The calcareous sinter vault of the Nymphaeum known as «Stadium» at Villa Adriana: Geometry and Statics for an hypothesis of anastilosy

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The great number of the various architectural solutions preserved at Villa Adriana (Hadrian’s Villa) does not allow a superficial analysis of the building techniques in Roman times; nor does it attempt supplying inaccurate dates; the wisdom and knowledge in their applying building systems can still be read today in the damaged parts of its walls, in the left-over portions of the coverings, supports and foundations’ structures.

Such an incredible and undisputed skill can be acknowledged not only within the large, sumptuous buildings of the Villa doomed for entertainment activities, but also within far more humble ones, often intended for secondary activities, like for example in the building located in the Ninfeo area¹ (see map 1).

Along the sides of the Ninfeo —for a long time erroneously known as a Stadium— two over-looking buildings appear: one with three exedras and one including the Fish-Pond (Peschiera) and the Cryptporticus, whose foundation part is obtained by a series of barrel-vaulted intercommunicating covered spaces characterized by a simple, well-ordered set-up.

The central hall consists of an ambient 11,50⁸ 8,80 mts, with a barrel vault in «opus caementicium», as well as of two orders of side-corridors also vaulted. The lower ones connecting the main hall with neighbouring ones through openings, while the upper ones being secondary service ways, perhaps præfurnia».³ Such a severe partition of a specific ambient —looking as a one-system one according to the map—is explained by a different flooring; what is left-over today speaks clearly in terms of an «opus sectile», which was very much in use at Villa Adriana, however with different dimensions and decoration drawings as to corridors and the central hall. (See map 2)

The ordered asset of walls supporting the building’s arched cover shows a building where parallel twilled walls, however different in their garnish, that’s to say wall curtains and not walls entirely brick-made. The walls’ nucleus, constructed according to building techniques of cement, is finished in «opus reticulatum» as to the exterior,
while the intermediate part, the abutment piers supporting the central vault, are in «opus latericium»; finishing is by scarfing in «opus listatum».

Building systems supporting the whole vault cover—the large barrel vault as well as the smaller ones—do not show relevant characteristics on their own, given the fact that they represent an element which is technically part of the widely spread traditional building technique for Roman vaults.

It is still possible to see today—in the intrados soffit of the main vault—tracks of square bricks flatly disposed to adjust with the wooden structures, and of the sloping ones placed in such way as to secure a better coating stiffness, increasing also the scarf with the cement thrown on it (see map 3). The use of a curve-type wall in «bessali» proves that a more advanced technique was used in the Empire age, in respect to the one where jet is directly thrown on the wooden structure, like the one applied in the service corridors of the building, considered less important and therefore less esteemed. In this case the soffit scaffolding is obtained starting directly from the vault crest (see map 4).

Roman engineers cleverly used to set abutment piers slightly larger in size in order to include the thickness of the jet containing surface. The protrusion jutting out was then normally used for decorative purposes.²

Next to the building façade, as terminal of crest of the barrel vault, there was an arch with accurately set «bipedals».

The cement technique and its use find their peak in expression in the construction of barrel vaults, although largely in use before in humble buildings, since considered «more practical and faster».³ (Lugli 1957, 385).

The vault is the most relevant element of Roman architecture and the dominating one in monuments. The number and variety of its types, although partially inherited by a more ancient art, are the basis of space concepts obtained through an inner connection with building systems harmoniously and mutually solved between aesthetic and static effects.
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The deriving effect originating the calcareous sinter vault and its aspects as a structure, have to be approached and interpreted in the light of unavoidable factors, not entirely due to the jet quality; they occur at «crucial moments» —as stressed by Gustavo Giovannoni,— altering the structure behaviour up to the point of making a substantial change in the statics' scheme. The expanding cracks and inside detachments within the cement mass split the monolith in big pieces provoking side-pressing actions (see map 5).

[Map 4]

The barrel vault of the side service area. Please note the platform axes on which jet was directly thrown.

[Map 5]

Schematic drawing of the fractures produced in a concretum vault. (Giovannoni [1925] 1972)

This is the specific behaviour of a cut-stone vault or of a vault with a wedged cotter mechanism.

At the base of knowledge and constructive roots feeding research and experiments, well-known and widely consolidated notions are to be found; not only, but also experimented and verified both through experience, but also owing to a special intuitive feeling suggesting the best possible exploitation of the structure’s specific qualities.

Roman engineers dealing with cement work, and their culture, showed full confidence in the results of endurance of mortar used and mixed with small stone or cotto or marble pieces. The outcome is a compact, solid structure monolithic-looking, while the cohesion between inerts and mortar —as well as the presence in it of a substantial amount of setting binder— guarantees for a remarkable decrease of pressing stresses —typical for such a building system.

An in depth knowledge of traditional building materials in use, of work processes, as well as the acknowledgment of a historical stratification, represent the pillars on which to found any reasonment before any intervention to be undertaken can become successful.

In the refined practice of the building technique in calcareous sinter, unforeseen events can therefore occur.
The mediation usually put in act by Roman engineers consists of a few but cautious shrudnesses; the impost structure between he walls’ and vaults’ masonry is obtained without causing discontinuity in its realization; the size of abutment piers is at times enlarged; the supporting vaults’ sections are sometimes unburdened from the cement mass by means of ribbing and unloading arches.

In the specific building under studying consideration here, we notice such exact characteristics, typical of the Roman experience as to optimization and to structures’ perfecting.

The Nymphaeum building is part of a far more articulated architectural set-up, with adjoining rooms also helping the balancing of the vaults’ stressing action till the outside walls, nowadays reinforced by brace shoulderings. The collapse mechanism of the cover is therefore not chargeable to the upsetting of abutment piers, since the structure of the other halls is still today intact. On the contrary, we could hypothize that the abutment piers collapsed under the pressing action of loading charges, having reached an unbearable stressing pressure.

One of the suppositions advanced to explain such happening is based on the assumption that the cover’s supporting elements resistant section might have considerably decreased; the cause for this being perhaps two-folded. One is degrading or something different but not unusual, that’s to say the picking up of precious materials for possible re-use in other building yards.

We should also remember that the area where Villa Adriana was built has been subject to many and one earthquakes: a seismic quake could have caused the final collapse.

Until the moment when the decision was made on the fixing of the so-called «Stadium» its image was the one of an archaeological ruin well established within people’s recalls. The culture and cult for the inherited fragment persisted throughout recent days: a historical and architectural legacy legitimated in its acquired image acknowledgement. (See map 6–7)

On the contrary, now, the romantic attitude towards ruins as ruins having been overcome —there is a tendency to give meaning to reconstruction, allowing the legitimate put-back of lacking parts of buildings.

The opportunity for this specific intervention —acting within the frame of anastilosys codes— brings into the scene a number of technical and methodological issues. Within this frame the historical building is brought back to a present actuality by the use of traditional materials, the keeping of ancient building characteristics and the use of modern reconstruction techniques.

The most delicate issue in the project, centered on the attempt to re-instate a structural and «linguistic»
ancient unity, can be solved in the persuasion of the need for stopping deterioration of the structure’s intact parts as well as of the large vault fragments crashed.

The question is here on how to accept a restoration intervention technically difficult; but not only technically: also «language-wise»: which are in fact the parameters and rules guiding such action of replacing in their original position the crashed parts, so to enable them to find their harmony again within the whole architectural set-up they belong to.

Project makers had this question in their minds: but this is a risky ground, a stage on which different ideas and debates on restoration theories will take place. The strict rule followed while projecting was the one of re-shaping architectural space, avoiding interventions on the parts lacking serious documentation, like in the case of the façade.

Re-building discretely, suggesting by restricted however essential completions the lost shape of the architectural ensemble: this is the idea, the aim to give the whole place its’ archaeological ruin image: not only its hall —under study— but the whole of the preserved structures of the Palace form the scenery, the monument front, which is significant and relevant in the understanding of its architectural importance.

Project makers are convinced —just because of the above— that no lacking parts —though many— are to be filled in by unreal reconstructions, while intervention is needed where statics’ problems and up-keeping ones demand action in order to avoid further deterioration. (See map 8–9).

The above described considerations are the code-lines along which the project runs: on one side, the attempt to preserve the architectural value of the building as a legacy of culture and knowledge; on the other side the awareness that interventions and reconstructions deny the statics’ set-up of the structure’s original system —under study.

On these assumptions the intervention is based: it would be impossible to set-up again the coherent strength of the calcareous sinter vault: therefore one would suggest a new structural contexture considering the present building’s conditions, changes and alterations in the course of time.

Transformations’ awareness results in a choice: the large vault’s fragments, laying on the ground for various centuries, are considered as monoliths still able to keep their original cohesion power.

Map 8
Computer simulation of achieved anastylosis. In the hypothesis advanced by A. Falzetti and A. Giuffré professor, please not the intention «not to re-build» the façade and the brick wedges in the vault’s in the soffit intrados. (TAV. XXII in graduation thesis of Antonella Falzetti)

Map 9
Drawing of achieved anastylosis. (TAV. XXXIII in graduation thesis of Antonella Falzetti)

This fact requires a new relationship between the structure scheme and the architectural set-up, re-qualified by an upsetting of the statics’ system. Such monoliths will have to act as hewn quarry stones with a gravitation structure.

One could object to such solution, as an indiscriminate alteration of the original structure’s
characteristics disregarding the protection of the building’s identity; but building is not only a question of statics. In this particular case it is just the in-depth knowledge of building techniques and of their limits that suggests and demands a firm attitude in order to solve the problem.

On the other end, once the unavoidable transformations as well as the relevant adjustments incurred in by the calcareous sinter vault between the moment of its actual building to its reaching a natural balance condition acknowledged, the taking into account of such specifications as data become timely compulsory; pressures on abutment piers occurring at any rate are the direct consequence of the building technique itself; effects due to side stresses do not fade away though being partially absorbed by the setting binder’s cohesion power.

In the new structural being, on the contrary, with its stressing actions and relevant pressures —the first thing to do is a re-dimensioning of abutment piers to secure their steadiness and to avoid the risk of their upsetting.

Next comes the placing back of «monoliths», a substantial part of the vaults’ system within the Nymphenum hall, and the re-composition of the impost pillars’ system of the rising barrel vault and of the small side ones.

Such ideas and theories and the strategy for their feasibility should be checked on the spot in the course of building-yard’s operational processes, this being the suitable milieu for so doing.

Going back to the problem: the connection between the quality of technical solutions and the reached architectural outcome.

Studies on the achieved result do confirm that this is an extraordinary intervention project however ascertaining that the importance acquired by such restoration project does not necessarily promise quality and accuracy along the actual practical execution processes in the building-yard.

Let’s therefore go back here to the basic steps of such work in order to understand its difficulties in execution and to catch the variations —vis-à-vis the given datas— made while working at it on the spot.

For securing the best possible displacing and picking-up of the large vault’s parts laying on ground, the first idea occurred was the one of a bad level and of articulated supports.14

However, the will for planning every single procedure in detail after serious thinking it over, is subject to independent events that might occur within the building-yard operation. Saving money conceptions prevail on the project itself, showing a quite utilitarian attitude as well as a full confidence in the practical experience on the parts of those who face problems and solve them directly on the spot where works take place.

The first large piece, weighting about 62 tons, is picked-up by bad level with wooden staves and steel cables going through two longitudinal holes placed on a provisional wooden structure.

The same happens for the other pieces. (See map 10)

The crashed pieces are put back into position on a suitable sofit scaffolding re-designing the original barrel vault’s shape and on newly-built abutment piers; such solution was adopted owing to the need of avoiding the use of bulking bad bedels moving slowly while the piece is being put back to its original place and is hard to remove; the large quarry hewn stone is suspended in perfect shape in correspondence to the barycentre by means of a steel wobbler going through two holes equitably apart from each other and taken to its housing place. (See map 11–12–13)
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The lacking abutment piers re-construction — a pillars' and «bipedales» cover-plates system — is obtained by using a modern version of the ancient «emplecton» for re-reading as to consistency and differences building ways in the course of time: a bricks' lining similar to the original ones as to dimensions; the pillars «souls» being in concrete.

The theoretical aim justifies the technique used for the building of new independent elements and not of integrations of part of existing structures.

The reason — not so much linked to a cultural requirement, in this case — has its support on the promise that concrete will respond to quite an extent as a warrant for its resistance to stresses due to heavy loads.

It is important to draw one's attention on how a pragmatic attitude prevails as well as the supreme aim to turn the complexity of the building subject into a programs calculations' instrument easy to apply. Only to the latter we are in fact granting confidence.

The same destiny occurred to reintegration of the large pieces put back in their place.

Although strictly following the rules of restoration codes applied in such a way as to leave a sub-frame in order to secure the individuation of non-original pieces, it was not possible to put in act — owing to problems concerning statics and its steadiness — the linking of locks by cutaway bricks as a «stitching and unstitching» technique to follow the cracking lines of already replaced pieces.
There is a substantial discrepancy, therefore, between the first hypothesis—which was already experimented practically, though—and the fear to insist on a technique which does not meet the safety requirements of the new structure, notwithstanding its deep values.

This cautious attitude is well justified by the dealing with the presence of loads of such entity; practice and experience—essential items for true knowledge—go to the edge of scientific know-how suggesting cautiousness.

Such fact was responsible for the choice of the technique adopted in the attempt not to go against the historical basis of the Roman technique. The necessary fill-in for putting together the original vault’s fragments is in calcareous sinter as similar as possible to the ancient one, consisting of a jet of traditional mortar, with lime, pozzolan, inerts and a very small amount of cement and additional materials; the «concretum» pieces are also inter-connected by inox steel bars with improved cohesion power; the continuity between the main barrel vault and the two smaller side-ones—for the great part missing—is also obtained by the use of steel bars and metal nets placed on pattering ground.

The new image obtained witnesses the formal and historical value of the intervention: it is today an acknowledged fact. (See map 14–15)

Through the problems concerning «building conceptions» by traditional techniques and of re-building, one acquires notions on the real essence of the built patrimony.

Awareness of the idea that the need for full respect of the past is the basis of preservation-culture, creates a link between architectural space’s structure and form.

The structural interpretation of the building has to be subordinated to building «wisdom and knowledge» of works of the past, without becoming a prominent instrument.

Such final considerations have a question-mark on the intervention: did this restoration-yard—for sure a contribution to building techniques of Roman architecture’s knowledge—respect the ethical «must» of re-establishing a true relationship between formal expression and structural reality? Or did technical reasons prevail on unity reasons?

This question does not represent a critique towards the lines adopted in such intervention; it’s only a thinking over the strategies used in re-assigning to this very building its entire and specific value as an archaeological witness-legacy.

NOTES

1. When looking at the area of the Nymphaum-Stadium we can see two overlooking buildings, one on the West side, with three exedras, the other one on the East side called «with Cryptoporticus and Fish-Pond» (Criptoportico and Peschiera). Such building was raised on three levels: the ground floor, corresponding to the garden of the Ninfico-Stadium: the middle one corresponding to the Criptoportico and the upper one to the Peschiera. In the center, at ground floor, is the main
hall whose vault sank — study subject — with four smaller adjoining rooms.

2. For many centuries referred to as «Stadium», due to its shape — as explained by A. Penna in the pages of his «Viaggio pittorico della Villa Adriana». «Such building looks as a hippodrome at first sight — and as such I described it; however, having found among its ruins a pond, I have no doubts now: I’m convinced it is a Stadium ...»

G. Nibby, in his «Descrizione della Villa Adriana», states «a limited olive-tree valley — meridian oriented — is called Stadium. Its shorter curve-side looks South ...»

As from 1955 up until the 80’s, a number of excavations took place in the area: R. Vigli (1955–1960), S. Anzio, A. Hoffmann and the Soprintendenza Archeologica per il Lazio were in charge of works. These allowed to prove the mistake in considering it a Stadium. It was therefore since then considered a Ninféo, an anomalous one though.

3. The whole building is part of the area where high-level entertainment activities used to take place in winter time.

The courtyard of the Peschiera had a high wall all around protecting from wind-blows: an ideal place for walks on sunny winter days; on the lower level a Criptoprotico full of light where to walk along on rainy days; the upper area on top of the main hall of the ground floor was perhaps a «triclinium» supplied with «praefurnia» for the heating placed over the small vaults.

4. In Hadrian’s age (117–138 a.C.) the jet vault building system was improved and changed in order to adjust to temporary requirements, such as a reduction of the armouring or more refined systems setting the jet in horizontal coats of different consistency in order to reduce the fill-in weight, or the putting of brick-arches — not seen — placed according to main curves due to the vault shape, in order to harness and restrain the mix mass.

5. «...we do not know when the calcareous sinter vault came about in Roman architecture, since we lack or miss ancient examples of it with accurate dating. The fact that we find it in use with perfect knowledge of its statics’ problems in the large Sillian plants ... proves that it was already in current use since long, with very successful practical results». Lugli 1975, 385

6. The comment notes by Gustavo Giovannoni concern mainly three very specific items characterizing changes in the static mechanism of the calcareous sinter vault: the effect of a giving up when the mass has not yet reached its setting behaviour; deterioration due to weather inclenecy and to a lack of maintenance with consequent crumbling; last but not least: the yielding of foundations causing in turn a sudden detachment of parts of the structure itself. Giovannoni [1925] 1972, 44

7. In the middle of the nineteenth century, a number of reinforcement interventions took place within the whole of villa Adriana, under advice of the consulting General Commission for Antiquities and Fine Arts. Works consisted in the building of brace shoulderings and new scarring of building’s main walls. However, a lot of these were removed beginning 1960 and on. This fact should be acknowledged.

8. In 1996 the Soprintendenza Archeologica per il Lazio started re-instating work for replacing in their original position the portions of crashed vault. Such building-yard is intended within the frame of the funds by Ministero per i Beni Culturali e Ambientali for research and planning of anti-seismic works.

9. Villa Adriana’s ruins have attracted, in the course of past centuries, the attention of eminent visitors; see engravings by Gian Battista Piranesi. Agostino Penna, P. Gusmann.

10. A preliminary study analysis on how and if to re-instate the vault’s big fragments was the subject of the degree work on Restoration’s Statics’ Problems discussed by Antonella Falzetti at the Rome University La Sapienza — Dept. of Architecture — supervised by professor Antonino Giuffrè and Professor Francesco Piccarreta. Such research work — taken in consideration by the Fine Arts’ Soprintendenza as a scientific starting ground, faces transversely all problems involved in a potential intervention: like the consideration and examination of the vault’s crashed portions, with special attention drawn on the «where» they were found and of their edges; an estimate of the size of missing parts — the outcome of which shows that they represent an 80% of the whole cover; an evaluation of the mass center in crashed parts through solid samples as well as a weight evaluation of each single element to be removed from where it lays after crash; the individuation of an appropriate slinging system for removing such parts and criteria for the choice of pick-up equipment; restoration and consolidation of actually existing pillars; re-placing fragments where they were originally; re-asset and finishing of lacking parts by cut-placed bricks, to witness the new induced static’s mechanism and the elements explaining the filling-in compensation for the lack.


12. Adolf Hoffmann’s theory proposing a façade solution
and the re-structuring of the whole Nymphenron’s garden (Hoffmann 1980).

13. The project of anastilosys suggested in the study-work by Antonella Falzetti (see note 10) emphasizes the idea of the façade not to be built anew, the intervention remaining within the inside of the main prospect. The computer work simulating what could be the visual impact of the place after the fixing made according to codes and parameters above described, will be of great help in explaining the process.

14. Such research-study and its basis for freeing the area by removing the vault’s crashed pieces, tended towards a possible pieces’ pick-up without damaging their integrity.

It was necessary for this purpose, to foresee the planning of a simple yard’s structure with longitudinal pivots put into proper fitting drillings, connected at the ends by ribbed metal slabs carrying a pivot up to the height of the barycentre of the piece to be moved, to which to link pick-up hooks.

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