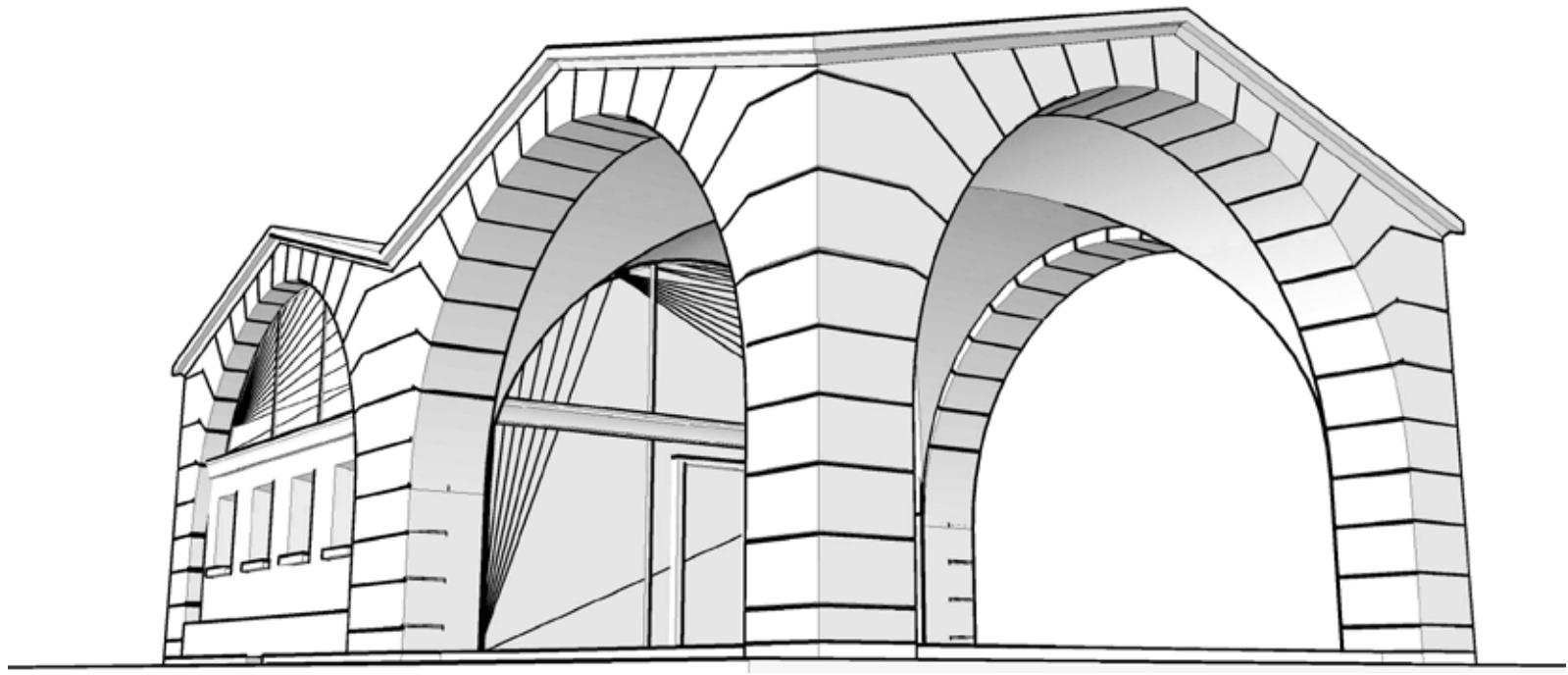
95. Utensili da lavoro, disegno
di C. Gaul

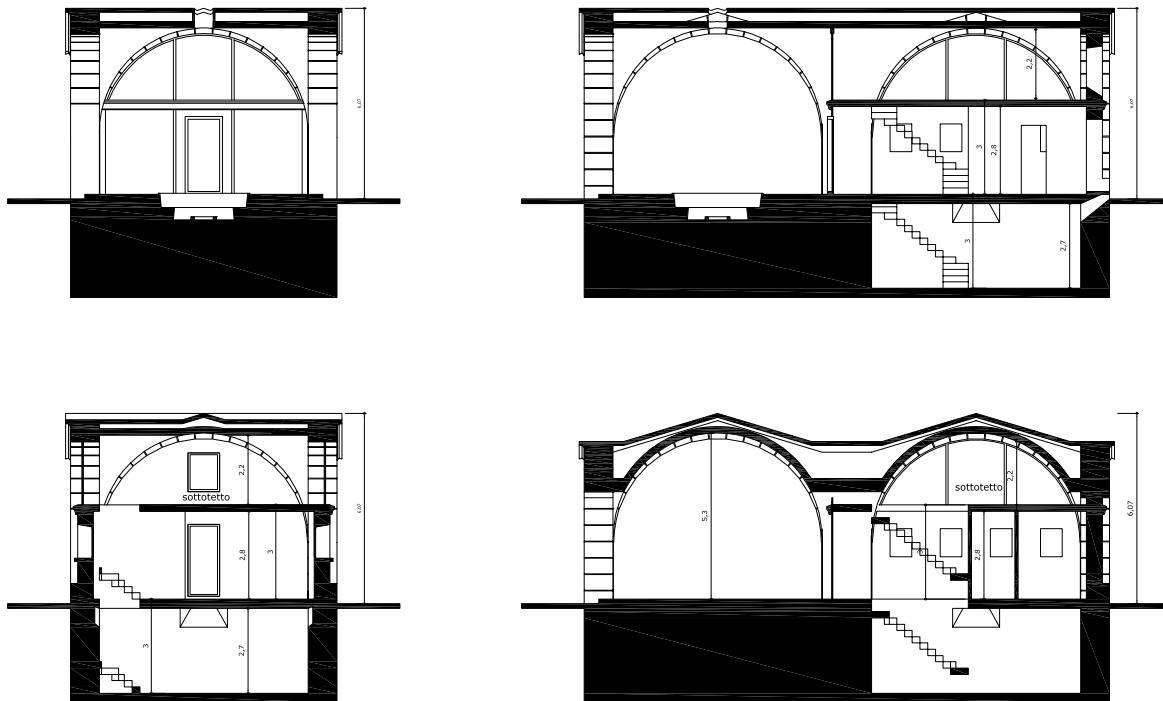
96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



defined the different spaces which were not only separated but united in a relationship of contiguity between inside and outside. The house is composed of two square vaulted units, one inside and the other outside, two coincidental spatial modules occupying a minimum of space: the rational matching of parts of a work and their relation to the whole, both on the level of proportion and symmetry. Modularity is based on the notion of 'quantity', that divides space according to a double compositional valency: space seen either as two areas, one repeated in the shape of the first, or as a large single area divided into two sub-units.

This compositional form has to bear in mind the relationships of congruency between the individual modules, the distribution of subordinated spaces, separating the inside rooms into service spaces or living spaces, and to the necessities of static construction techniques for vaulted architectural systems based on oppositional thrust. Respecting the traditions of local construction cultures, the building was designed using stone vaulted architectural methods. It has a regular shape, a rectangle formed by two squares, each with a vaulted roof (c. 8 mt. per side) a sloping pitched roof made of local stone tiles.





95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

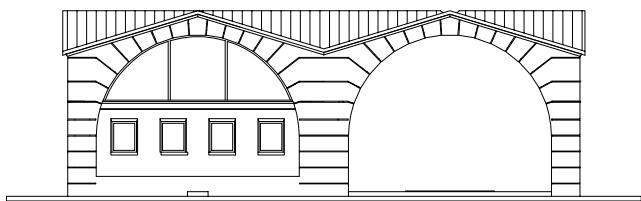
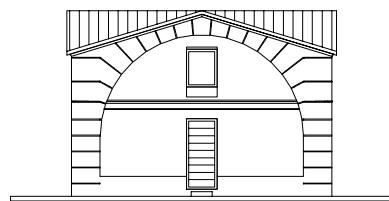
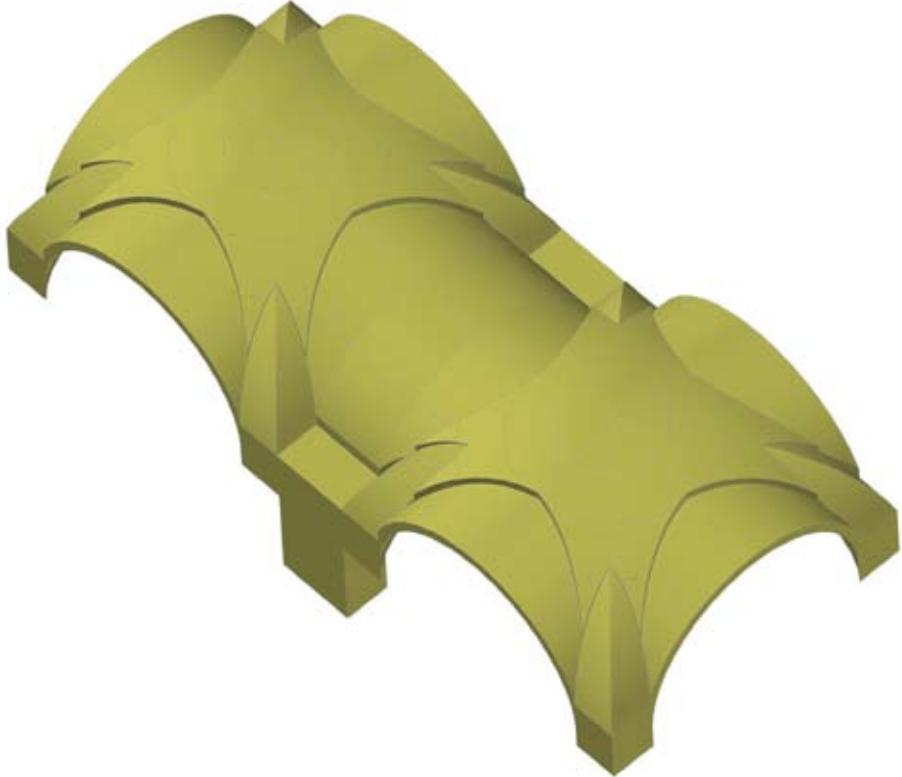


95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993

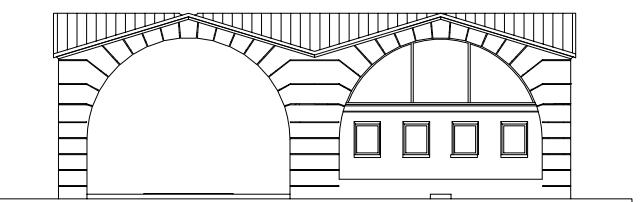
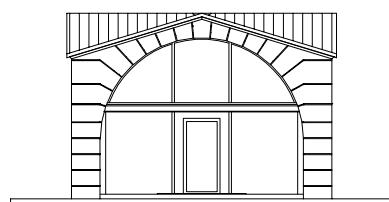


The walls are made of stone (Apricena and Trani limestone for the vertical systems, tufa from Canosa or Gravina for the square vaults) cut thickly to ensure that the stone mass, in association with the underground area beneath the house, can regulate the temperature inside the house in the Summer. The external façade of the house has a mixture of opaque stone facings and transparent glass, to allow for a view. The stone façade is made of local stone and white lime plaster.



95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



Zucaro Winery

Corato, 2010 | 2012

The project was to design a building to house a wine making plant with a rural house annexed to it, in the countryside near Corato (Bari) in Puglia. The commission specified that the building had to be suitable for both wine production and wine-tasting, that it be a simple project both as regards the design and the costs. The location of the structure is influenced by the many XVII buildings around it, mainly farm-houses, and by the imposing view of Castel del Monte just 2km away from the site.

The design plan deliberately engaged with several features of rural architectural in the area: volumetric composition based on the juxtaposition of pure volumes, colours, material and roof morphology, while giving free reign inside the building to a more experimental approach to space, that joined the functionality of the work place with architectonic quality.

The construction is articulated around two adjacent bodies. The first, the biggest, was designed to hold the wine-making facility, including large metal storage containers or "silos". The space was constructed using a metal framework and arch with a single bay (c. 20 mt.) A false ceiling in wood panels was fitted to case the inside of the building, giving the whole the appearance of a 'barrique'.

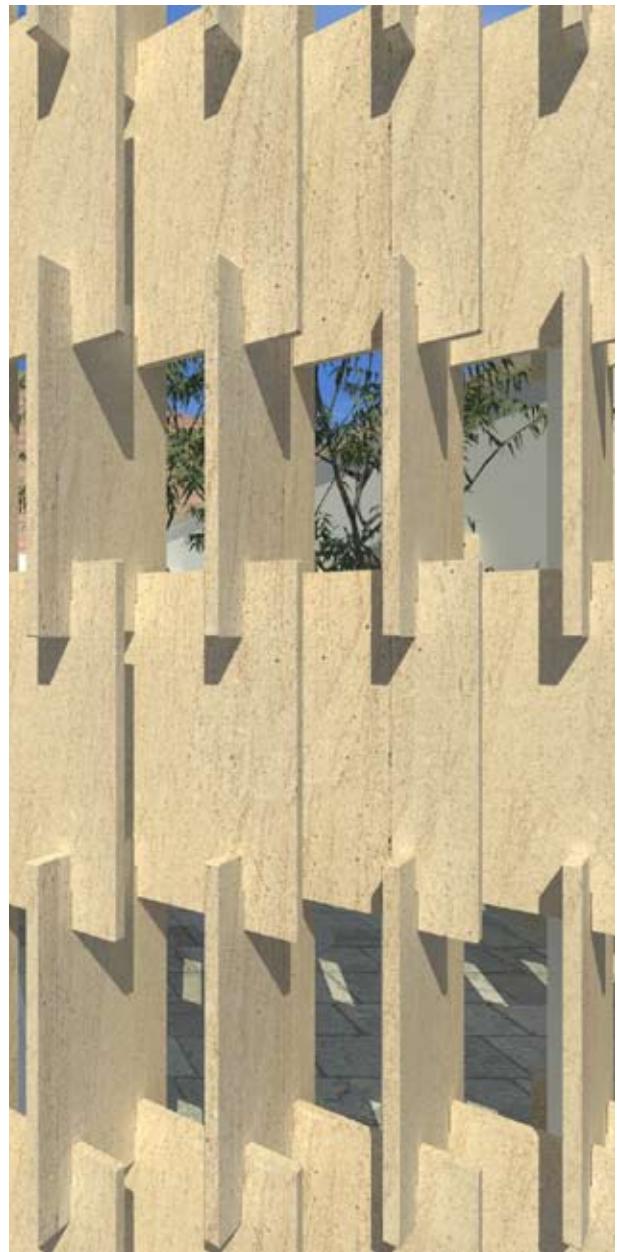
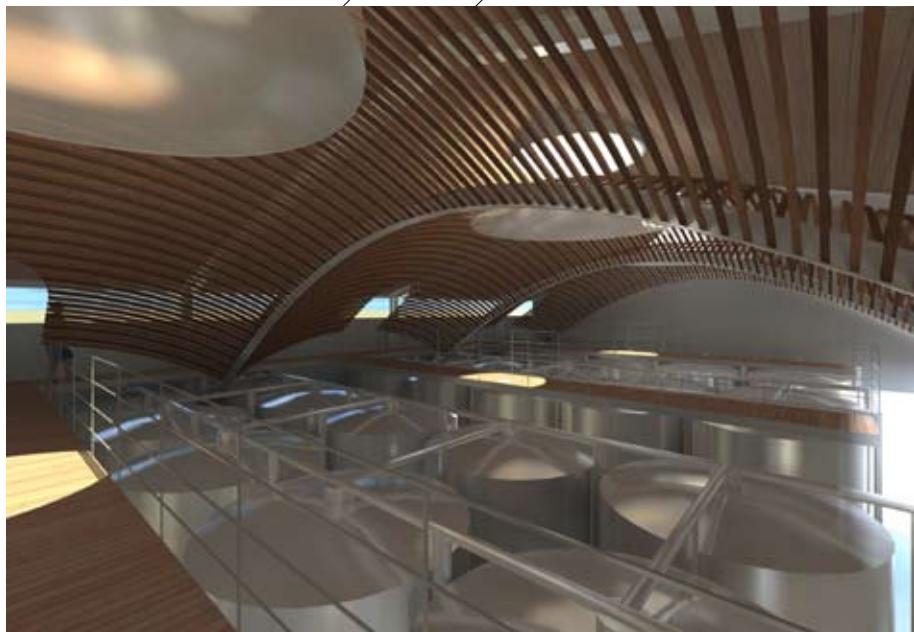
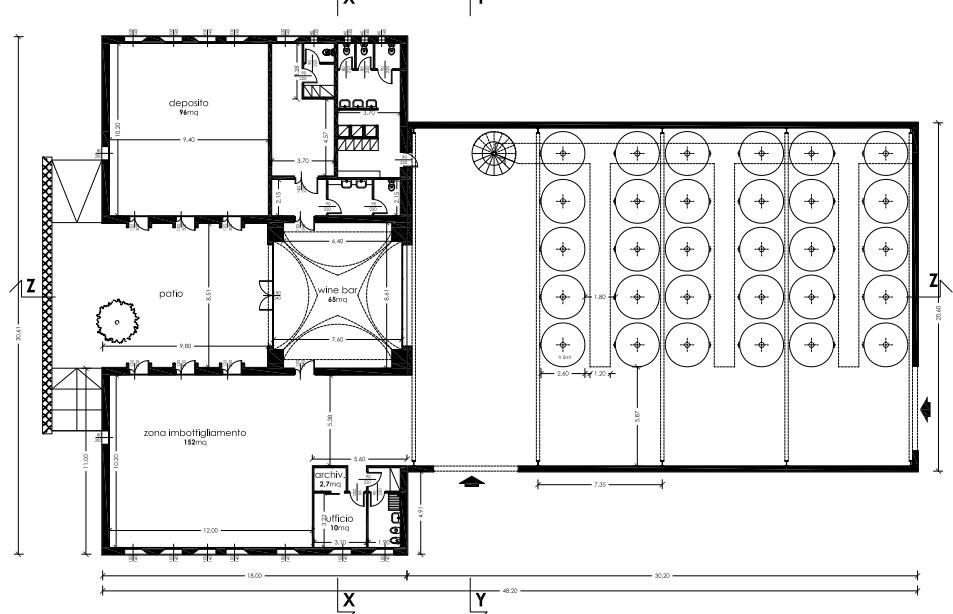
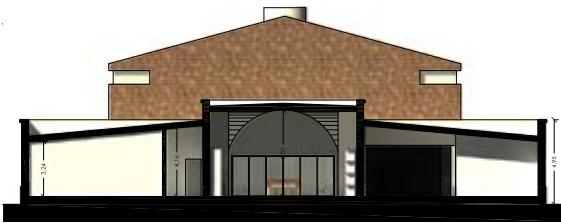
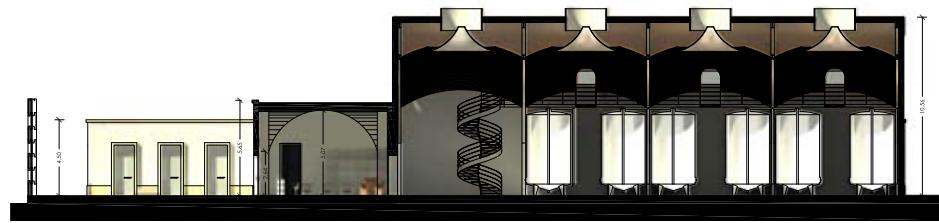
95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyiegyhaz
del 1993

95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993





The repetition of the intervals between the steel arches running the length of the space, conferred a transversal rhythm to the space. The external casing of the building entailed the use of thick local tufa (75cm thick) whose degree of thermal inertia, combined with the temperate climate of the area, allows an almost constant internal temperature and eliminates the need for mechanical air conditioning. The roof is clad with tiles similar to those made locally and used frequently in local architecture.

The second building was designed to house smaller offices and accessory structures generally, the wine-tasting room and the house. A traditional model was chosen with thick walls in tufa (50cm) with a wooden truss roof, and a vaulted stone roof for the wine-tasting area. Here a square Lecce-type vault was constructed (8,5mt per side). On the South-West side, an open patio was constructed that serves several of the internal spaces as well as constituting a passive thermal regulator for all the internal spaces that look out on to it. The patio offers a shady space for wine-tasting in the Summer. The patio is closed on the

South-facing side with a screen wall of Apricena stone slabs set in such a way as to reveal glimpses of the surrounding countryside.

95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

Korch Turturo House

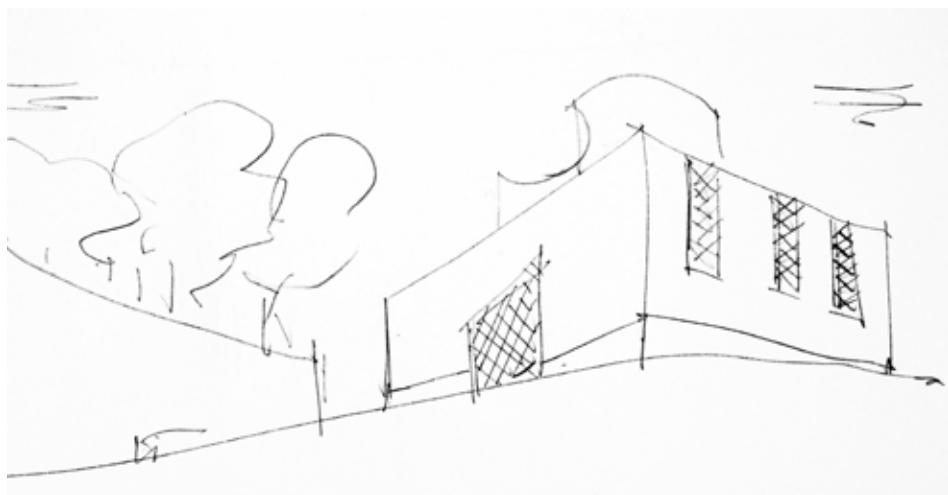
Trani, 2011 | 2013

The building is situated in the Capirro district of Trani, a place that while maintaining some of the common themes of the landscape between the Murge and the sea (dry stone walls and olive groves), has undergone a progressive deterioration due to the processes of urbanization, resulting in a plethora of 'second homes' set behind impenetrable fences that give a rather commercial and at times banal appearance to the area. However, some small enclaves reminiscent of an earlier, autochthonous landscape still exist, in particular some wonderful eighteenth century villas; one of these is located next to the site where the new house is to be built, allowing the owners the possibility to contemplate this *genius loci*.

The house is rectangular in shape and is organized around a central living room, the heart of family life.

The internal spaces represent their day to day functions: the central room, the heart of the house, is a vaulted structure constructed on a North-South axis to make the most of the sunlight in the Winter months and, in the Summer, to benefit from transversal ventilation.

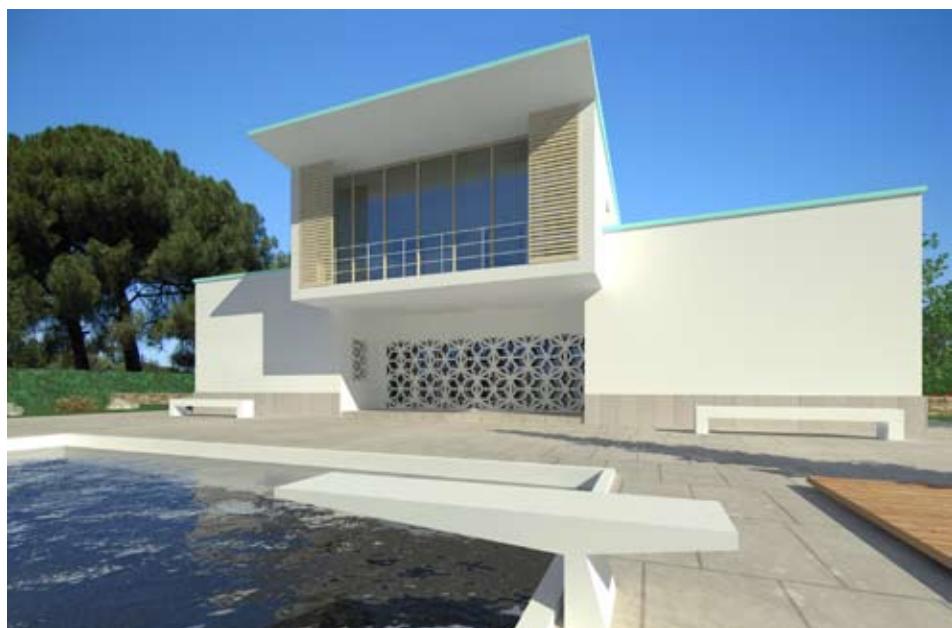
On the North side, the study and the entrance hall are located, while in the bedroom with a North-facing wall, a niche





95. Utensili da lavoro, disegno
di C. Gaul

96. Fasi costruttive della
torre campanaria di Tivadar al
museo all'aperto di Nyieghaz
del 1993



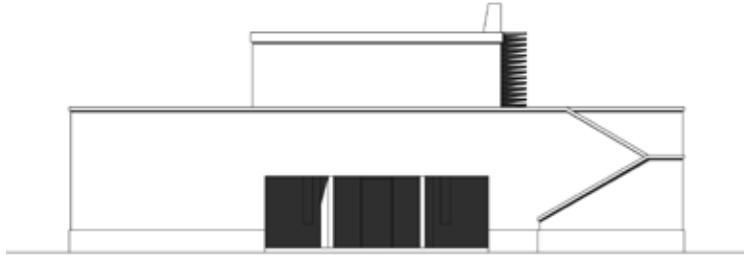
(recuperated from the external 'a proferulum' staircase) was designed to act as an insulating 'cushion'.

For those approaching the house from the North, the house may appear 'introverse' in its lack of openings and in the manner it is closed around the central vaulted living-room. All the rooms are organized around this centre which becomes the nodal point for family life. Against this conception of space another, more 'extrovert' tendency appears, a natural progression of family life towards the outside, with an opening up of the central space.

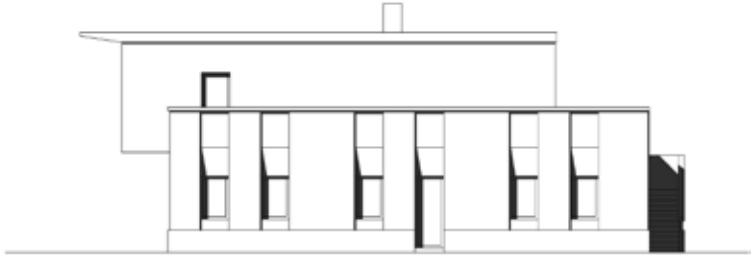
The seasonal variability of sunshine has led to the introduction of specific architectonic solutions that make the most of, or correct, the passive behaviour of the building.

The big glass windows on the South side are carefully screened (on the ground floor the windows are set back 3 mt. from the wall, while on the first floor a 2 mt 'veil' was added) guaranteeing comfortable thermal stability throughout the Summer months, preventing the sun from penetrating the rooms directly while allowing the benefit of solar radiation in the Winter.

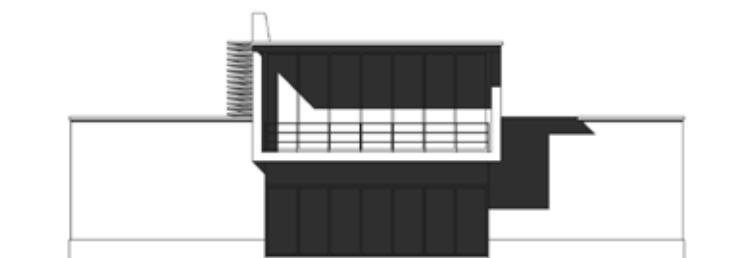
The large vaulted central room is the principle means for a passive use of solar energy. In the Winter, the South-facing window creates a greenhouse effect, the



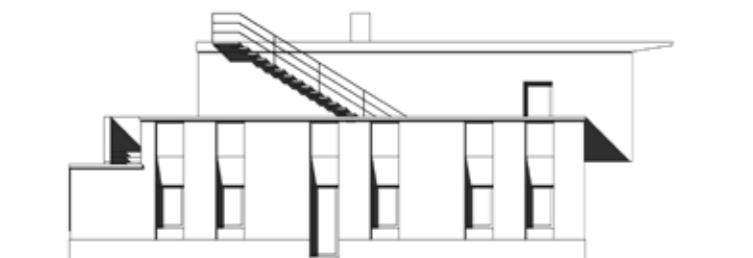
PROSPETTO LATO NORD



PROSPETTO LATO EST



PROSPETTO LATO SUD

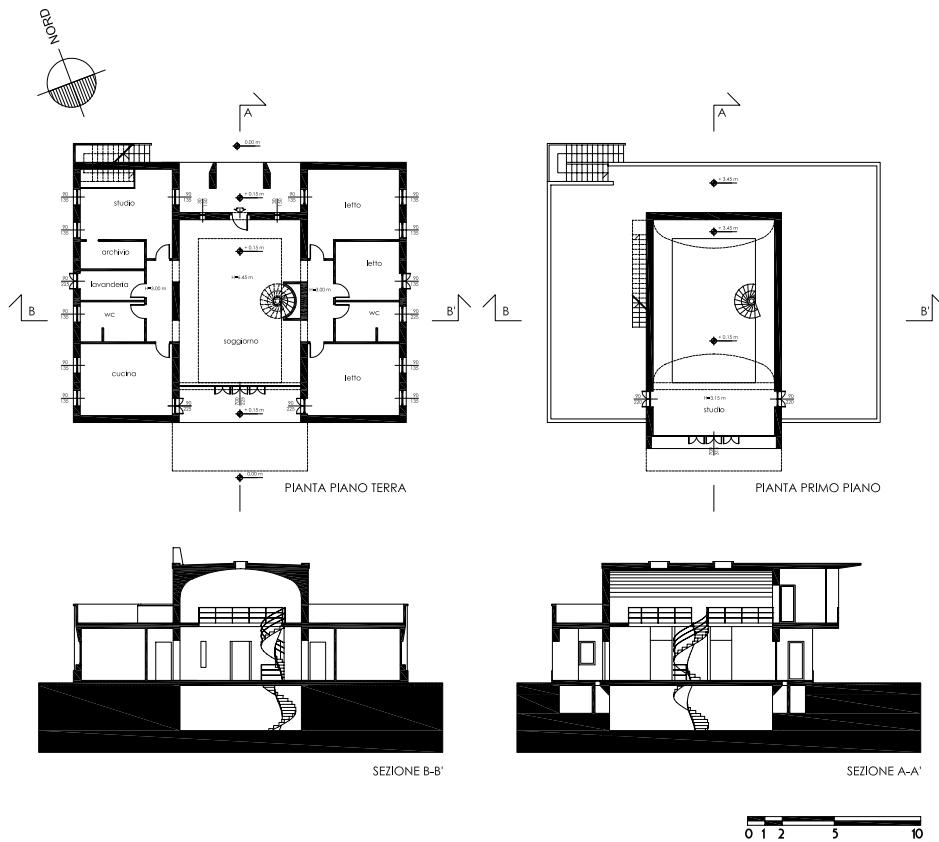


PROSPETTO LATO OVEST



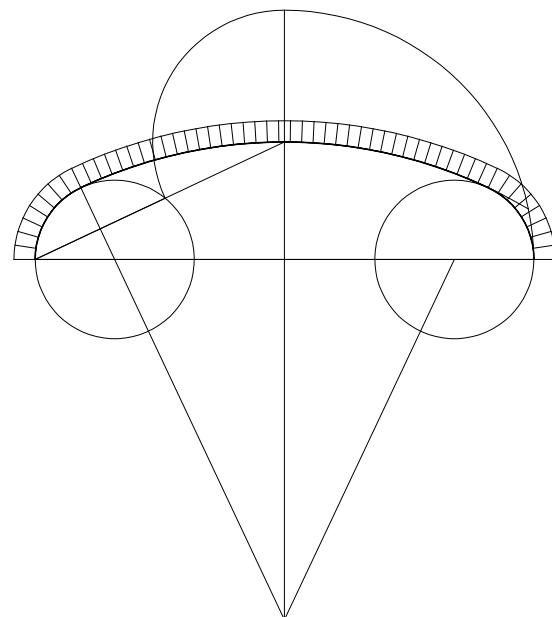
95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyiegyhaz del 1993



95. Utensili da lavoro, disegno di C. Gaul

96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

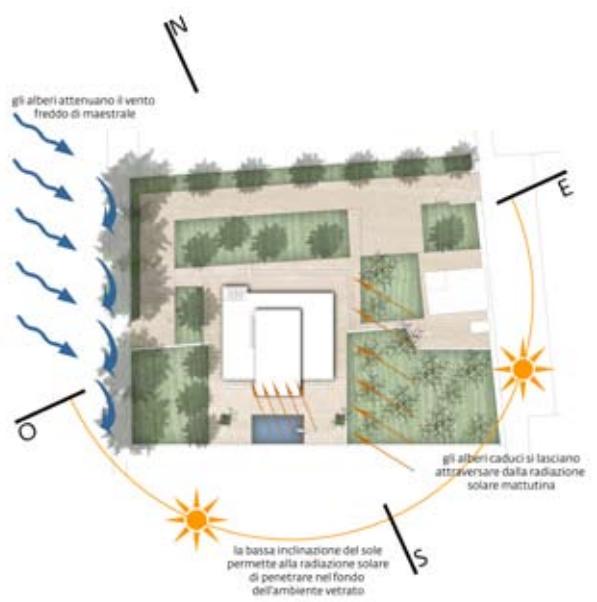
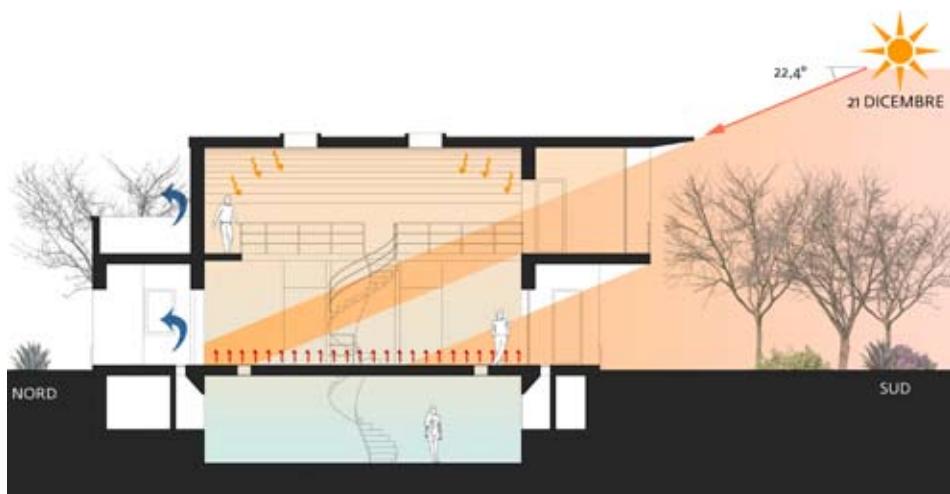
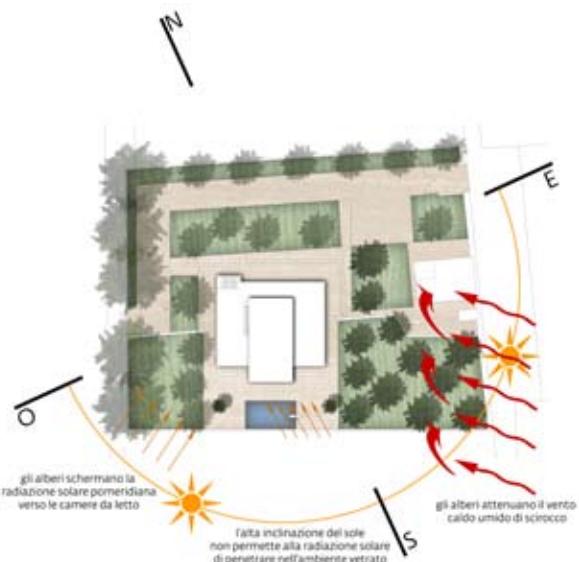
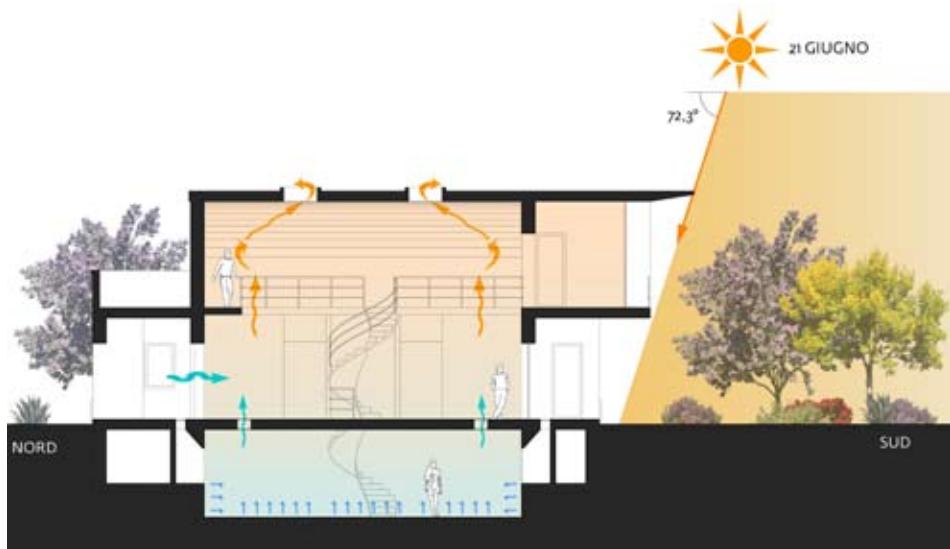


heat accumulates in the stone mass of the vault (c. 60 mc of Lecce type tufa), the inside walls and the floor in Trani limestone; after several hours, the heat is released into the central space and then, through processes of natural convection, warm up the other living spaces (bedroom, study, kitchen).

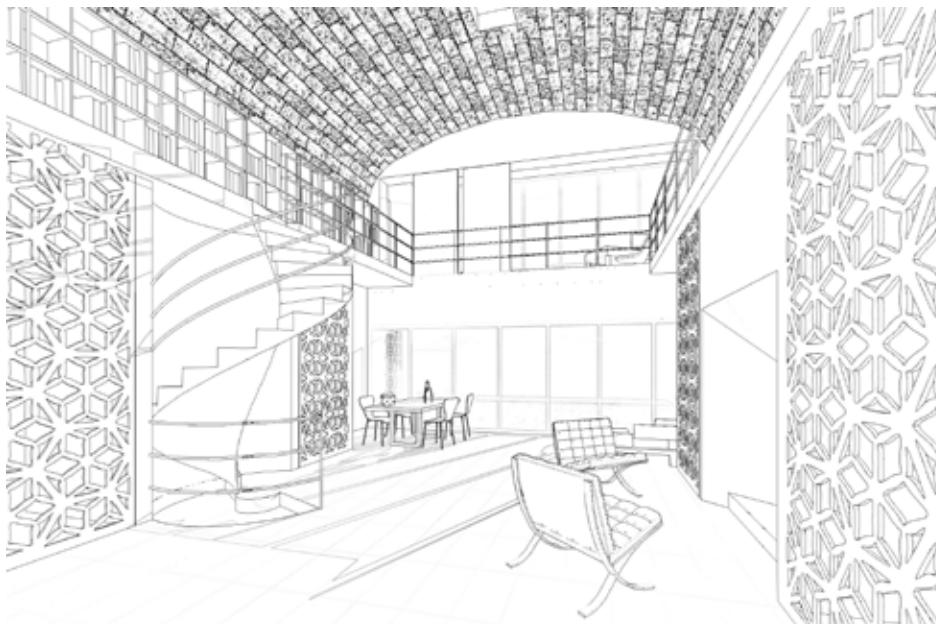
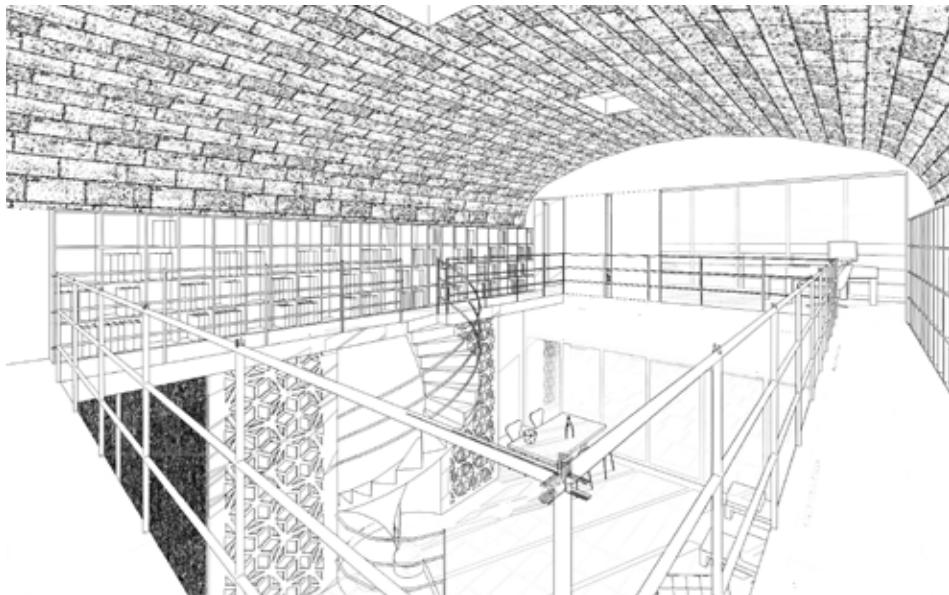
The architectural composition is highlighted by the purity of volume, the simplicity of lines, the preference for fullness over emptiness and sober decoration. Using pure form implies observing the simplicity of elements, while at the same time regulating the complexity of composition in order to enunciate the expressive nature of the organism. The simplicity of the volumetric aggregation of space is enriched by plastic elements that give depth to the whole, like the external staircase and the wide portico. Openings (windows and doors) are rendered precious through the use of decorative wooden screens (musharabiya). The living-room has a barrel-vault ceiling with three centres. Initially we thought that the vault could be covered in tiles, avoiding the use of ribs, utilizing techniques experimented with at the Faculty of Architecture in Bari, and saving a substantial amount of time and money, but the clients preferred a stone vault with the dressed-stones of the



96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993



96. Details of the interior space

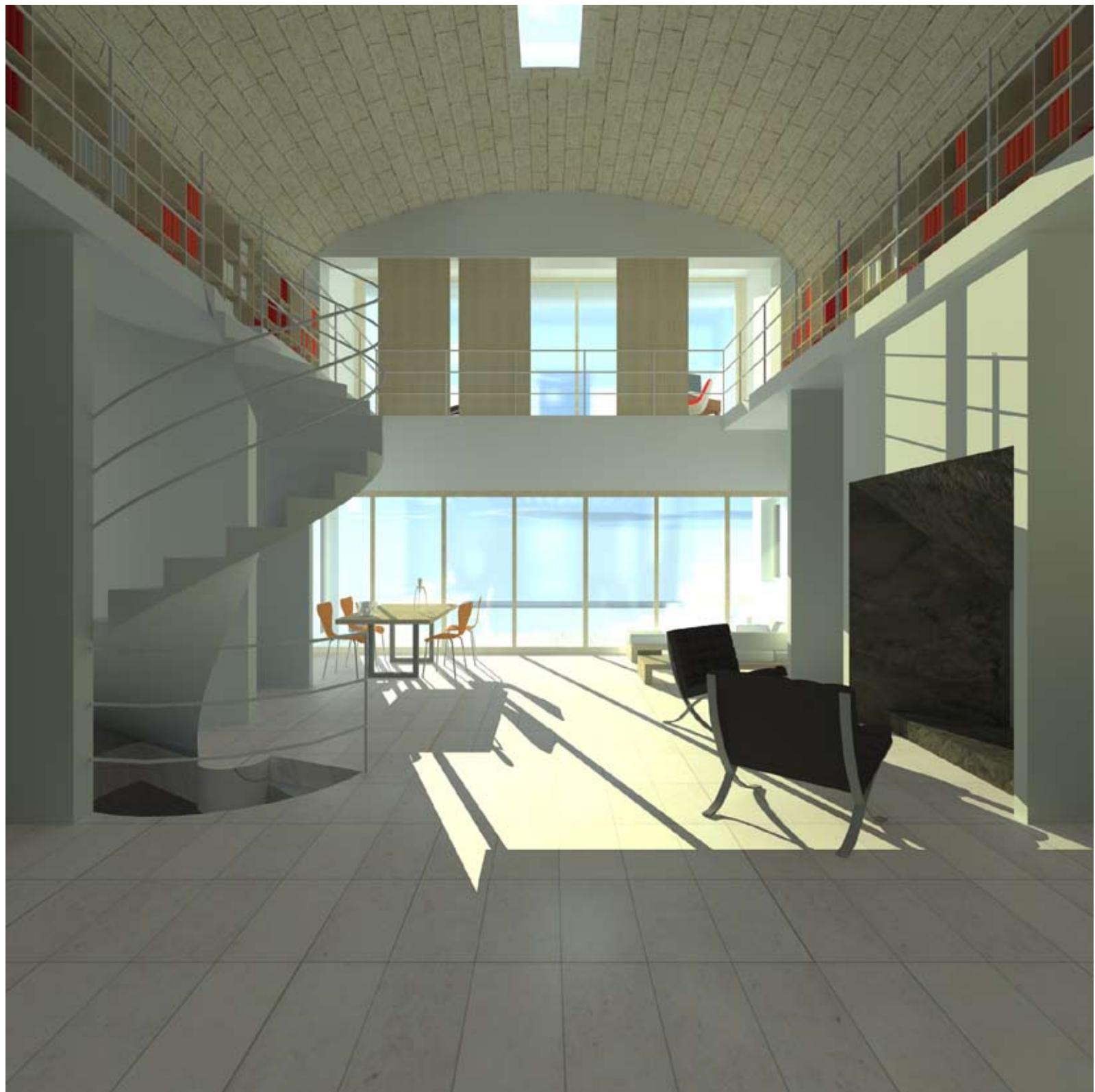


arches visible to the eye. The height of the vault also caused problems of strong sideways thrust, problems that were resolved by using a 'belt' beam along the perimeter placed at a height of one third of the structure.

One further consideration related to the choice of a vaulted structure regarded incentives given by the Regione Pugliese for vaulted architectural structures. These guidelines calculate volume considered as 'height' the sum of the height of the structure multiplied by one third of the distance between the vault and the structural ceiling extrados.

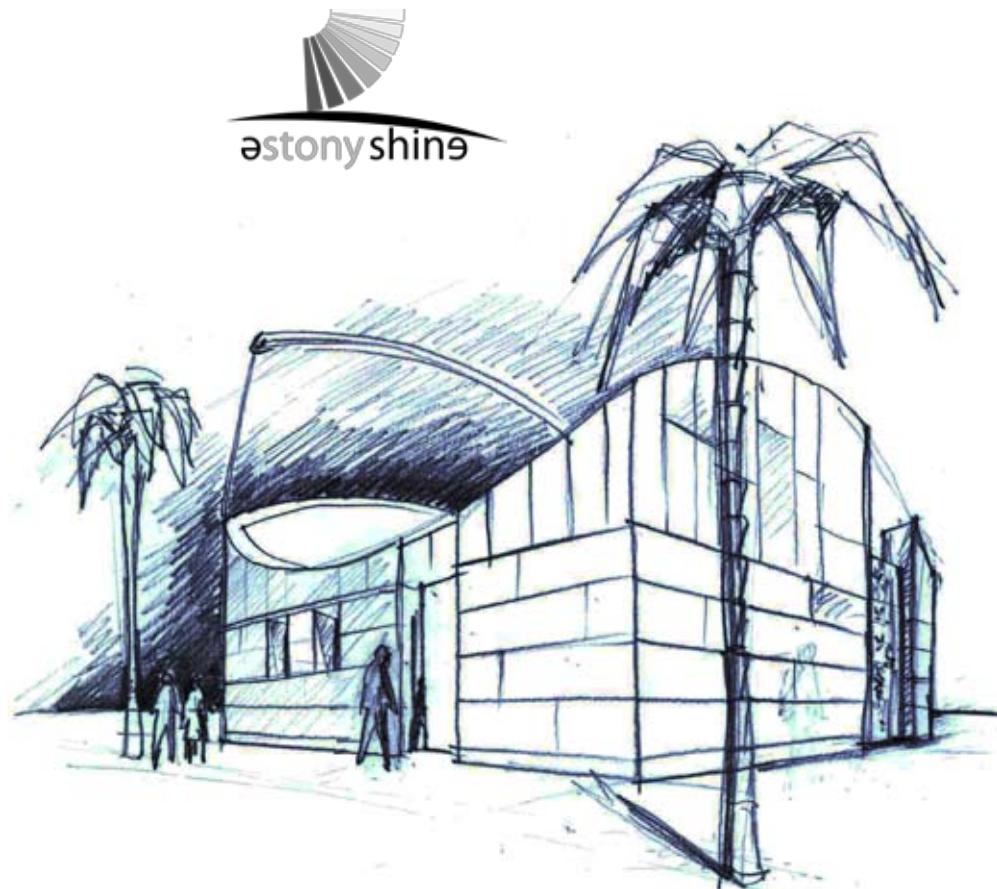
96. Details of the interior space





Astonyshine

Madrid, 2011 | 2012

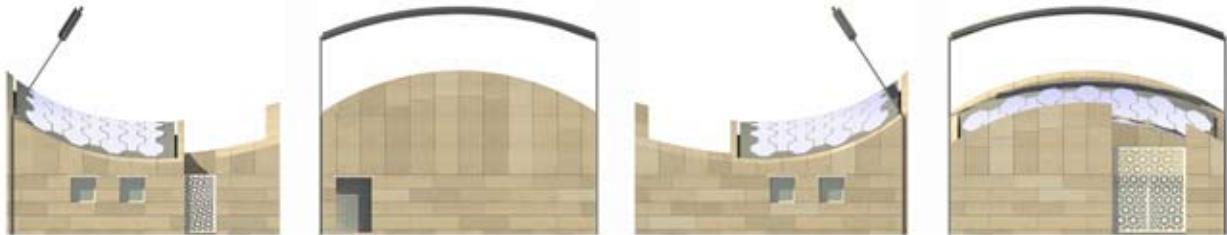


The project entitled Astonyshine/Casa Solare has been entered as a candidate in the prestigious architectural design competition 'Solar Decathlon Europe', 2012. The project was designed by the Ecole Nationale Supérieure d'Architecture Paris-Malaquais in conjunction with the Facoltà di Architettura del Politecnico di Bari. The competition specified the design of a passive solar house, in other words, a house powered exclusively by solar energy. 'Solar Decathlon Europe' is an international competition for universities, aimed at encouraging research into habitable, energy self-sufficient prototypes that are powered exclusively by solar energy. The aim of each participant group is to construct a building that consumes an absolute minimum of natural resources and that will produce a minimum of waste materials. Particular attention is given to solutions that seek to reduce energy consumption and that explore ways of obtaining all necessary energy from solar power.

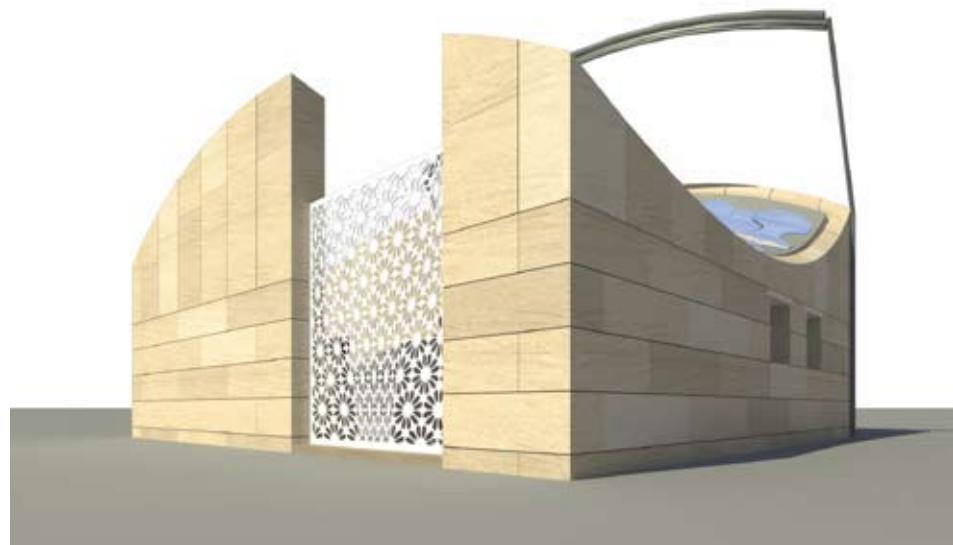
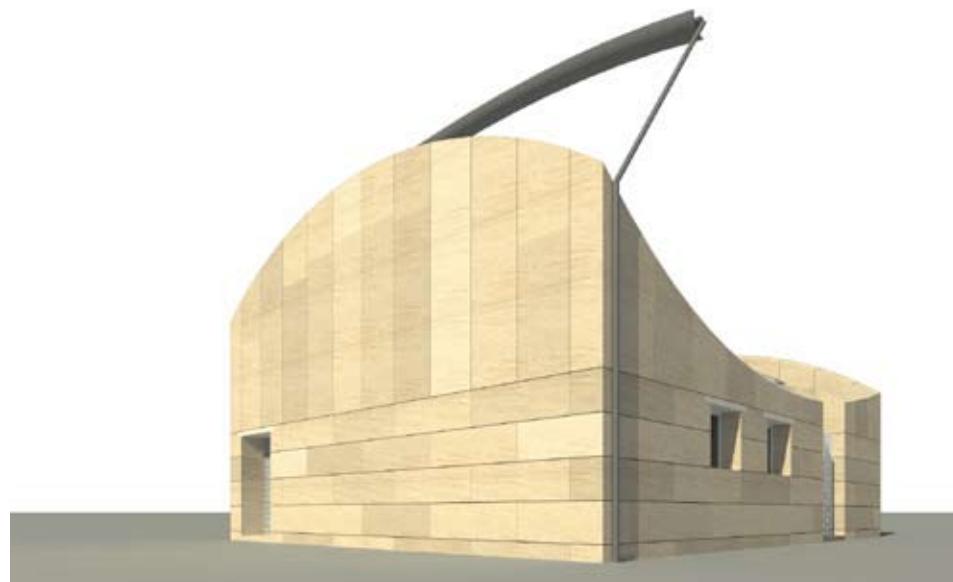
In the final phase of the competition the team has to construct the prototype in the Solar Village, Madrid, a space open to the public, where the building process becomes a public event. In the last edition of the competition, some 300,000 visitors came to watch the construction of the



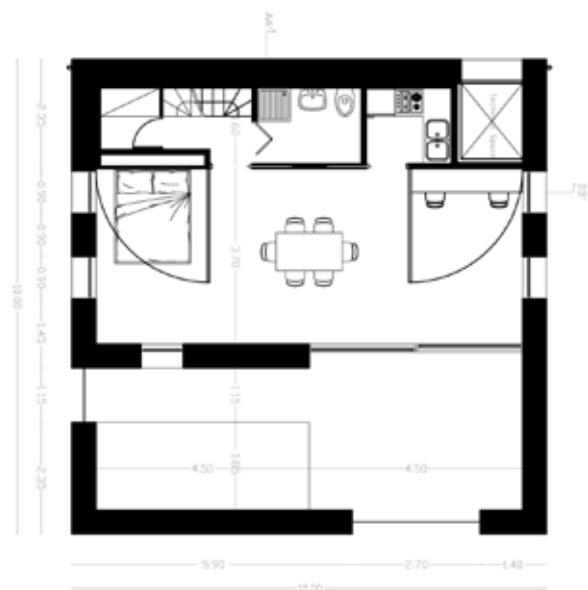
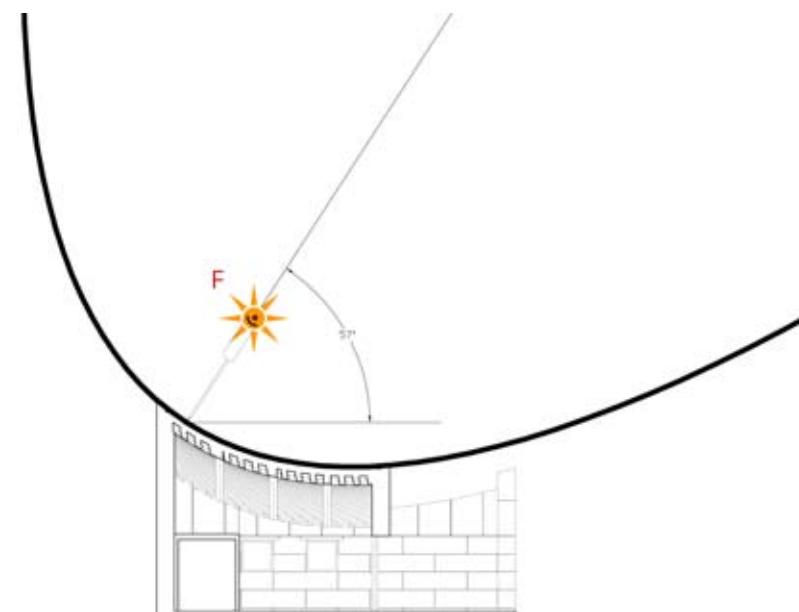
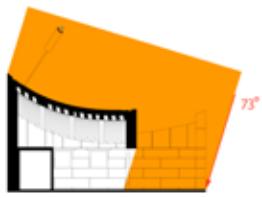
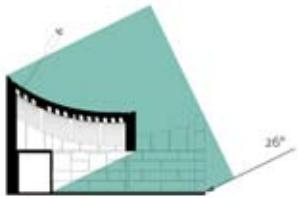
95. Utensili da lavoro, disegno di C. Gaul



96. Fasi costruttive della torre campanaria di Tivadar al museo all'aperto di Nyieghaz del 1993

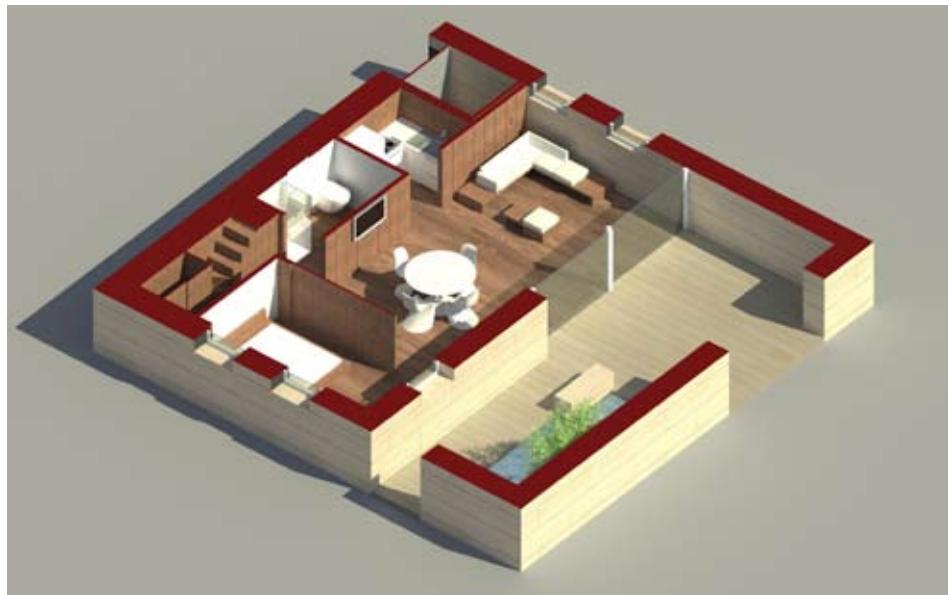


prototypes. There are 10 heats (for this reason the competition is described as a 'Decathlon') to choose the final winner. This being the first time that Italy has made it through to the final phase of the competition, it will be an occasion to test our know-how as far as sustainable architecture is concerned, in an attempt to construct a building that responds to the exigencies of climate, economic and social cultures. The Solar Decathlon competition is an outdoor laboratory for the construction of life-size prototypes. One of the most stimulating aspects of the event is the constant interplay between researchers and technicians working in the field, and the chance to work with new materials and innovative, dedicated technologies. The result is the creation of an ideal context for knowledge –sharing done in the spirit of cooperation, between university research centres and industry. The experience is not only a useful marketing tool, but an occasion to create avant-guard components dedicated to improving techniques and energy saving practices.



95. Axonometric design of the internal space

96. Internal view



The aims of the Astonyshine/Casa Solare are:

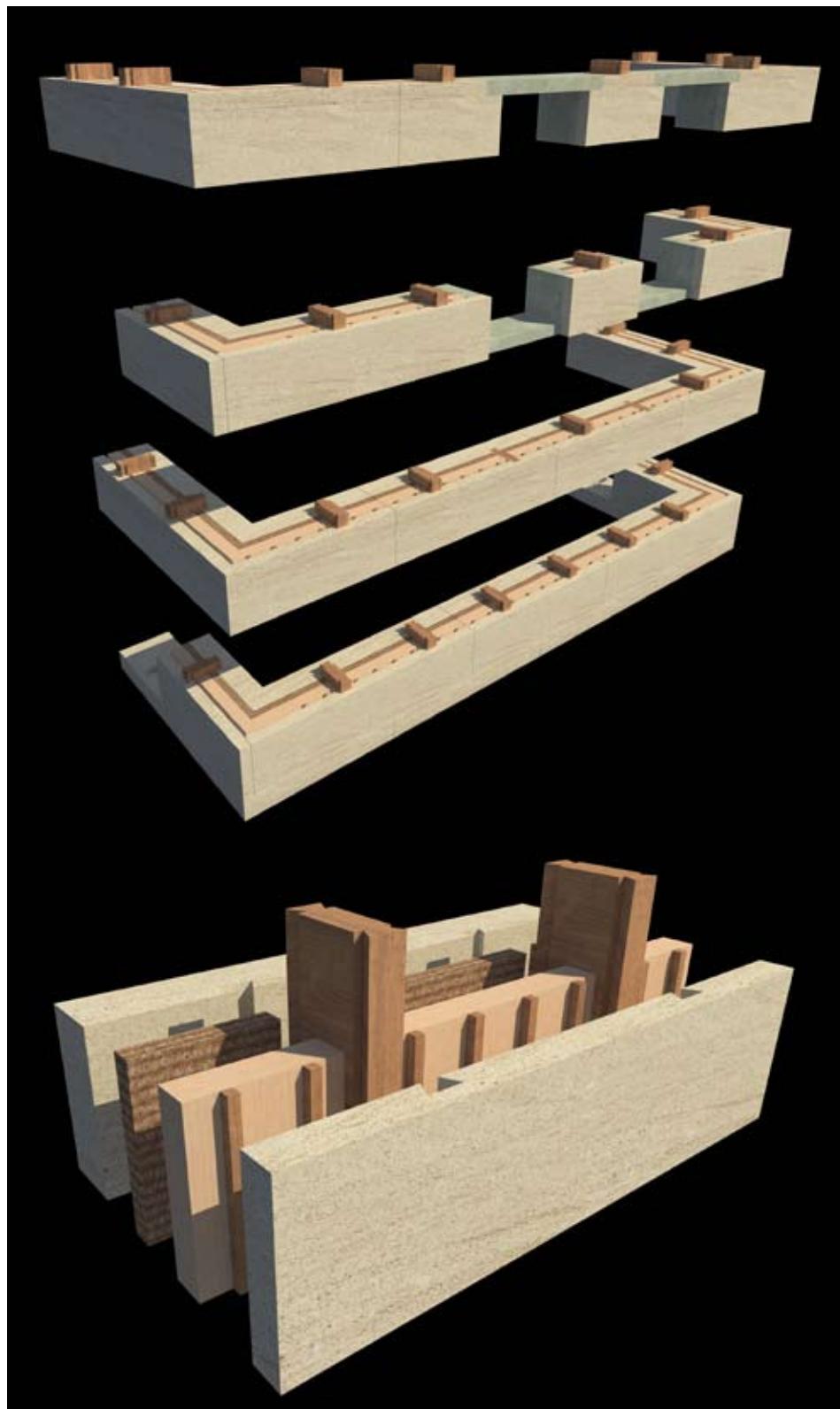
- A house designed primarily according to bio-climatic, 'passive' criteria;
- The use of natural, bio-compatible and completely recyclable materials and the use of construction techniques typical of the Mediterranean area: stone architecture with specific characteristics to render the house environmentally sustainable; good mechanical characteristics, easily workable materials; a highly resistant, perfectly stable wooden roof structure, with no mechanical defects.
- Low environmental impact: eco-sustainable project using materials whose production and use require low energy and resource consumption. Apart from the high standard of eco-sustainability, the building is also energy efficient and cheap to run.
- Use of energy efficiency technologies, such as photovoltaic systems, capable of supplying the whole house and that are fully integrated into the architecture; greater energy efficiency and low energy consumption.
- New design approaches regarding materials and technologies utilized, including the regulation of temperature,



ventilation, heating and cooling and new approaches to the problem of prefabrication for production cost reduction.

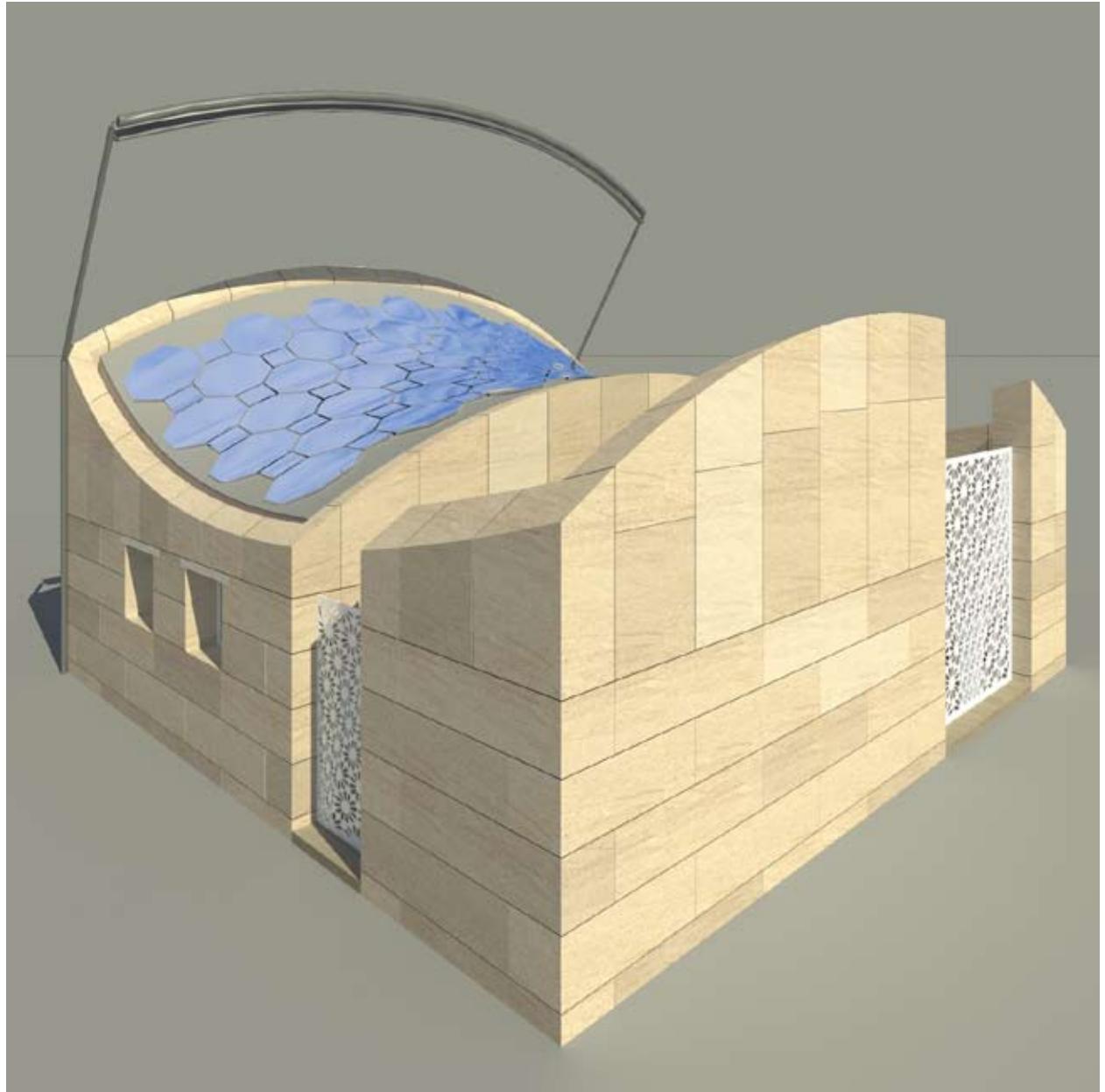
- Careful consideration of logistics for the production and saleability of the prototype, with respect for the environment and the health and safety of the workers.

The Astonyshine/casa solare project describes a single-family house using a square floor-plan (10 mt x 10 mt) with a patio (c.25 mq) on the South-facing side offering direct access into the house. Inside there is a large living area, designed in such a way as to be enlarged, through the presence of a sliding 'box' containing a bedroom, which can be moved forwards or backwards in the space depending on the owner's needs. To the North, service areas are positioned, constructed in wood, including the kitchen, bathroom and a staircase up to a small mezzanine. The mezzanine (2,60 mt) is divided into another bedroom (2 beds) and a small study. The stone walls are conceived as a stratification of blocks (50 cm), with the load bearing elements in thick stone slabs, both inside and out, with transversal and longitudinal junctures in wood.



The whole structure is internally insulated with wood fibre. Only natural materials are used.

The patio functions as a barrier, protecting the inside of the house from heat and the sun's rays. The roof is geometrically conceived using a fluted surface with a double curve made of rectilinear beams forming the primary and secondary frame. Wooden layers to complete the roof and the solar panels are then positioned onto this surface.



95. Details of wall system

96. View

CREDITS

PROTOTYPES

Trompe Biasise

project	Giuseppe Fallacara
project team	-
sponsor	-
realizzazione	-
stone employed	-

Escalier Ridolfi

project	Claudio D'Amato, Giuseppe Fallacara
project team	Marco Stigliano
sponsor	Impresa Leopizzi 1750
realizzazione	Impresa Leopizzi 1750, Mecastone
stone employed	pietra leccese

Portale Abeille

project	Claudio D'Amato, Giuseppe Fallacara
project team	-
sponsor	Fondazione Biennale di Venezia
realizzazione	Impresa Leopizzi 1750, Mecastone
stone employed	pietra leccese

Obelisco Alexandros

project	Claudio D'Amato, Giuseppe Fallacara
project team	-
sponsor	Fondazione Biennale di Venezia
realizzazione	Mecastone
stone employed	pietra leccese

Ponte Truchet

project	Claudio D'Amato, Giuseppe Fallacara
project team	Vincenzo Minenna
sponsor	-
realizzazione	-
stone employed	-

Sphera

project	Giuseppe Fallacara
project team	-
sponsor	-
realizzazione	-
stone employed	-

Stone surfaces

project	Giuseppe Fallacara, Marco Stigliano
project team	-
sponsor	-
realizzazione	-
stone employed	-

Foglia

project	Claudio D'Amato, Giuseppe Fallacara
project team	Marco Stigliano, Fiore Resta
sponsor	Impresa Leopizzi 1750
realizzazione	Impresa Leopizzi 1750
stone employed	pietra leccese

	SNBR Arch [1]	SNBR Arch [2]	
project	Giuseppe Fallacara	project	Giuseppe Fallacara
project team	Fiore Resta, Vincenzo Minenna	project team	Fiore Resta, Vincenzo Minenna
sponsor	Société Nouvelle Batiment Regional	sponsor	Société Nouvelle Batiment Regional
realizzazione	Société Nouvelle Batiment Regional	realizzazione	Société Nouvelle Batiment Regional
stone employed	-	stone employed	-
	Oblique obelisk	Alveare	
project	Giuseppe Fallacara	project	Giuseppe Fallacara
project team	-	project team	-
sponsor	Société Nouvelle Batiment Regional	sponsor	PIMAR srl
realizzazione	Société Nouvelle Batiment Regional	realizzazione	PIMAR srl
stone employed	-	stone employed	pietra leccese
	Viollet Le Duc Arch	Portale Murgia	
project	Giuseppe Fallacara	project	Giuseppe Fallacara
project team	-	project team	-
sponsor	Société Nouvelle Batiment Regional	sponsor	Azienda Agricola Zucaro, REMS costruzioni
realizzazione	Société Nouvelle Batiment Regional	realizzazione	Mecastone
stone employed	-	stone employed	tufo di Gravina
	Flexi Arch	Deco_wall	
project	Giuseppe Fallacara	project	Giuseppe Fallacara
project team	Marco Stigliano	project team	-
sponsor	Azienda Agricola Zucaro, REMS costruzioni	sponsor	-
realizzazione	Mecastone	realizzazione	-
stone employed	tufo di Gravina	stone employed	-

ARCHITECTURE

Domus Benedictae

project	Giuseppe Fallacara
project team	-
site team	Giuseppe Fallacara
structural engineers	Girolamo Fallacara
environmental design	Marco Stigliano
client	Benedetta Strippoli
stone employed	pietra leccese, tufo locale
dimension	-
period	2007 2009

SNBR Bureaux

project	Giuseppe Fallacara, Marco Stigliano
project team	-
site team	-
structural engineers	Giuseppe Fallacara, ??????
environmental design	Marco Stigliano
client	Société Nouvelle Batiment Regional
stone employed	-
dimension	-
period	2008 2012

EcoMaison

project	Giuseppe Fallacara, Marco Stigliano
project team	Francesca Barone, Raffaella Sanseverino
site team	-
structural engineers	Giuseppe Fallacara
environmental design	Marco Stigliano
client	Société Nouvelle Batiment Regional
stone employed	-
dimension	-
period	2009 2013

Casa Ardito

project	Giuseppe Fallacara
project team	-
site team	Giuseppe Fallacara
structural engineers	Giovanni Masciavè
environmental design	Giuseppe Fallacara
client	Privato
stone employed	-
dimension	-
period	2010 2012

Cantina Vinicola Zucaro

project	Giuseppe Fallacara, Marco Stigliano, Rosalia Loiodice
project team	-
site team	Giuseppe Fallacara, Giovanni Masciavè
structural engineers	Giuseppe Fallacara, Giovanni Masciavè
environmental design	Marco Stigliano
client	Azienda Agricola Zucaro
stone employed	tufo di Gravina
dimension	-
period	2010 2012

Casa Korch Turturo

project	Giuseppe Fallacara, Marco Stigliano
project team	-
site team	-
structural engineers	Giuseppe Fallacara
environmental design	Marco Stigliano
client	Privato
stone employed	-
dimension	-
period	2011 2013

Astonyshine

project	Maurizio Brocato, Claudio D'Amato, Giuseppe Fallacara,
project team	Marco Stigliano, Francesca Barone
site team	Marco Stigliano
structural engineers	Maurizio Brocato, Giuseppe Fallacara
environmental design	-
client	-
stone employed	pietra leccese
dimension	100 mq
period	2011 2012

Thanks to

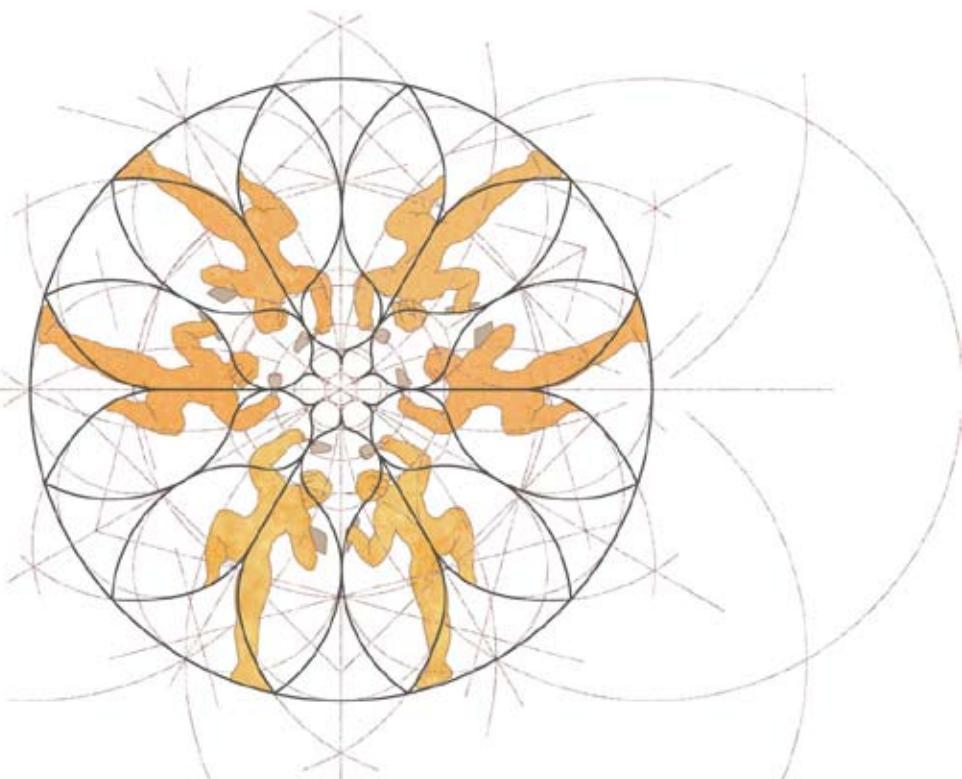
S.N.B.R.

Troyes - France

www.snbr-stone.com

Presentation of SNBR

S.N.B.R., Société Coopérative Ouvrière de Production, répond grâce à ses hommes hautement qualifiés aux exigences contemporaines de l'art de restauration et de sauvegarde du patrimoine architectural.



Le savoir-faire traditionnel ne peut être garanti que par des hommes qui maîtrisent les gestes du passé en appliquant les technologies d'aujourd'hui. S.N.B.R. fonde son développement sur les rapports entre les sciences technologiques modernes et les savoirs, qui pendant des millénaires ont permis de créer l'architecture.

A travers nos réalisations apparaissent bien sûr, les travaux les plus prestigieux qui ne sauraient faire oublier que nos chantiers, même modestes, ont la griffe particulière de notre société et que nous sommes pour tous nos clients au service du «bel ouvrage».



Know-how





Innovation

