Survey and technical analysis: a must for understanding monuments

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Abstract
Studying ancient monuments allows one to gather a remarkable amount of significant and relevant information, not just about the construction itself, but also about the historical and cultural context. This happens only if the task is entrusted to professional people with a specific training in the analysis and the understanding of ancient buildings, and a sound knowledge of ancient building techniques. The results of a research performed according to this standard has a value added in providing valuable data for planning the restoration of monuments; virtual reconstructions and step-by-step illustrations of the building process can offer a noteworthy contribution to the public presentation of archaeological sites.

The study of ancient monuments is still the Cinderella of archaeology: in an archaeological context the value attributed to moveable finds such as statues, mosaics, and vessels, is often considered much more relevant than the remains of a building, which is usually regarded just as a 'container' for the exhibits that really matter. Moreover, it is not really clear who should study the buildings: an engineer? Or an architect? Or a particular kind of archaeologist? Of course, cooperation is always welcomed, but the results are valuable only if each specific field of work is well defined, the risk being that only some aspects will be examined, while the overall understanding of the construction will be missed. I suggest that only a trained archaeologist with specific competence in the analysis of ancient buildings and building techniques can cope successfully with the study of monuments by extracting all the possible meanings within its cultural context, thereby making them a primary source of information. This kind of study should have high priority in field research planning because it provides the framework for the other types of evidence found on a site. The necessity to operate in a broad chronological spectrum and to deal with a variety of types of work, from the scholarly publication of results to the restoration of the monument and its public presentation, requires very specific skills and expertise but offers a stimulating and challenging work experience.

As a preliminary note, we should really consider an ancient construction as a building, not a monument. It should be seen as a structure with a dynamic life of its own often resulting in a product that differs from the original intention, with its own construction techniques and processes, a unique articulation of interior space and lighting, and its own set of modifications, reinforcings, and alterations. Furthermore, the more complex and ambitious a construction is, the more composite will be the technology needed to build it.

The quantity and the quality of the information the remains will offer depend not only on the skill of the researcher, but largely on the importance and meaning the researcher attaches to such information: in a sense, the monument will speak only to ears prepared to listen. Actually, this means also spending a lot of time in the building, allowing our eyes to pass from merely looking at it to really seeing it, experiencing different conditions of light and feeling the suggestions that even a damaged interior space is likely to offer.

Accordingly, the working model to deal with monuments should provide for:

- analysis
- understanding
- virtual reconstruction
- suggestions for restoration

The correct methodology to achieve a satisfactory result should be as follows:

Analysis

Analysis involves survey of the building remains by direct or indirect procedures (Fig. 1), and providing documentation with every type of two dimensional drawing required for a detailed description of the construction, i.e. plans of several levels, cross sections, and elevations in a scale with an adequate coefficient (usually 1:100, 1:50).

Equal attention and similar treatment should be given to the survey of the architectural elements, sometimes the skin but often both the skin and the skeleton of an ancient building, using a scale with an even lower coefficient (usually 1:20, 1:10) (Figs 2-3). Whenever possible, the person who makes the survey should be the one to study the monument because he, or she, is the only one who really has become sufficiently acquainted with it, and can extract from it the maximum amount of information, sometimes very significant and innovative not only from a technical, but also from a historical point of view.

If an indirect procedure, such as working with a total station or a laser scanner, has been carried out, careful checking of the graphic results by the screening directly on site of the remains should be done and any extra information made by direct observation of the building should be added. Ultimately all information should be integrated with a graphic mapping of the cracks and other damage to the building (Fig. 4).

Understanding

'Understanding' means checking, comparing and combining all the data acquired during the survey with a wide range of bibliographic, archival, historical and artistic research; the purpose is to acquire a 360° knowledge of the building.

The task involves asking questions, solving problems, asking new questions, and trying not to miss anything. Every construction represents some considerable financial commitment so even apparently irrelevant factors usually have a sound reason for existing (Figs 5-9). When in doubt, remember: the building is always right; and don't forget that the builders were not stupid, they usually knew what they were doing even if they were doing it 2000 years ago. Otherwise, we would have nothing to examine today.

Virtual reconstruction

Virtual reconstruction of the building should take into consideration dimensional specifications, scale drawings, digital images, topographical and historical data, building techniques within the historical context, and physical laws (very often forgotten by archaeologists). The process is very similar to the planning of the original building; it means a full understanding of the building process, which can lead to a better understanding of the structure and to original and new interpretations. Working in a 3D context, one is bound to deal with the building as an articulated but homogeneous complex. Any possible solution to a particular or unusual problem must be related back to the general context. One cannot 'forget' even a minor or secondary structural element: every component of the building has to form part of a coherent whole. Whenever possible, a reconstruction of the previous topographical setting should be provided. Often it can explain or can give useful hints about specific or baffling features of the construction (Fig. 10).

A 3D model is an open system: it can be modified, increased, integrated, and (alas!) endlessly improved. In a way, it is something very similar to a real scale model of a construction, like those conceived and carried out during the Renaissance. It is worked out with diligent but dynamic attention to the building itself and is imbued with multiple meanings and significances (Figs 11-13).

If possible, the 'skin' of the monument should be recreated, applying suitable textures to the structural model according to the remains, or when sufficient documentation is available (Fig. 13).

Several virtual animations from inside and/or outside should be made so that the articulation of the interior circulation system and the original sources of lights can be understood better. At present this is the most successful method available to give a clear and suggestive idea of the interior space, which is actually, in an architectural sense, 'the' building: it expresses the relationship between an artificially modelled space and the time and motion one needs to appreciate and 'use' it.

Suggestions for restoration

The comparison between a mapping of the cracks in the existing remains of a structure and a virtual reconstruction provides insight into the static and structural behaviour of the building over time. Often the reasons behind perplexing adjustments and adaptations become clear when juxtaposing these different types of studies. Emblematic is the case of the Basilica of Maxentius, where this kind of comparative study has suggested a new reading of the main features and modifications of the building, with remarkable consequences even on its historical interpretation (Figs 14 -17).

This kind of data is not only apt to provide extra information about the monument and the possibility of relating the damage to specific causes, such as earthquakes, which are often well dated, but it also serves to identify the critical zones of maximum stress and therefore helps to assess the stability of the structure, which in turn provides extremely valuable data for planning the restoration of the building (Figs 18-19). This is particularly relevant if the 'philosophy' of the restoration process is an active one, based on preventing collapse rather than an 'old style' passive reinforcement, which is applied only when the existing structure starts to collapse resulting in significant and visible damage.

An approach of this kind, dealing with monuments with a holistic perspective, is bound to provide an exhaustive understanding of the ancient building, which can then be translated into the broader cultural context. Furthermore, the documentation acquired in the process is particularly appropriate for public presentations and for developing the archaeological site.

The conservation of an ancient monument is not only the preservation of its physical reality, but is a continuous process of informing, showing, disclosing and popularising the building, which leads to a common understanding of cultural heritage. It should be remembered that a true respect for and genuine desire to protect and preserve ancient structures are born only from a conscious and mindful appreciation of cultural heritage. More prosaically, this means that as public funding is directed towards the enormous cost of excavating, preserving, and managing archaeological sites, the public should be included in the process as a way of promoting appreciation for the preservation of the monuments.

Virtual reconstructions, particularly the 3D models and virtual animations can be used for public presentations and displays of an ancient building. Even the illustration of the building process step-by-step can be an extremely effective means of communicating the value and significance of a structure (Fig. 20).

Actually, serious intellectual examination of the building through these means should be matched by the accurate popular presentation of the results; only in this way will the survey of an ancient monument not only increase significantly general historical information but also the level of public cultural perception.

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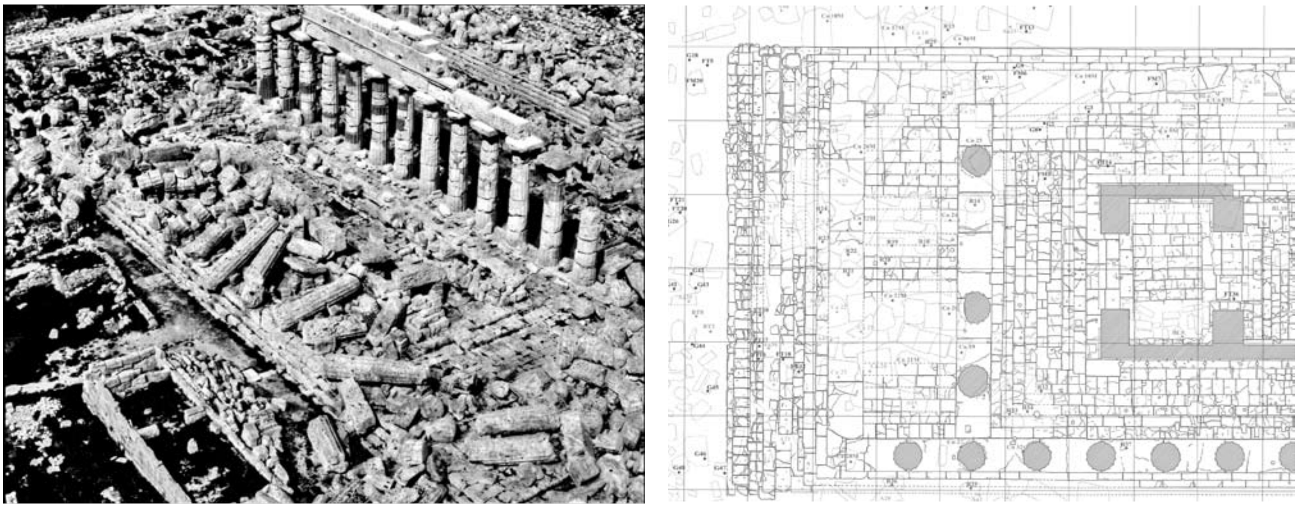
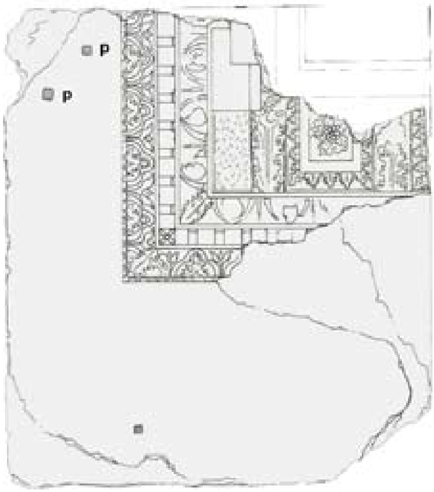


Fig.1a-b - Selinunte, Temple C. General photo and a sample of the survey; the original is 1:50. A very clear example when the use of direct survey is compulsory.

Fig. 2 - Rome, Forum of Caesar, temple of Venus Genitrix. Blocks of the entablature of the back side.



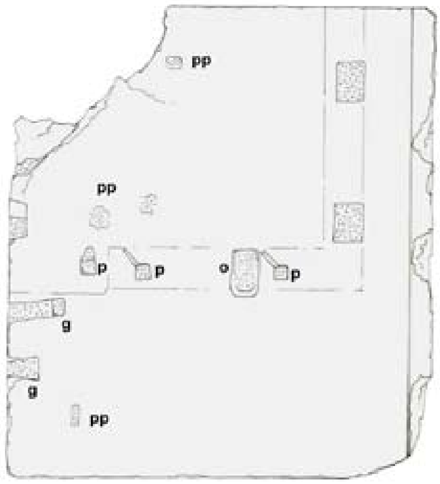
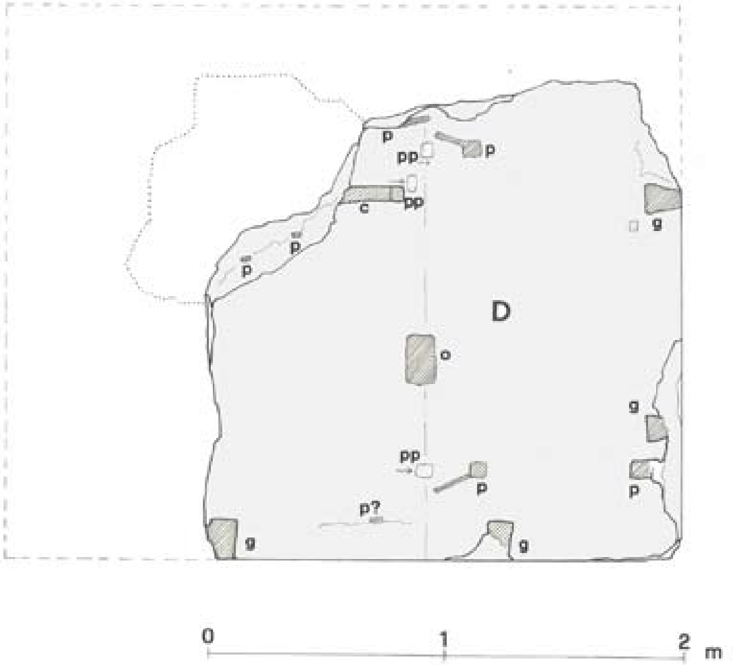
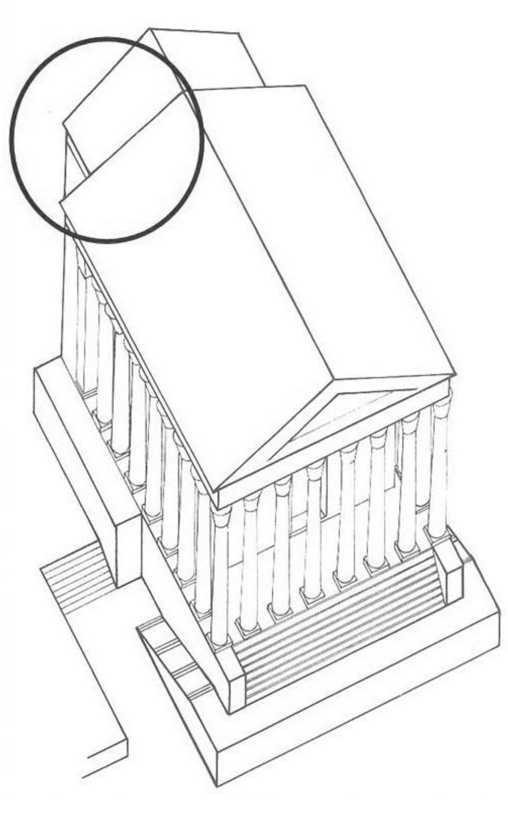
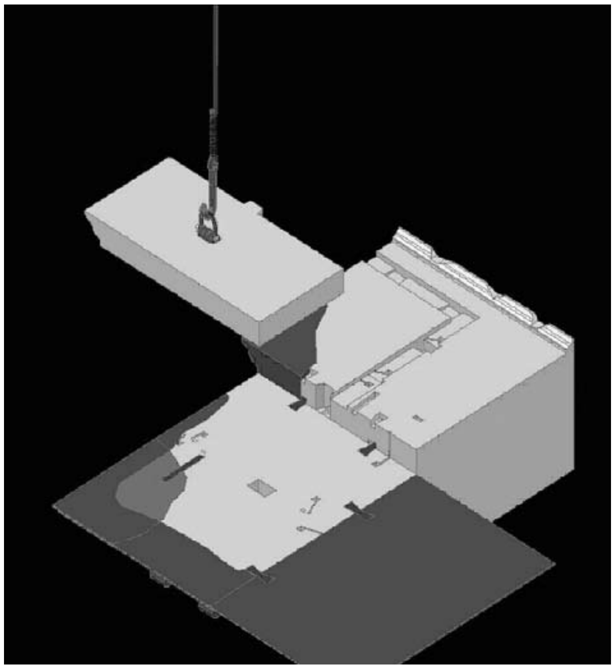


Fig. 3 a-e - Survey and analysis of the cornices, reconstructing the technical progression of the building procedure and the position of the blocks at the back side of the temple.







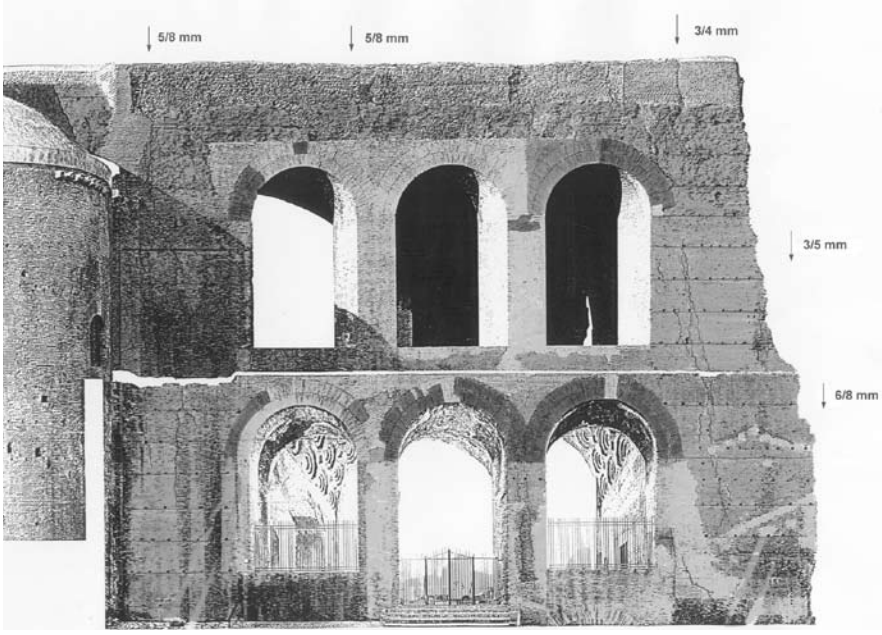


Fig. 4 - Rome, Basilica of Maxentius, perimeter wall, northern side, exterior; orthophotogram (Fokus GmbH - Leipzig). Screening of the wall facing and mapping of the cracks; width in mm.

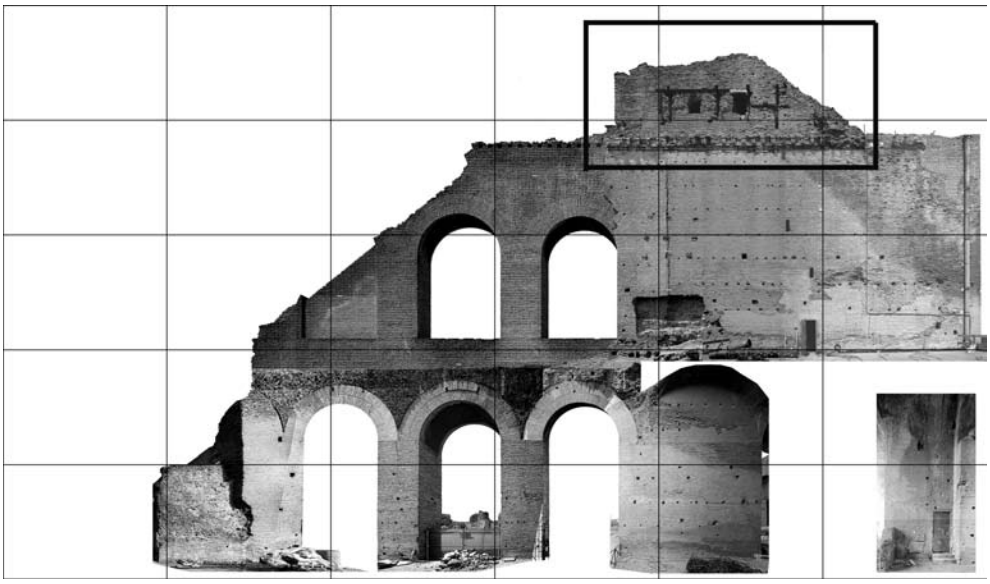


Fig. 5 - Rome, Basilica of Maxentius, east side, perimeter wall, orthophotogram (Fokus GmbH -Leipzig). As an example, only the part emphasised is here considered.

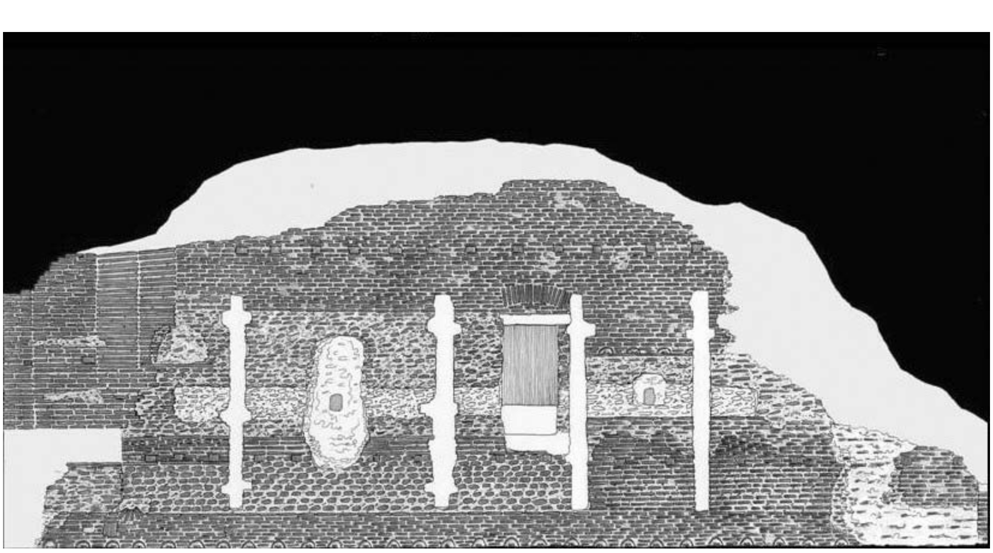


Fig. 6 - north-east buttress, detail of the exterior elevation. The drawing documents clearly the imprints left by reinforcing work.

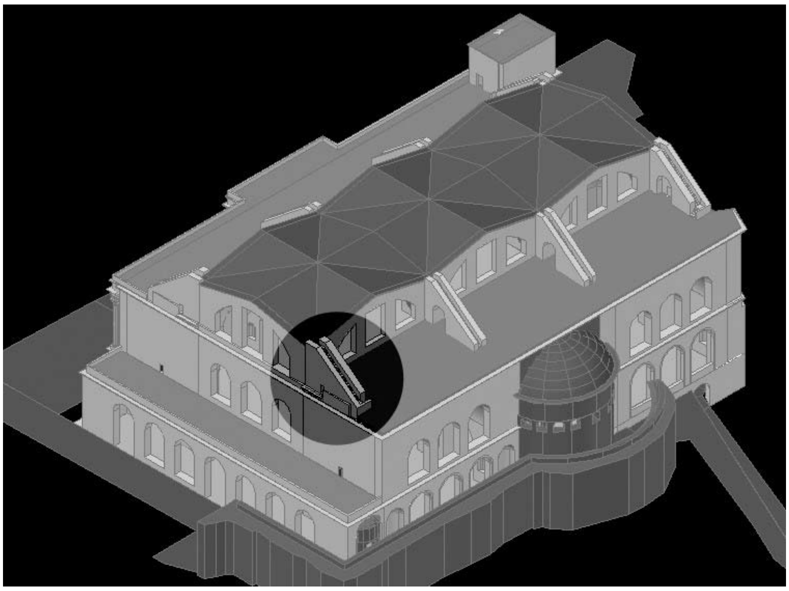


Fig. 7 - Rome, Basilica of Maxentius, axonometric reconstruction from north-east, showing the original features of the buttress. A passage made it possible to access the overhanging balcony for maintenance of the upper windows of the east façade, otherwise unreachable.

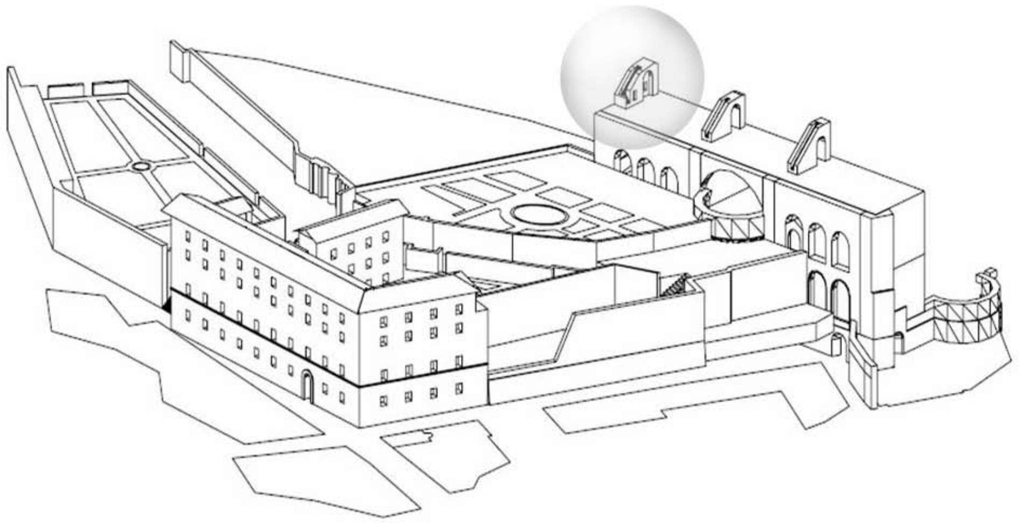


Fig. 8 - Axonometric reconstruction of the surroundings of the Basilica of Maxentius, Rome, in the 16th century, partially incorporated into Palazzo Silvestri da Cingoli, clearly built over previously existing structures. In the circle the buttress is emphasised.

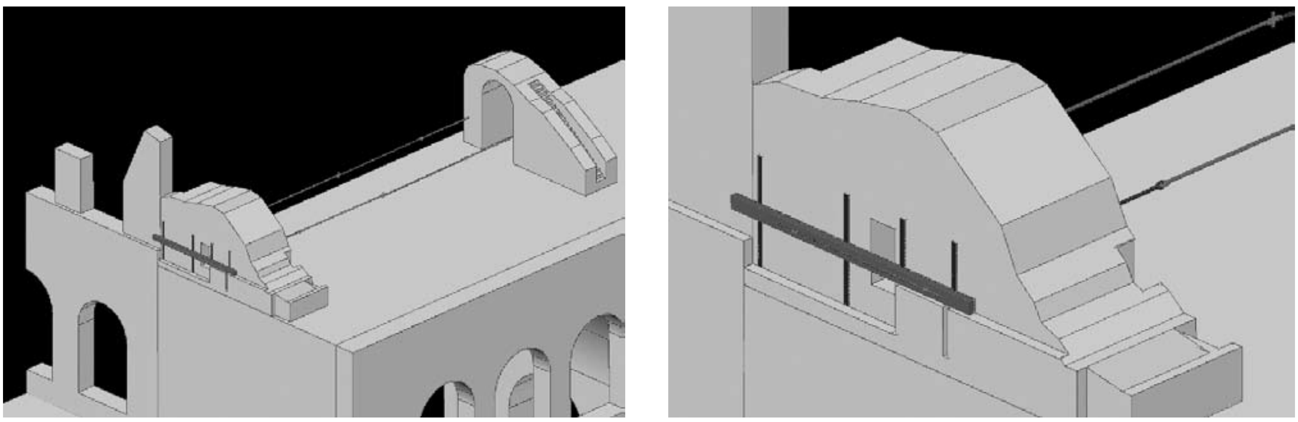
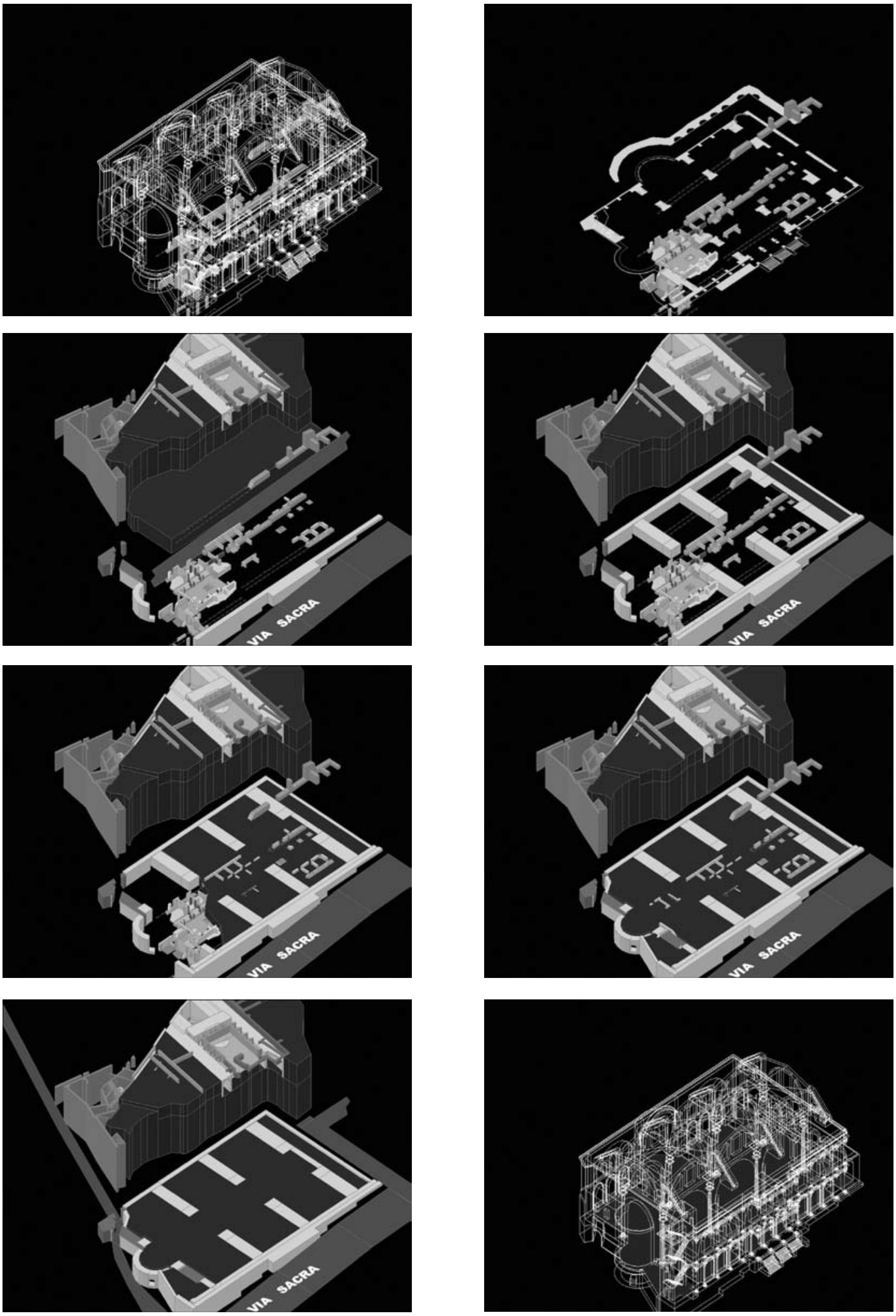


Fig. 9a-b - Reconstruction of the reinforcing system added to the buttress, probably during Renaissance times, to permit safe access to the lower terrace, still used in that period by the residents in Palazzo Silvestri.



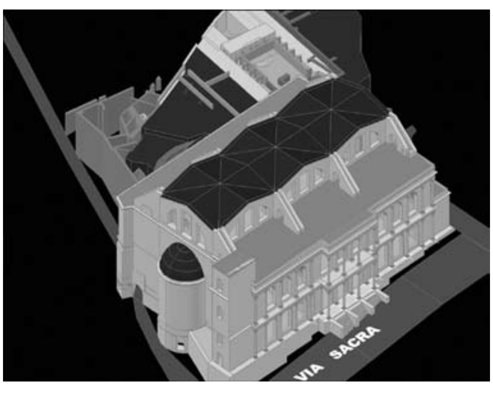


Fig. 10a-i - Rome, Basilica of Maxentius, reconstruction of the previous topographical setting. The level of the floor of the highest sector of the Horrea Piperataria, the Flavian market which formerly occupied the area, was selected as the level of the future ground floor of the basilica; the Velian Hill was excavated for approximately 30 m to the north-east, causing a drastic reduction in size of the existing Flavian-Trajanic villa above. The earth from the excavation was used as fill, thus resolving the problem of the progressive difference in level between the terraced floors of the Horrea and the new floor level, as well as the problem of what to do with the excavated material. The remains of previous structures clearly influenced the planning of the Basilica, and several walls of the Horrea Piperataria were used as formwork.

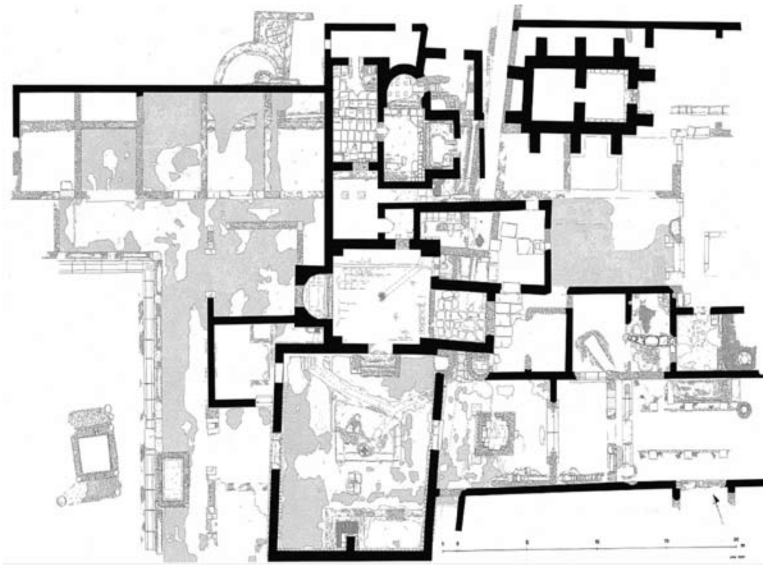
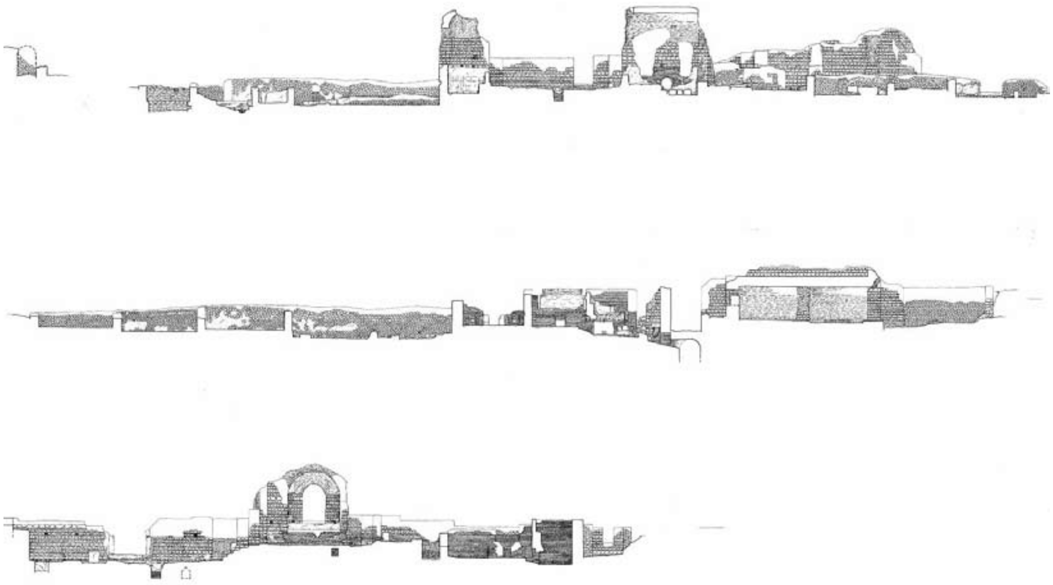
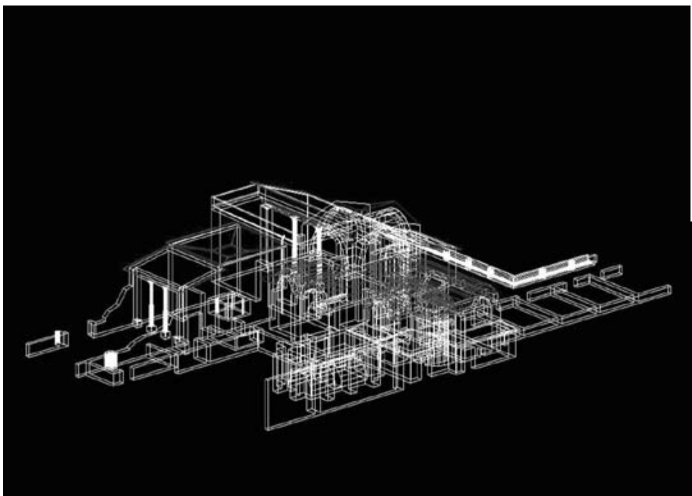


Fig. 11a-b - From survey to 3D model: Privernum (Latina). Thermae and Domus dell'Emblema: plan and elevations, carried out with direct procedure, allowing a very sound and reliable technical analysis.





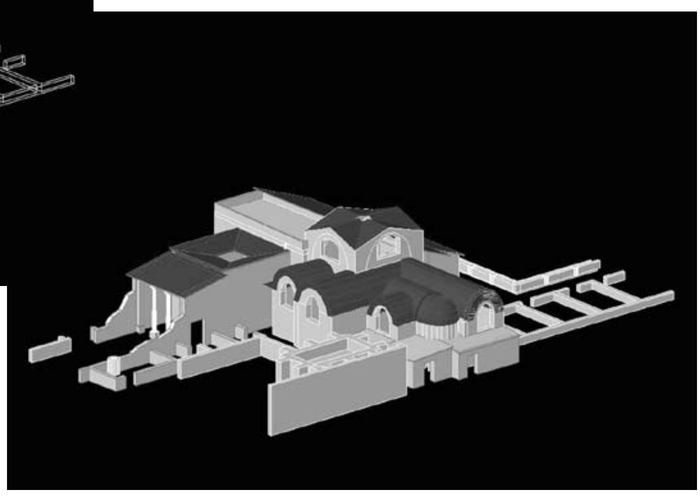


Fig. 12a-b - From survey to 3D model : wireframe 3d and realistic 3D of the thermal building.



Fig. 13a-c - From survey to 3D model: virtual reconstruction of the interior of the thermal building with wall decoration patterns strictly deduced from the remains.

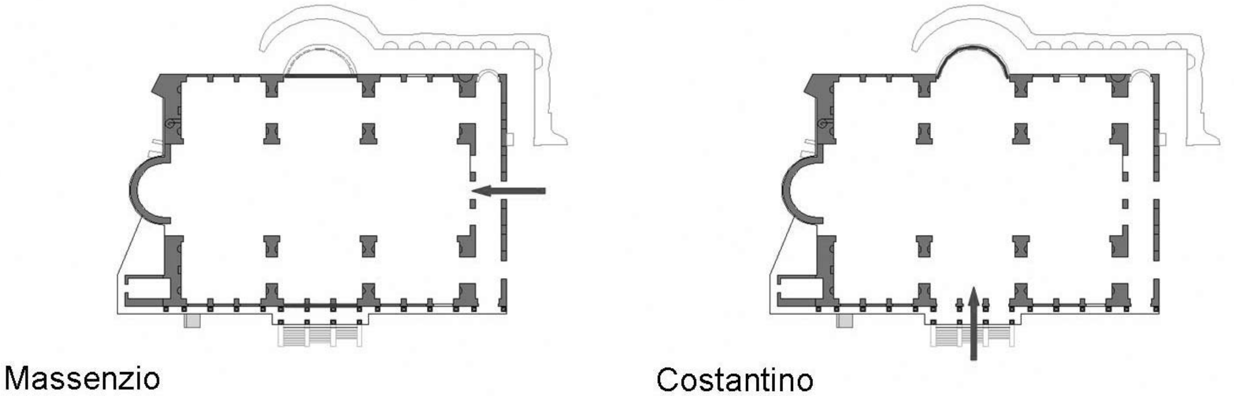
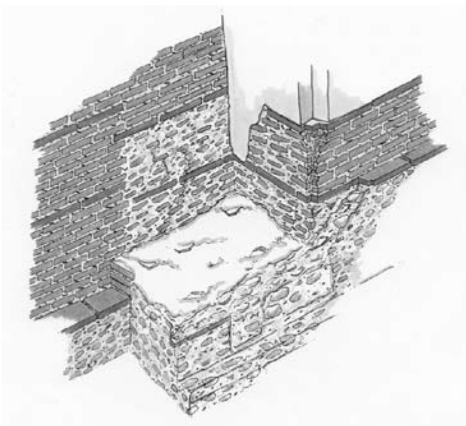


Fig. 14 - Traditional interpretation of the structural setting of the Basilica.



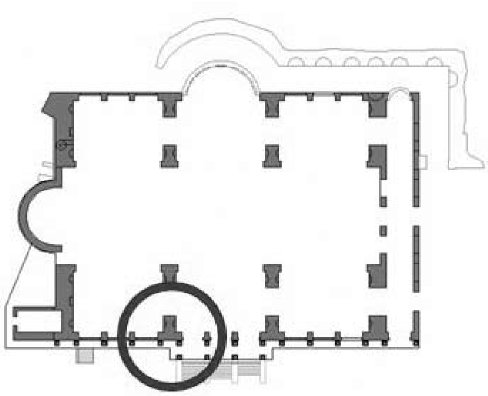


Fig. 15a-c: Pronaos, south-east end. The construction of the projecting pronaos was prepared building a foundation, in part against the ground and in part against blocks, and then an elevated section with blocks at each end. Both were clearly bonded to the foundation and the perimeter wall of the Basilica; consequently it must be attributed to the first phase of the building, in Maxentius time.

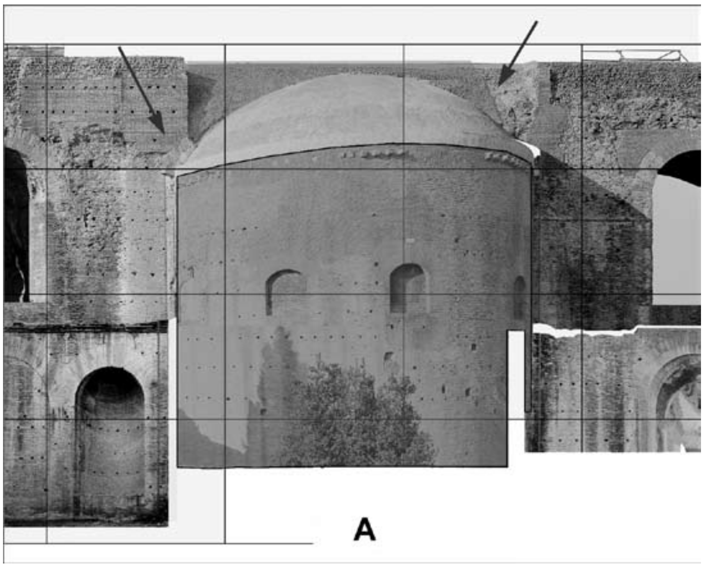


Fig.16: Basilica, north apse, (A), exterior (orthophotogram by Fokus GmbH - Leipzig). The deteriorated section of Maxentian wall was demolished and repaired, following the course of the existing structural crack, indicated by the arrow on the right, by inserting a large buttressing apse. The arrow on the left indicates the remains of the springing of the arches in bipedales of the truncated windows of the original rectilinear wall.

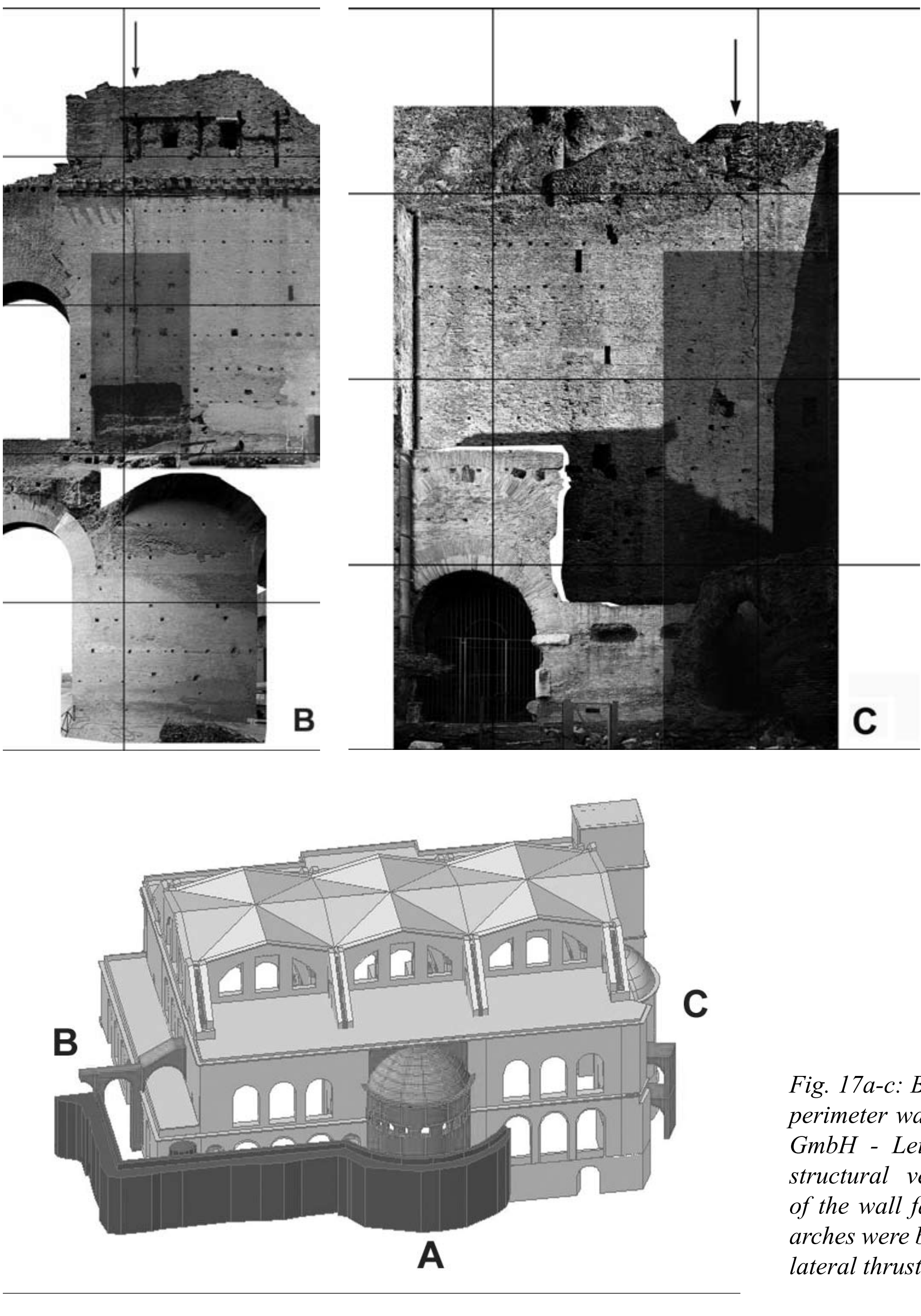


Fig. 17a-c: Basilica, east (B) and west (C) perimeter wall (orthophotogram by Fokus GmbH - Leipzig). Arrows indicate deep structural vertical cracks; the analysis of the wall facings shows that buttressing arches were built against them to cope with lateral thrusts and external inclination.

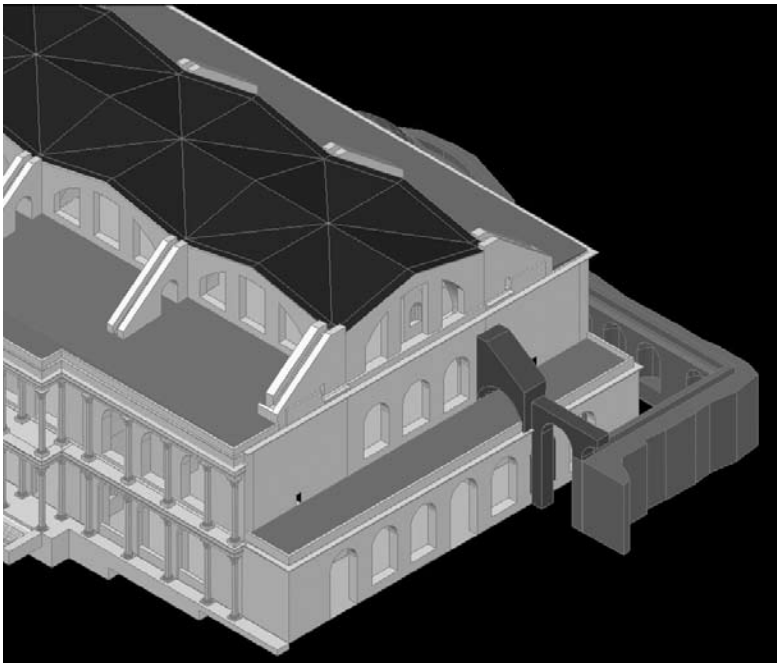


Fig. 18: Model of the Basilica in its original condition, showing the Finite Element mesh with degrees of tension stress. (Prof. Ing. A. Samuelli Ferretti). The geometry of the model is derived from the 3D analytic reconstruction.

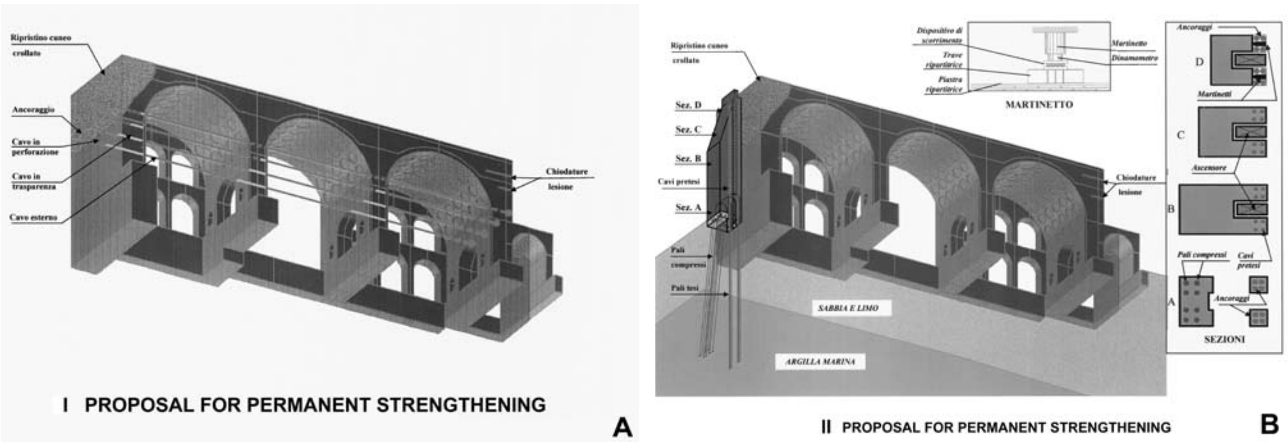
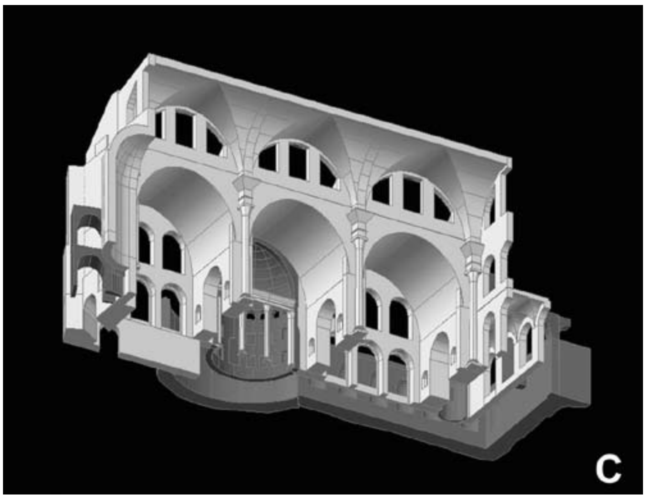


Fig.19 a-c: Proposals for permanent strengthening (Prof. Ing. A. Samuelli Ferretti). Proposal B strongly takes into account the suggestions offered by the arched buttresses built during the second phase of the construction of the Basilica (cf. Figs 16 – 17), adapting to changed topographical and structural conditions.



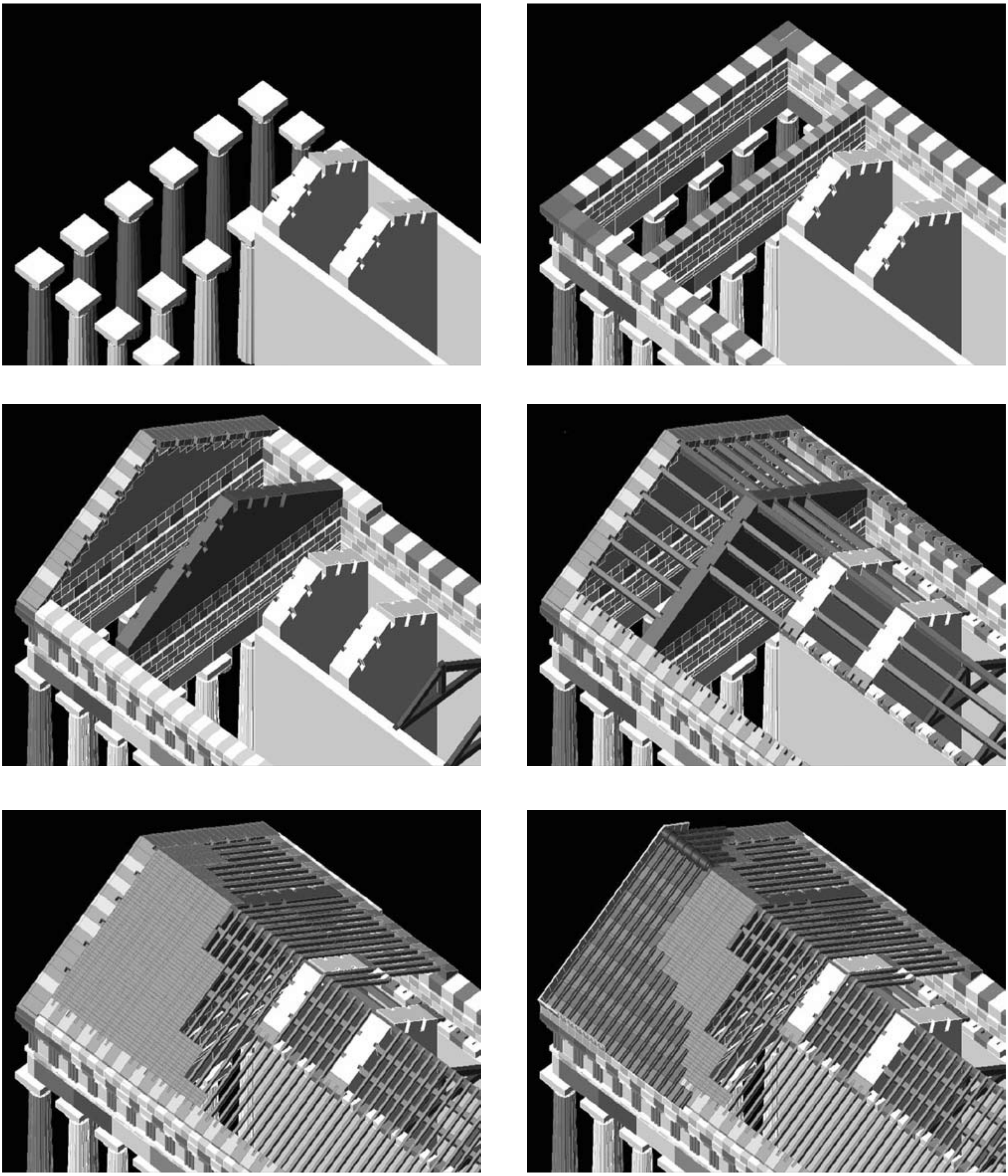


Fig. 20a-f: Selinunte, Temple C. Virtual reconstruction of the building process of the pediments and the roof.