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THE CATHEDRAL OF S. LORENZO IN PERUGIA AND THE HYPOGEAL SPACES. GEOMATIC TECHNIQUES FOR SPATIAL INVESTIGATIONS AIMED AT THE KNOWLEDGE AND INTERPRETATION OF THE ORIGIN OF THE TRANSEPT

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ABSTRACT:

The area of the monumental complex of the Cathedral and the rectories of S. Lorenzo, located on the “acropolis” of Perugia, has been for more than two thousand years the main religious and civil reference site of all populations since the origin of the city of Perugia. The aim of this research was to survey the monumental complex of the Cathedral of San Lorenzo through the use of various geomatic techniques, with particular attention to the areas of the apse, the transept, the attic, the upper courtyard and the lower one, together with the hypogeal rooms of the Capitular Museum underlying the church, including important and impressive ruins as a portion of an Etruscan terracing wall (2nd century BC).
The complex is extremely articulated, so it was necessary to correlate external and hypogeal internal spaces; the site is also characterized by the existence of numerous archaeological traces of various origins, resulting from the succession of events developed over the centuries and countless works that have been integrated, juxtaposed and in some cases replaced by previous ones. All this circumstances contribute to make not easy the understanding of the planimetric and altimetric relationships existing between the different parts and the identification of the real context of the architectural elements is equally complex. The need to connect different areas of the monumental complex located at different levels (from hypogeal rooms and vaults to the church, the attic and the external squares and streets) has required a coordinated and integrated use of geomatic techniques such as precision GNSS positioning (outside the building) and the creation of a very articulated three-dimensional geodetic network connecting the external GNSS vertices with the internal reference points and targets placed in the different areas to frame in a unique global datum the subsequent detailed surveys performed with LIDAR and photogrammetric techniques, so that the single scans and local surveys could be assembled to form a unique 3D model. Among the many aspects highlighted, in particular, it was possible to understand the genesis of the cathedral transept, whose size was dictated by an imposing Etruscan wall. Until now the ruins of the ancient cathedral complex were known - referring to three different buildings, the cathedral, the dodecagonal bell tower and the chapel of Sant'Ercolano - incorporated into the side of the basilical body in front of Piazza IV Novembre. From additional ruins attributed to the structure of the ancient cathedral, it was obtained that the level of the floor of the church has been substantially maintained in the current cathedral.

1. GENERAL INTRODUCTION

The Cathedral of S. Lorenzo was built in the fifteenth century on one of the most eminent areas of Perugia, considered as the city's acropolis, where the "platea magna" was located, characterized by important remains from Etruscan and Roman times. The continuity of use of this area has left many traces even of the subsequent centuries, and its constant importance over time is attested by the choice to build in this place the original cathedral of Perugia, of which only a few traces of walls are still surviving.
In the eighties of the twentieth century a vast excavation campaign which lasted until 2006 was carried out: the spaces and structures under the transept, apse and cloister of the cathedral were brought to light, partly included today in the visit itinerary of the “Capitular Museum” (Cenciaioli, 2011, 2014 and 2018; Sisani, 2014).
The rich and complex urban spaces highlighted by the excavations has been the subject of studies and investigations aimed mainly at archaeological aspects of characterization and dating of the remains. The articulated system of underground environments offers the possibility of relating the transept and apse of the cathedral to the underlying structures and to understand how the layout of this part of the cathedral was conditioned by the existing structures. However, this is a problem made particularly complex by the lack of direct connections between the cathedral and the underground chambers, and the labyrinthine shapes of the latter, with modest amplitude, extremely irregular and with continuously variable altimetry. For this purpose, a laser scanner and topographic survey was specifically designed, which allowed to obtain a 3D model of the entire complex, from which the data were then extracted to obtain accurate two-dimensional drawings (plans and sections). From the survey results derive the new studies presented in this paper.

2. SURVEY WITH GEOMATIC TECHNIQUES

The purpose of this research has been to carry out an accurate survey of the monumental and archaeological complex of the Cathedral of San Lorenzo in Perugia, creating a three-dimensional model from which obtain detailed drawings such as plans, elevations and sections, and from which it is possible to analyze the materials used and their conservative state, and the building techniques, with the aim of trying to reconstruct, as far as possible, the succession of the most important interventions over the centuries from an historical and structural point of view, and to identify the relationships existing between the spaces on the lower floors and the cathedral above.

The survey of the complex has covered an area of about 8000 square meters, with variations in altitude between the hypogeum environments and the top of the cathedral of about 50 m.
The complexity of the survey, in particular from the point of view of the correlation between the different internal and external levels, has required the use of adequate and modern high-resolution three-dimensional survey methods, in particular digital photogrammetry and terrestrial laser scanning, integrated with topographic survey techniques (Radicioni et al. 2017; Bevilacqua et al. 2017; Balletti et al. 2015; Tucci et al. 2015). For this reason, the work was divided into successive phases: firstly, a reference network was created over the area under study by means of GNSS satellite positioning and total station for aligning and georeferencing the model; subsequently, internal and external laser scans were carried out to allow the reconstruction of the geometry of the complex; finally, digital photogrammetry was applied, limited to some areas.
More details and drawings concerning the geomatic survey are present in Marconi (2017), Risoluti and Vicarelli (2015).

2.1 Total station and GNSS positioning

For the georeferencing of the laser scans, a total station (Leica TS06) was used, through which an adequate number of points signalised by laser targets with a checkerboard pattern were measured, in addition to some external and internal recognizable points.
A first reference network, consisting of a series of vertices materialized with permanent markers, was created in the external spaces surrounding the cathedral area. The network was then extended to other vertices inside the building, materialized with topographic nails or graphic signs on the floor, in order to connect the internal and external spaces. The data were subsequently processed and adjusted using topographic software.
In order to be able to geo-reference the polygonal in the global datum ETRF89, the position of some points of the reference network was determined with the GNSS technique, by means of relative positioning in static mode, so as to reach 1 cm order accuracies. Two Topcon GR-5 receivers and two Topcon Legacy GGD receivers were used, mounted on tripods on four external points (figure 1). The receivers were kept in position for about 3 hours, acquiring GPS+GLONASS twin frequency phase/code data at 5 seconds interval.
The choice of the GNSS points was made after a preliminary planning to analyze the effect of the obstructions on the satellite signals: for this purpose the online GNSS Trimble Planning procedure was used, allowing to simulate the obstructions.

Figure 1. Static GNSS in Piazza IV Novembre.

The acquired data were post-processed with the *Topcon Tools* software, obtaining the coordinates of the four GNSS vertices.
To obtain the positions in the global ETRF89 datum, a connection was made to some permanent stations of the GPSUMBRIA regional network (connected to EUREF EPN continental network).
The final coordinates obtained are expressed in UTM/ETRF89 zone 33N projection. The orthometric heights (referred to the average sea level) were estimated by means of the local undulations of the ITALGEO2005 national geoid model.
The result is an extremely articulated network (as can be seen from figure 2) that connects the hypogeum environments with the upper levels and the external spaces around the Cathedral.

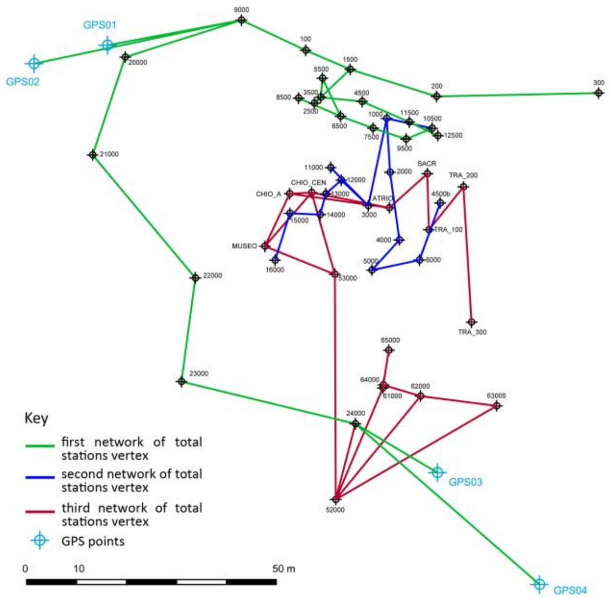

Figure 2. Network connections between total stations vertex and GPS points

2.2 Laser scanning

The laser scanning survey interested the interior of the underground rooms of the Chapter Museum of the Cathedral of San Lorenzo, part of the elevation, the interior of a part of the Cathedral, and in particular the apse area, the transept, the attic and the upper and lower courtyards. The survey was performed over a period of about two years (2015-2017), during which about 170 scans were performed.
The laser scanner produced as output an extremely high number of 3D points which required an accurate and laborious processing phase by means of specific software for point clouds processing.
The laser scanners used for the present survey were:
- a RIEGL LMS-Z420i, with RISCAN 1.7.4 software, pulse and long range type scanner, for the external and some internal scans of the Capitular Museum. A digital camera was mounted on the scanning head for high-resolution image recording during scans.
- a CAM2 FARO FOCUS 3D X130 Laser Scanner, with SCENE 5.4 - 6.2 software, used for most of the internal scans of the Capitular Museum and the Cathedral. It is a small-size, very light and extremely fast phase-measurement scanner, suitable for short range interior surveying, equipped with an integrated 70-megapixel color camera with automatic color cloud overlap.
For the acquisition of the single scans both planimetric targets and a set of 6 spheres calibrated for the relative orientation between contiguous scans were used. The 6 spheres are

positioned so that they are simultaneously visible in the same scan. For the subsequent scans 3 spheres are moved while the other 3 are left in position: thus there are always 3 spheres common to two contiguous scans, which allow a relative orientation and a merge of the scans in a conceptually similar way to an aerial triangulation.

The first scans were performed with the Riegl LMS-Z420i Laser Scanner: in total with this instrument 22 scans were made from different positions, lasting about 20/30 minutes, with a spatial resolution of 5 mm at 10 m. By means of a Nikon D200 camera, installed at the top of the instrument, it was possible to acquire images (10 frames per scan) and assign the RGB color to each individual scan. Targets of 5.5 cm x 5.5 cm made of reflective material were used to align the various scans; the target center was marked to measure it accurately with the total station.

The data from the scans were processed through the *Leica Cyclone* software, with which the individual point clouds were aligned to each other and assembled into the global ETRF89 datum network given by the already described reference network. From this procedure the mean error obtained, intended as difference in terms of distance between the targets in the point cloud and their network coordinate, is of the order of one centimeter.

Due to its characteristics and rapid acquisition, the CAM2 FARO FOCUS 3D Laser Scanner has permitted to perform about 150 scans within a reasonable time. As for the scan setting, for indoor environment the resolution was set by selecting a distance between scanned points of 15 mm at 10 meters, with an acquisition time for each scan of about 5 minutes.

The FARO scanner requests opaque targets, consisting of square cards with a pattern of four black and white alternating squares, and the aforementioned reference spheres. The advantage of the spheres with respect to the targets is that the scanner software automatically detects them and accurately determines the coordinates of their center from each scanner position; in this way the maximum scanning efficiency is obtained from different directions and the error in the relative alignment of the point clouds is reduced. The targets, whose coordinates are known from the reference network, are necessary for the absolute model georeferencing.

The software used for processing and managing the FARO scanned data is SCENE, thanks to which it was possible to record the scans and perform the spatial rototranslation of the single clouds: this way each single point cloud is oriented in a local reference system (coinciding with the instrumental reference system).

The scans are then aligned with each other. The successful outcome of the registration is evaluated using the "normalized tension" parameter. In general, a maximum normal tension of 1 mm has been considered admissible; for some complex environments from the architectural/structural point of view, such as the attic of the cathedral, values up to 4 mm have been considered admissible.

Being equipped with an integrated 70 mega pixel internal color camera, the acquired frames (85 for each scan) are automatically oriented in the reference system of the instrument, and it is possible to associate the image-derived RGB colors to the point cloud obtaining a realistic visualization of the scan.

Given the high number of scans, the point clouds were previously aligned with each other in groups based on the acquisition day; subsequently we proceeded to align all the clouds together, so as to obtain a single locally oriented model: the overall point cloud is composed of about 3.7 billion points (figure 3).

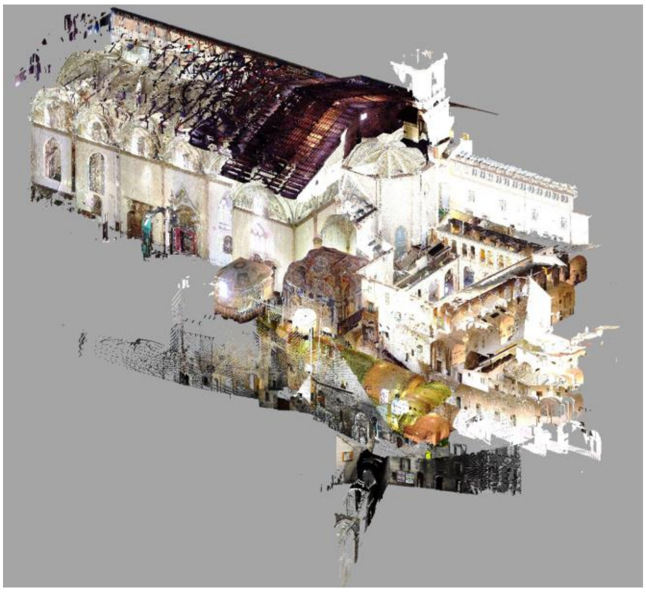

Figure 3. Final cloud of the S. Lorenzo complex

2.3 Georeferencing

The next phase consists of the georeferencing of the point clouds, carried out by means of the Leica Cyclone software. With this procedure we pass from the local reference system to the absolute datum (ETRF89) thanks to the previously measured targets. During this "registration" procedure, which allows to recognize the constraints existing between the point cloud and those belonging to the target network, a mean residual was obtained, intended as a difference in terms of distance between calculated and known position, less than 0.5 cm.

2.4 Bi-dimensional representation

The next phase consisted on the creation of classic CAD vectorial drawings (plans, sections and elevations) by exporting orthoimage files in .tif format from Cyclone software. By choosing appropriate cutting planes intersecting the three-dimensional model parallel to the various fronts to be represented, it was possible to study the complex by choosing from the infinite profiles that can be obtained. Well representative images are obtained which allow a clear visualization of the geometry, of the relations between the various architectural elements, and of the altimetric connections between the various parts (figure 4).

Figure 4. Elevation of S. Lorenzo complex

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2.5 Digital Photogrammetry

Due to the complex system of rooms and structures that form the monumental complex, and given the scarce illumination of the underground structures, it has not been possible to apply the photogrammetric technique to the whole building. It was therefore decided to focus it on the area of the Etruscan wall and on two of the urns in a museum room.
The images were taken with a Nikon D800E SLR camera, equipped with a 36.3-megapixel FX (full frame) CMOS sensor. The software adopted for the photogrammetric processing is Agisoft Photoscan, which uses image-based modeling and SfM (Structure from Motion) techniques to produce point clouds, 3D models and ortho-images from two-dimensional images.
The software follows a very simple workflow: the images are processed through the SFM algorithms to create the 3D models (image alignment and scattered and dense cloud reconstruction) and a subsequent post-processing which consists in the creation of the desired products (meshes, ortho-images, ...).

2.5.1 Urns: For the two urns, after the first phase of image alignment, high-definition dense clouds were obtained, consisting of about 13 million points. The dense point cloud was modified before proceeding with the mesh generation, “cleaning” it by eliminating points that are not part of the object to be modeled. The next step was the creation of a 3D TIN mesh model and the application of the textures from the images. Given the nature of the object, the “arbitrary” algorithm was used, valid for surfaces of any geometry, starting from the dense cloud and setting the highest value as number of faces, for a total of about 2.5 million.
The result is a very detailed and realistic model of the manufacts, that can be used to create a digital archive available at any time for further archaeological studies (figure 5).

Figure 5. Photogrammetric models of the two urns (mesh and texture)

2.5.2 Etruscan wall: The procedure used for the Etruscan wall is the same applied to the two urns. 65 images were used to cover the area; given the limited space available and the height of the wall, in some cases the shooting directions were very inclined. The model was georeferenced using 6 GCP (markers), whose coordinates expressed in the datum ETRF89 were extrapolated from the laser scanning model. In choosing these points, we tried to cover the entire area of the wall so as to guarantee a correct scaling and georeferencing of the model.
Once the reference system was set and the text file containing the coordinates was imported, these points were manually identified in all images where they were visible. The procedure for the alignment of the images is optimized in order to increase the accuracy in estimating the internal and external orientation parameters of the camera and to correct possible deformations present in the model.
At the end of the process, an overall residual on the markers of 0.0056 m and 0.38 pixels was obtained, corresponding respectively to the distance in m between the coordinates of the GCPs entered and the positions estimated by the program, and the mean square error of reprojection of the markers calculated on all the photos in which they are visible (table 1).

	Totale Errors (m)	X_error (m)	Y_error (m)	Z_error (m)	Pixel
Markers Errors	0,0056	0,0023	0,0028	0,0043	0,380

Table 1. Markers errors

The dense cloud obtained is composed by about 100 million points (figure 6). Once cleaned of unwanted points, the cloud was exported in .pts format and imported together with the one deriving from laser within the *CloudCompare* software to perform a comparison.

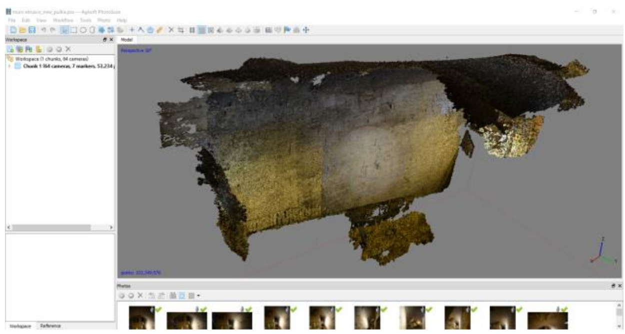

Figure 6. Points Cloud of the Etruscan wall from photogrammetry process

In particular, a comparison was made to calculate the distance values between the two clouds, through the *Cloud2Cloud* distance command. The method used to calculate the distance is that of the "nearest neighbour distance": for each point of a cloud, the algorithm searches for the nearest point in the reference cloud and determines their euclidean distance. Since the photogrammetric cloud is much denser than the one derived from laser scanning, it was decided to use the first as reference cloud.
The result is a complete mapping of the differences between the two clouds, by means of a color scale (figure 7): in blue all the points with an "error" less than 1 cm. At first glance it can be

seen that the major errors are concentrated near the joints, while in most of the wall there is an acceptable error of 1-1.5 cm.

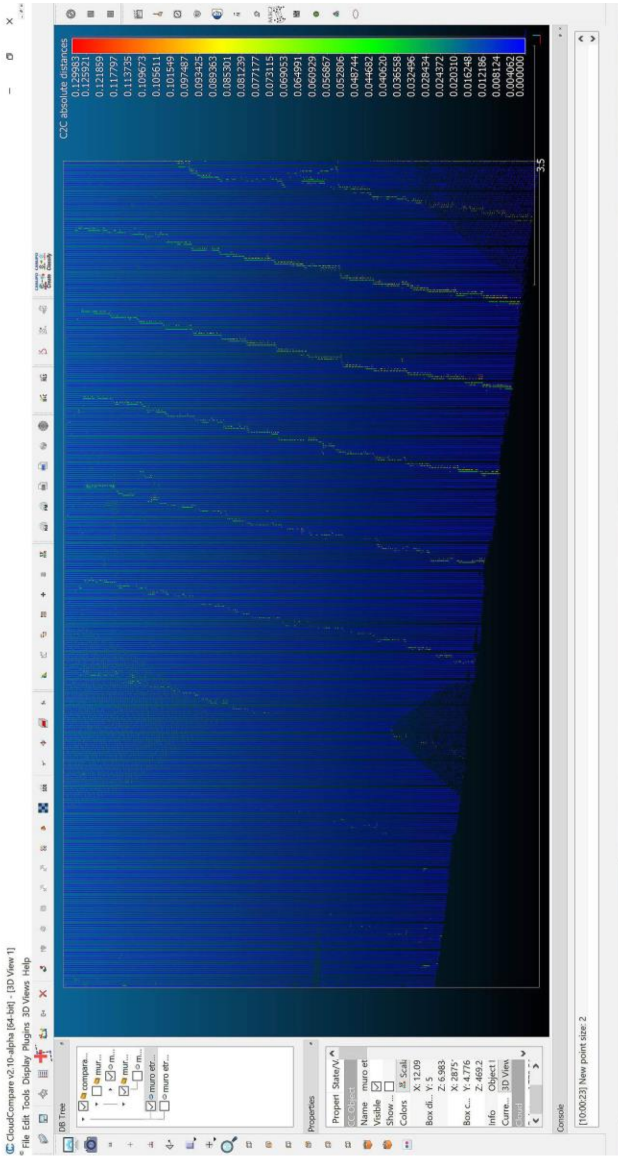

Figure 7. Mapping of the differences between laser and photogrammetric clouds

A histogram (figure 8) shows that most of the differences (around 96%) fall within the range between 0 and 1 cm.

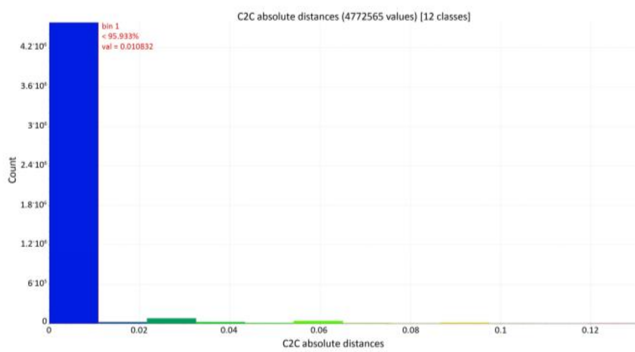

Figure 8. Histogram

3. THE ETRUSCAN WALL

The study of the relationship between the construction of the cathedral and the pre-existing buildings had concerned the wall remains incorporated by the side of the basilical body and by the adjacent fifteenth-century loggia of Braccio Fortebraccio. In particular, the elements identified are the pronaos and the dodecagonal bell tower of the old cathedral, as well as a portion of the wall of the chapel of S. Ercolano, of which an idealized representation is shown in the painting "S. Ercolano presents the city of Perugia" (14th century, 2nd decade), hosted by the National Gallery of Umbria (Matracchi, 2006).
The new information provided by the surveys of the hypogeum environments have allowed us to relate the transept and underlying structures and to identify the reused structures and those of new construction (figure 9). To this end, only the masonry structures linked to the construction of the transept and apse will be considered in this paper.

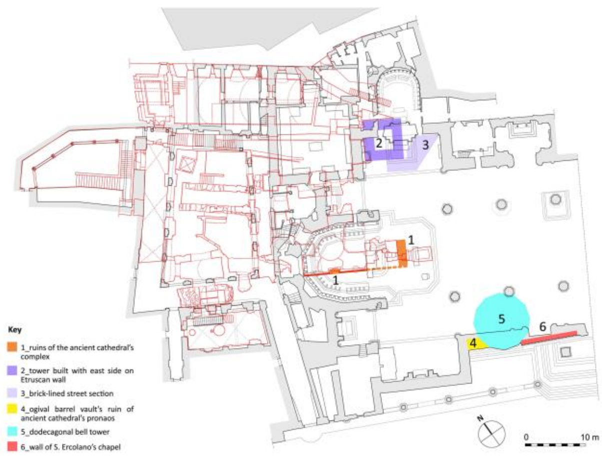

Figure 9. Planimetric relationship between Cathedral and basement structures

In the basement areas is incorporated an imposing Etruscan wall still perfectly preserved, dated to the 2nd century BC, which delimited the terracing placed in the most important area of the city (figure 10).
The wall constitutes today for a long stretch the inner side of the rooms along Via delle Cantine, where there was originally a single large space called the "Conclave Room". The accurate building technique of the Etruscan wall (figure 11) is well visible in large square travertine blocks placed on predominantly continuous rows, except for sporadic adaptations and displaced joints. The wall has the particularity of having been built with offsets of about 2 cm in each overlapping row, resulting in a slightly inclined profile in the direction of the embankment. Furthermore, the rows are not always perfectly horizontal but have inclinations up to a maximum of 2°. Thus, in the same continuous row, there are ashlars with a height varying from about 38 to 53 cm.
The biggest blocks are 120 cm wide and 50 cm high; the wall for a stretch has a thickness of about 2.50 m and in the remaining part, of equivalent length, of about 1.70 m. This difference in the two sections of the wall, which from what can be observed in the face is not due to a construction phase or a variant, since the masonry appears homogeneous, seems to find an explanation on the greater height of the embankment towards North-East, where it was indeed endowed with a more conspicuous thickness. The wall has a length of about 27.40 m

and a height of about 12.00 m, considering also the parts temporarily visible during the most recent consolidation works.

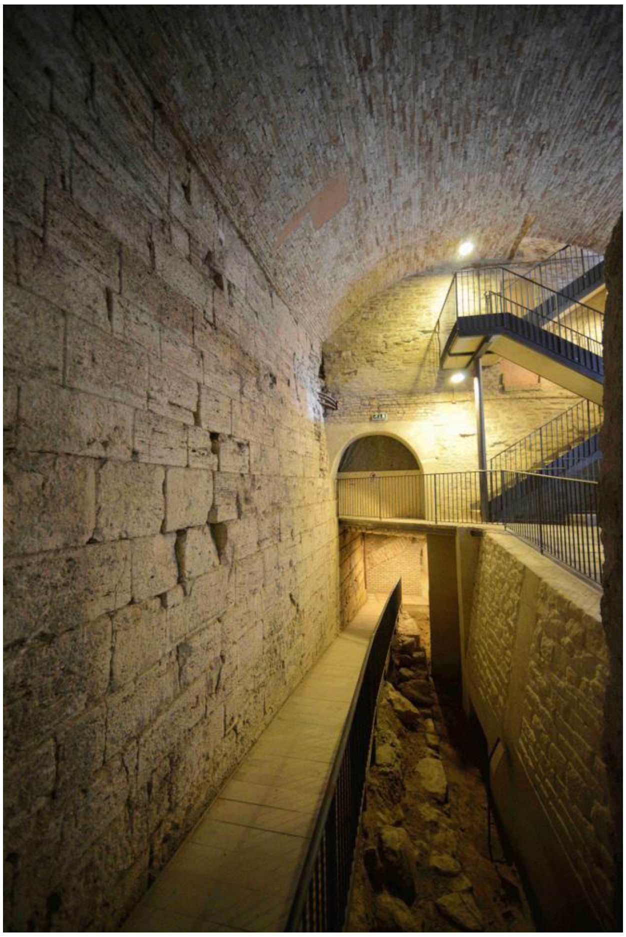

Figure 10. Etruscan wall

The Etruscan wall ends in the north-west with a corner, beyond which it continues for a short distance with an orthogonal aspect, delimiting here the extension of the Etruscan terrace. At the other end the current conclusion of the Etruscan wall seems to have been determined by dismantling works that were extended to its entire height. In correspondence of this section of the wall, the basement areas, bordering a road, have a progressively reduced width; perhaps to create a larger room, gaining space in the side of the Etruscan wall. And it cannot be excluded that the purpose of the dismantling of a section of the wall was the re-use of the large ashlars from which it is made.

Beyond the dismantled zone of the Etruscan wall there is a further limited portion of the wall in ashlars of travertine, incorporated in a triangular narrow area (figure 11). The characteristics of this wall structure, which rises beyond the summit of the great Etruscan wall, are not homogeneous; on the side of the dismantled area it is formed by large ashlars, similar to those of the Etruscan wall, which rise almost to the entire height of the wall forming a corner.

The remaining part of the wall continues with smaller ashlars and with rows that are not always continuous. This wall is also to be considered part of the Etruscan wall; the constructive continuity between these parts becomes in fact more evident also taking into account that the widest wall is not straight, but has a slightly curved shape with which the minor wall portion is in continuity. The differences in masonry are due to the construction phases; and it is likely that in the highest part of the walls of the Etruscan terrace the builders begun to use ashlars of smaller size, due to the lower thrust that, at this level, acted on the wall of embankment.

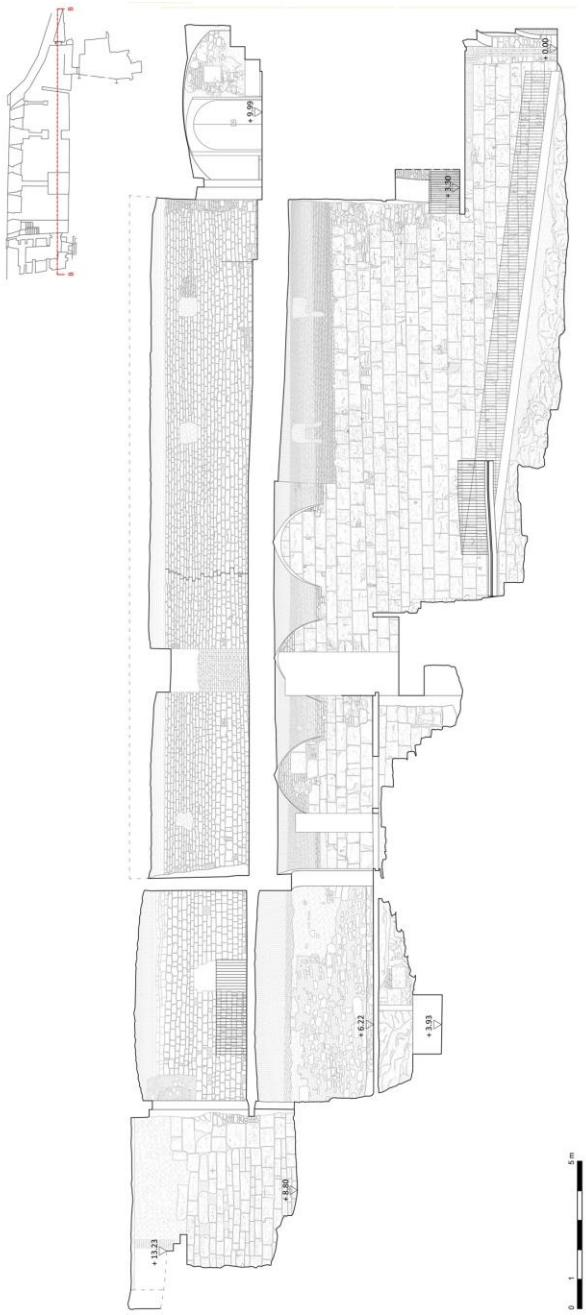

Figure 11. Front of the Etruscan wall from the survey.

Anyway, for the most ancient floor levels of the terrace we should consider that the archaeological investigations have ascertained the lack of stratigraphy or material from the Roman age, leading us to hypothesize that in medieval times the urban transformations had not only altered the most ancient levels but even erased the floor level of the classical age, perhaps higher or coinciding with the current one. This aspect could also lead to consider the possibility that the small portion of the travertine wall, being placed at a height comparable to that of the archaic foundations of a temple structure, may even be traced back to a phase of raising the terrace attributable to the Roman era.

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4. THE HYPOGEAN STRUCTURES USED AS A FOUNDATION

Near the highest portion of the Etruscan wall, the excavations have discovered the base of a tower, with a square plan of about 6.50 m per side and 1.60 m thick walls, which has an entire side leaning against this wall. The foundation level is visible in the tower and is positioned at an intermediate level of the adjacent Etruscan wall. On the south-east side of the tower the excavations have brought to light a stretch of brick-paved road (figure 9).

Two archaic foundation structures, of a thickness of about 1.80 m and placed in the area inside the 'platea magna', are connected orthogonally and are considered the northwest corner of a Templar podium: it is to this building that are attributed the fragments of fictile architectural decoration unearthed near the wall of Via delle Cantine. The foundations of the eastern side of the apse of the cathedral (figure 12) have been placed side by side to these archaic foundations, forming an irregular and wide bottom rock.

Figure 12. Basement plan; the new foundations of the transept in relation to the existing structures

The construction of the north-east wing of the transept, of the chapel on the side of the apse and of the sacristy, not being able to entirely rest on pre-existing structures of Etruscan and medieval times, made it necessary to build new foundation structures, consisting of brick arches that insist on pillars of a modest height (figure 13).

In particular, four large arches were built on massive isolated pillars and on smaller pillars leaning against pre-existing walls. A further arch of modest span rests on a pillar and on a portion of the archaic foundation, thus completing the support of the back wall of the chapel that flanks the apse. In defining the depth of the main arches, the different consistency of the structures above has been taken into account: the largest dimension is below a transept wall, the remaining arches are reduced to the lowest thickness below the north-west wall of the sacristy (figure 12).

It should be emphasized that the ancient structures underlying the transept wall are located on the edge of the dismantled Etruscan wall; this meant that the back wall of the transept wing, where the chapel of S. Onofrio is located, positioned itself further back than the outer side of the Etruscan wall, thus placing it further inside this gap (figure 9). One of these arches adheres to one side of the base of the tower incorporated in the north-east wing of the transept, which has a corner of the tower placed on the edge of the breach.

Figure 13. Cross section of the apse and the chapels of the cathedral; 2_Romanesque wall, 3_Romanesque breach walled up by fifteenth-century structure, 4_Medieval stone, 5_Romanesque tower of 6.50 m side with limestone stonework and mortar, 6_Romanesque wall(probably wall of the ancient cathedral), 7_Pilaster strips on romanesque wall (probably wall of the ancient cathedral complex), 8_Fifteenth-century arch foundations of sacristy, 10_Fifteenth-century furnace, 11_Fifteenth-century altar buried and replaced by the present one.

The pillars on which the foundation arches are based have in some cases the facing stone arranged on rows, and at their base the direct support on the ground is visible today. In other pillars the facing is much richer in mortar, the laying of the ashlars appears more casual and characterized by the presence of voids between adjacent stone elements. In the latter case the pillars appear to have been cast on pit foundations. This leads to think that in this area between the medieval wall built on the Etruscan one, the base of the tower and the archaic foundations of the Templar podium, at the time of construction of the current cathedral there could have been noticeable differences in the ground height.

In this area, once the pillars were built, there are traces of earth centrings for the foundation arches. The bricks arches have traces of this construction technique at their intrados: abundant irregular remains of mortar used to create a more regular and stable supporting surface on the centring, and the curvature lines of the arches left by the tracking system, prepared with bricks posed on the mortar lying on the same earth centrings.

5. THE RUINS OF THE COMPLEX OF ANCIENT CATHEDRAL

Below the apse, the excavations have brought to light the ruins of a limestone wall characterized by regular shapes and very thin joints (figure 9). This wall was also furnished with pilasters placed at distances of about 4.60 m; of the central one is entirely visible the shaft, 1.20 m wide, while of the two on the sides only one corner remains. At the base of the wall there are also some stone foundation rows. Continuing in the direction of the crypt below the presbytery, there is an additional wall of similar characteristics, but with a lower degree of finish. It is a conspicuous wall, 1.85 m thick, placed orthogonally to the other wall characterized by pilasters; both are to be traced back to the complex of the ancient cathedral. In fact, taking into account the dimensions of the wall with pilasters, these ruins have levels congruent with those of the ruins of the ancient cathedral incorporated in the side of the new cathedral prospecting on Piazza IV Novembre (figure 14).

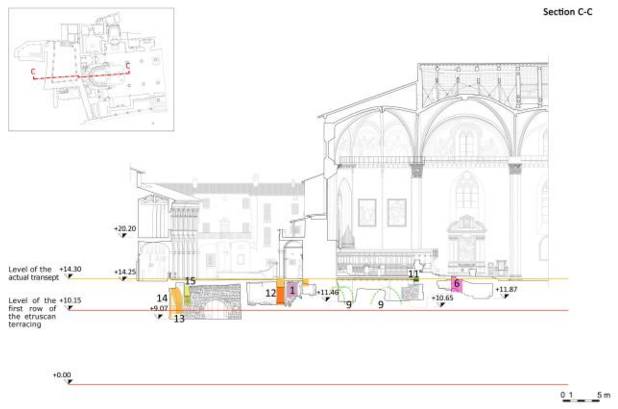

Figure 14. Longitudinal section of the apse;
1_Romanesque wall on Etruscan, 6_Romanesque wall(probably wall of the ancient cathedral complex), 9_Fifteenth-century arch foundations of apse, 11_Fifteenth-century altar buried and replaced by the present one, 12_Exposed well foundations on the east side of the upper cloister, 13_Foundation arch on soil centring on the west side of the upper cloister, 14_Retaining wall, 15_Ogival arch.

6. CONCLUSIONS

The transept stands close to the wall in ashlars of travertine that delimited the "platea magna" in the north-east side and in adherence to one side of the base of the pre-existing tower incorporated by the foundations of the transept itself. Given the substantial planimetric regularity of the new cathedral, these pre-existing walls were assumed to be binding and in fact determined the orientation of the cathedral built in the 15th century, which was placed almost orthogonally to the previous one. These pre-existing structures, together with the remains of the ancient cathedral incorporated into the side on Piazza IV Novembre, have in fact also dictated the size of the transept and the basilican body of the S. Lorenzo cathedral.
The floor levels of the new cathedral are substantially similar to those of the ancient cathedral, which stood just above the level of two important remains, the foundations of a probable temple podium and the top of the highest part of the wall supporting the 'platea magna'; while the summit of the great Etruscan wall of homogeneous characters almost coincides with the floor level of the Piazza IV Novembre area near the Loggia of Braccio Fortebraccio.
All these elements prove that the earliest Etruscan remains and subsequent contributions, up to the medieval ones, have continued over time to play a fundamental vital role in the destiny of urban planning and architecture in the most important area of the city of Perugia.

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