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Geometry as Matrix of Construction of Roman Stone Bridges: The Augustus Bridge at Narni

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Abstract

The study of ancient Roman bridges embraces various disciplines and professions: engineers, architects, historians, archaeologists, and geologists. One of the first experiments completed by this research group was conducted on the Augustus Bridge at Narni: an integrated digital survey followed by the application of 3D digital modelling. Although only one of its four arches has been preserved, it can still be seen that the bridge was conceived on a large scale of technical complexity based on a precise knowledge that guided the choice of materials and architectonic solutions. The structure is immersed in an enchanting green landscape, which has for centuries attracted numerous scholars and artists. They have left us a precious iconographic heritage whose interpretation is still debated. As far as the geometry and proportions of the construction are concerned, to compare its present state with the original one, the structural ashlars of the bridge were modelled parametrically on the basis of transforming elementary geometric elements having adopted the Roman foot as the unit of measure.

Keywords: integrated digital survey, Roman bridges, proportion, measure, parametric modelling

Introduction

A large number of Roman bridges can be found on the territory of Italy. So far studies have been conducted[1] on the Emilio Bridge, the Fabricius and the Milvio Bridges in Rome, the Augustus Bridge at Narni, and the Roman bridge in Rieti. It is possible to affirm that each bridge is unique both from the figurative and material point of view and from the topographical context in which it is inserted. The present research has attempted to trace a methodological path of comparative analysis regardless of geographic proximity and construction technique[2].

It is precisely to pursue this objective that collaboration was initiated with Antonio Pizzo[3] who added to the repertoire of Roman bridges the Spanish bridges in Mérida, Alconetar, Alcantara, Segura, and Villa Formosa in Lusitania.

The bridges studied in the territory of Roman Lusitania (Hispania), documented with the same methodological and technical procedures as the bridge analysed in the present study, exhibit a set

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[1] The present state of the bridges was the objective of surveying the above mentioned ones with 3D shape acquisition technique. The Emilio bridge was the subject of the M.A. Thesis in building construction engineering and environment systems (LM24): the candidate for the degree was Giulia Umana with the thesis “Art and technique in the ancient stone bridges. The Broken Bridge of the Isola Tibertina”, A.A. 2015/2016, supervisor prof.arch. L. Paris, co-supervisors prof. Arch. F Di Marco, eng. M.L. Rossi.

[2] The research presented here is a part of a larger university research project focused on integrated digital surveying, the construction and virtual communication conceived as one of the means of cognizing ancient Roman bridges in Rome and its provinces. Apart from the authors of the present study, involved in the project are Prof. Paola Quattrini, Prof. Tommaso Empler and other collaborators.

[3] Archaeologist and Cientifico Titular of CSIC (Spain) at the l”Istituto de Arquelogia (Mérida).

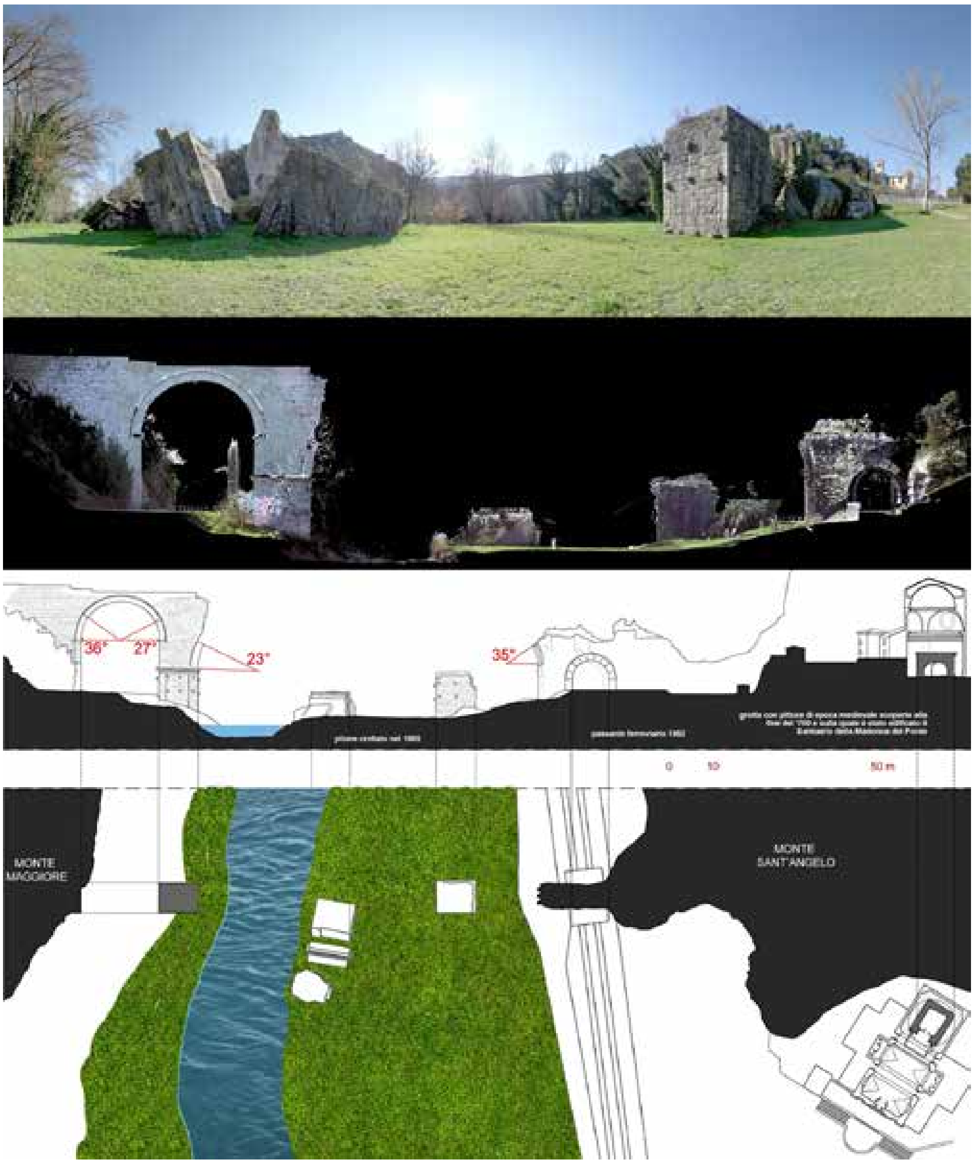

Figure 1. Ruins of Augustus Bridge in relation to the Sanctuary of the Madonna del Ponte and the cave inside it.

of common characteristics, which when analysed in detail yield information of considerable interest on the techniques applied, specialization of manpower employed, as well as on the transmission of technological knowledge in relation to architectonic models and materials used by the Romans. The data obtained in the regional setting, homogeneous from the historical and territorial point of view, could be considered as the frame of reference for case studies on Roman territories. Below we present the first fundamental piece of completed research, which is part of an ongoing project[4], on the famous Augustus Bridge in Narni, situated along an ancient route of Via Flaminia. Many hypotheses have been put forward as to the form of the bridge, the dimension of its arches, and original measures and proportions. This study attempts to provide answers to some of these questions. The research discussed here (be-

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[4] The present paper was presented at other conferences, among others, that of “The third centenary of the Sanctuary of Madonna del Ponte; a day of study” In Narni, 17.04/2015, supervized by the Center of Historical Studies in Narni and devoted to the initial stage of analysis. Among the participants were Wissam Wahbeh, post-doc FHNW University of Applied Sciences and Arts, Northwestern Switzerland and Pamela Maiezza, ph.d. Student from the Universitá degli Studi dell'Aquila. During the meeting an integrated digital survey of the bridge and of the Sanctuary together with their subsequent restitution were conducted. The second stage of analysis of the geometries and the proportions carried out on models two- dimensional and three-dimensional models of the bridge, finalized to define a reconstruction hypothesis and presented at the international conference “APEGA2016: Dibujar, Construir, Sonar. Investigationes en torno a la expresion grafica aplicada a la edification” at l'Universitat Jaume I a Castellon de la Plana, Spain, 1-2-3/12/2016.

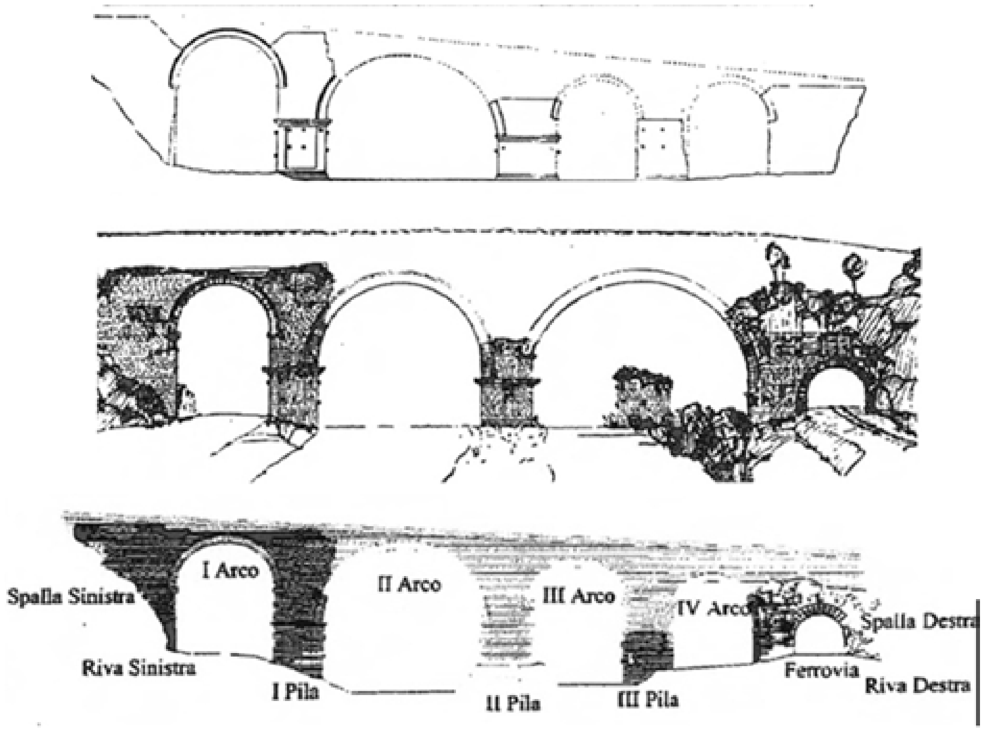
Figure 2. An engravingof Philipp Jakob Hackert (1737-1807), a small part of the iconographic heritage concerning the Augustus Bridge.

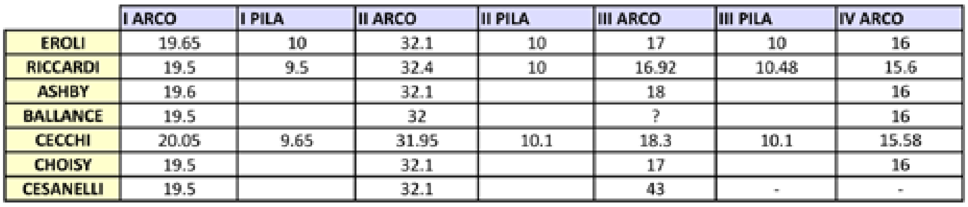
gun in 2015) extends the knowledge of the object of study, relating geometric and measurement aspects to structural ones as evidenced by the state of the ruins of the bridge.

Augustus Bridge and the Cave of the Sanctuary

In 27 BC, Augustus ordered the construction of a bridge across the Nera river valley to join two mountainous terrains: 1) the area of Monte S. Angelo to the north towards the plain of Terni, on the slopes of which there is today the Sanctuary of the Madonna del Ponte, and 2) the area of Monte Maggiore to the south, almost under the fortifications of the ancient city of Narnia (today's Narni). It is a strategic point that makes it possible to cross the river and join its banks. At the same time this area functioned as a kind of transition zonebetween the hilly landscape and the Terni valley. Thus, topographically, the relationship between the city and the landscape into which it is immersed has remained almost unchanged for 2000 years. The Augustus Bridge is an imposing work of masonry engineering with its four arches. Via Flaminia has remained until today one of the main arteries to cross central Italy.

Although in many parts the Via Flaminia corresponds to its ancient course, it is impossible to trace with precision its path at the point of the bridge, since between the final years of the 19th century and the Second World War, it was largely modified following the construction of hydroelectric plants and alternative roads. Numerous hypotheses have been put forward on this question over the course of centuries supported by 17th century discoveries that documented interesting pre-existing structures that could have been in some way connected with the course of Via Flaminia and the trail towards the cave of the Sanctuary of Madonna del Ponte with medieval paintings inside (discovered at the beginning of the 18th century). Recently a church has been built around the cave, which resulted in part of Monte Sant'Angelo being dug-up exactly on the side where the course of the Via Flaminia presumably ran. The erection of the Sanctuary was not the only work that influenced the layout of the landscape. In the 1860s, the bridge was also modified for the railway line Roma–Terni. For this purpose, a part of the substructure of the right abutment was demolished to make a new arch. In this way the right bank of the river was completely separated by the plain of Terni where today there is the residential area of Narni Scalo. Moreover, it functions figuratively as the fifth arch of the bridge, which





	I ARCO	I PILA	II ARCO	II PILA	III ARCO	III PILA	IV ARCO
EROLI	19.65	10	32.1	10	17	10	16
RICCARDI	19.5	9.5	32.4	10	16.92	10.48	15.6
ASHBY	19.6		32.1		18		16
BALLANCE	19.5		32		?		16
CECCHI	20.05	9.65	31.95	10.1	18.3	10.1	15.58
CHOISY	19.5		32.1		17		16
CESANELLI	19.5		32.1		43	-	-

Figure 3. Reconstructions of the original form of the bridge made by some scholars and reported in chronological order (the measurements are in meters)

changes completely the reading of the structure and the rhythm of the four arches of the original Roman bridge. In fact, the only arch that survived intact is the first one, just in front of the left abutment. After the collapse of the second and the third arch, the pillar which supported them tumbled down under the pressure of the river's waters in 1885. The problem of the second pillar and the lack of information as to its original position seem to be the main source of a succession of reconstruction hypotheses in most cases contradictory to one another. The objective of the present enquiry is to study in depth the positioning of the ruins of the Augustus Bridge in relation to a wider environmental context and with reference to previous studies (Fig. 1).

Digital survey of the bridge supporting or verifying reconstruction hypotheses

The landscape in the which Augustus Bridge is immersed, particularly evocative for its natural beauty and for the ruins themselves, has for centuries attracted numerous artists and scholars. Precisely for this reason, we have at our disposal a continuously accruing iconographic repertoire documenting the bridge and its surrounding landscape from the middle of the 17th century until the end of the 19th century (Fig. 2).

In these images the bridge in not presented as a work of engineering but functions as a part of the landscape (Tattoli, 2000). Some of these artists focused on representing the bridge, as if it were the fulcrum of the picture, others concentrated more on the engineering aspect of the structure with very realistic representations of documentary value, especially useful for attempts at identifying all the modifications it underwent over time. Moreover, because the ruins collapsed again and because of the inherent instability of the masonry structures that survived, many scholars treated the task of surveying the bridge as a means to program works of restoration. Hence, our iconographic heritage does not include only artistic representations but also scientific ones, which in most cases are accompanied by hypotheses on their original form. (Fig.3).

The most recent survey, conducted under the supervision of Alberto Cecchi in 2003, was carried out with innovative topographic and photogrammetric instruments (Cecchi, 2003). It responds to many questions in a convincing manner, but overlooks some fundamental problems. Just like numerous scholars before him, Cecchi comes up with a different solution to the problem of reconstruction, based on a careful reading of data from the survey (Fig. 4).

On these premises and considering the fact that Cecchi's survey can be integrated with new laser scanner acquisitions and photogrammetry, our research group came to the conclusion that it would be useful to carry out a campaign of digital survey. The first objective to achieve at the first stage of the survey was that to capture a unique point cloud integrated with RGB photographic values and topographic control points (Paris, 2015) that would include not only the ruins of the bridge on both banks of the river but also the whole area of the Sanctuary of Madonna del Ponte. This procedure allowed us to elaborate a model that related the whole Nera river valley to the ruins of the bridge and the interior of the cave. The survey stations, starting precisely from the cave, were positioned outside and inside the Sanctuary in order to reach the top of the right-hand abutment of the bridge, from which it was possible to take in the whole area, overtake the railway tracks, survey the ruins on the right bank of the river and finally survey the grand arch that survived intact on the left bank. One of the pillars adiacent to the river collapsed on July 17th 1885 when the river flooded, most probably due to its position in the centre of the riverbed but also for the lack of breakwaters. It was also shifted away from its original position by the sheer force of the water. Tumbling down, it broke into three blocks. The third pillar is well preserved, stable in its original position, and even though the upper cornice is lacking, its external parameters have been preserved perfectly. The second and the third arch, supported by the pillars described above, collapsed in 10503 also when the river Nera flooded. From that point in time, the Augustus Bridge appears in medieval documents as "the broken bridge." In order to provide the possibility to cross the bridge, a wooden scaffolding was constructed as evidenced by holes into which it was attached. It was but a temporary, expedient solution. A new bridge was built not far in 1217. Due to the difficult orographic situation at the point in which the bridge is coupled with the Monte Maggiore slope and where a new road to Narni was constructed in the 1960s, it was impossible for the moment to acquire information useful to carry out an in-depth study of the area where the Via Flaminia certainly ran behind the ancient nucleus of Narni. In total 31 scans were taken with the resolution of 10,000 points in the equatorial section. For the collimation of various point clouds, we decided for most cases to proceed marking out spheres of automatic recognition between adjacent scans. In some cases this was done manually by recognizing known coordinates surveyed topographically. Starting from the first elaboration of the point cloud it was possible to formulate some conclusions. We could deduce that the cave of the Sanctuary is not related to the bridge, neither in its the planimetric position nor in elevation, independent of the slant thereof. Moreover, it was clear that the pillars were all aligned and therefore the hypothesis that their position shifted, as was put forward in earlier reconstruction attempts, proved groundless. Visible in the first arch are fractures in its sides, similar to those in the other two arches: the second and the third arch collapsed because the pillar gave way under the pressure of water, but the first pillar had to be excluded from this pressure because it was erected in a place higher than the water level during these floods. Today the bow has a lowered key and corresponds to the sides at 36 degrees and 27 degrees at the springing line, compared to the side of the shoulder and that of the pillar. It was possible to establish the curvature of the second arch at the value of 23 degrees at the springing line. It was no longer horizontal as the pillar rotated by one degree in the vertical section. Hence we can say that the fissures in the surviving arch were caused by the absence of the second, the bigger one in the original design, which was most important for balancing out the shifts. After the second arch had collapsed, the second pillar inclined in this direction extending and

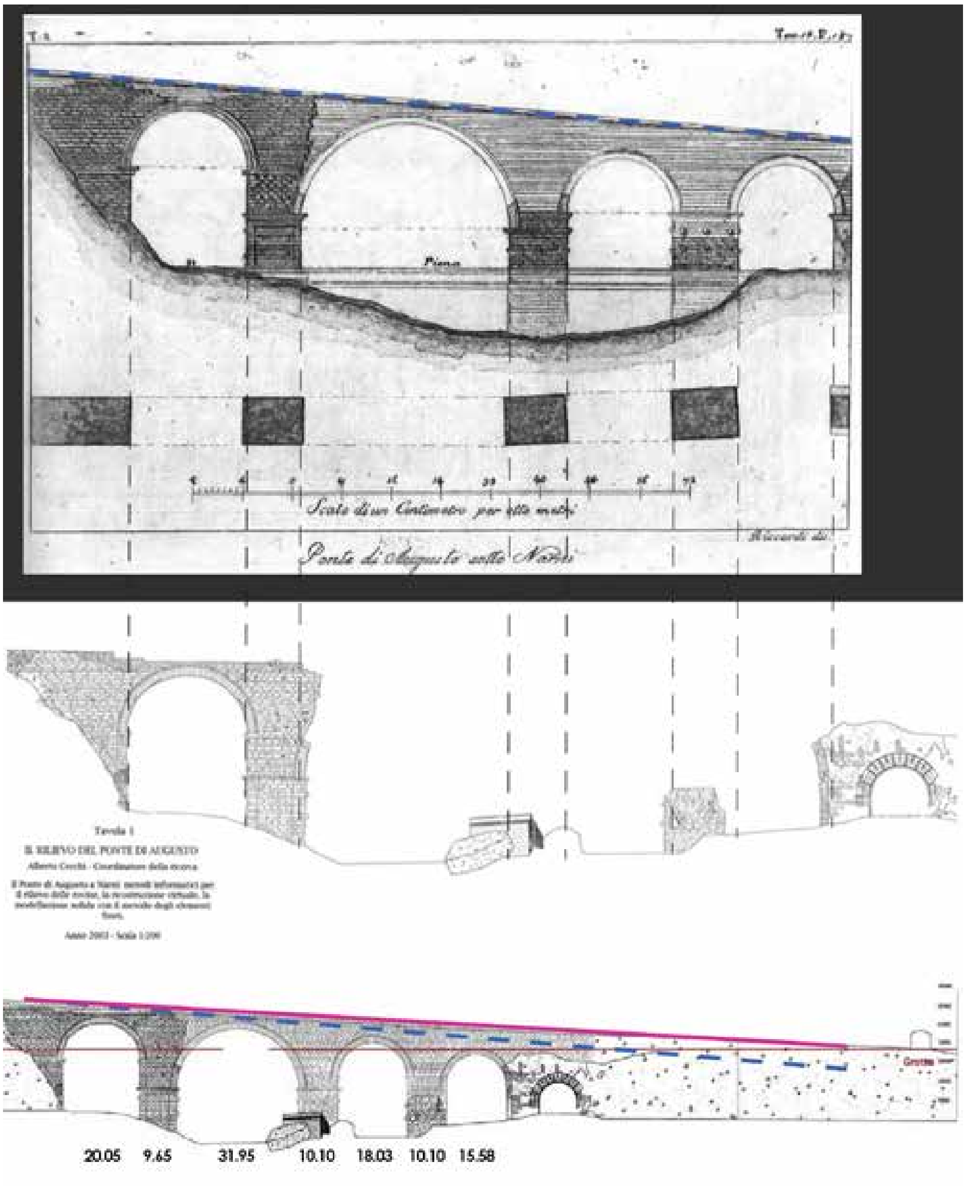


Figure 4. Survey and hypotheses for the reconstruction of the bridge by Eng. Giuseppe Riccardi in 1837. The differences in the springing line of the great arch, the declivity of the street and misalignment of the pillars are clearly visible (from Tattoli 2000). A comparison with Cecchi's survey. The dashed line represent the excessive slope of the road to Riccardi, compared with the slope

making visible the consequences of the rotations in the arch.

In regards to the constructive elements of the ruins of the bridge, it is noticeable that the structure of the northern span of the bridge is hooked directly into the Monte Sant'Angelo and definitely is the most degraded part of the bridge. One can see its nucleus as it is almost totally stripped of the stone layer that was removed when the railway line was being constructed. The arrangement of the blocks of the remaining side seems to be similar to the lower part of the left span. From an analysis of the remaining structures there are evident constructive and typological differences: the ruins of the fourth arch, which are interrupted on the right side at 35 degrees on the springer, shows a different method of assembling the blocks. This technique is probably posthumous to the first construction phase as it has 5 rings of parallel and alternating blocks, instead of an arc with a constant intrados. (Galliazzo, 1995).

The surviving arch rests on the left abutment and the first pylon. This pylon has a socle without rostra. It is endowed with a parament characterized by a regularity of alternating arrangements for the head and the cut of the keystones (pillars) as well as by an accentuated beveling of the ashlar, similar to the base part of the abutment. On two sides, upstream and downstream, there are frames. The data captured through the integrated digital survey were elaborated yielding 2D graphics and 3D models.

Models of the bridge for the purpose of a reconstruction hypothesis: From discrete to parametric models

The main target of our research group, as stated above, is to verify different interpretations and versions of the same object, through 2D and 3D models for the purpose of extending the knowledge of architecture. In the previous paragraph we described the application of the discontinuous numeric model to achieve this particular goal. Another type of model that helped us towards this aim was that derived from a point cloud (the continuous polygonal model) we had recourse to in order to uncover forms and positioning. It must be said, however, that this model – in comparison with the one from which it was extracted – can only provide the factor of continuity, the principal feature of architecture, given that the same operations – enquiry and section – can be carried out on the point cloud.

On the basis of analyses carried out on models described above, we have constructed a continuous mathematical model which constitutes a synthesis of prevalently geometric character. It is a model of compromise between the numeric data, a faithful representation of reality, and an ideal geometric model that can be representative of a design idea. With respect to the form of the arches, we proceeded with a comparative reading of the data surveyed on the first arch partially preserved. Bearing in mind that the springing line is not horizontal, the growth of curvature parameters of the arch to the splitting point corresponding to the flanks have been calculated along the thickness of the surviving arch, with circles passing through three significant points obtained from the point cloud. The thickness has been analyzed in its totality through vertical planes of the arch placed at 10 cm intervals. In this way we obtained the first datum enabling us to determine the generatrix of the arch and put forward a hypothesis as to the position of the collapsed pylon. Since this is the most important factor of uncertainty, the form and positioning of other arches could be determined. Before the arches collapsed the bridge had the construction rhythm of four arches similar and dissimilar in some aspects. The reconstruction hypothesis was supported by geometric hypotheses – according to our analyses of the curvature of the arch ruins – as well as by the measurements of the geometries. Unlike other studies, instead of putting forward again the hypothesis of a decimal metric solution, whose values, as we have pointed out, are derived from a reading of the present state of the arches (which in the course of centuries were subjected to various and sometimes significant modifications) we sought a solution that would be somehow compatible and would be confirmed by the ancient unit of measure: the Roman foot (29.65 cm) This particular methodology was applied since in numerous work of architecture of similar dimensions, and mainly for ancient works of infrastructure, a correspondence with the entire values of the unit of measure had been observed. It was also noticed that the measure of the first arch was perfectly compatible with the third one. Identical measurement values of the diameter of the arch would be fully justified given how it was possible to optimize the yard in the construction of provisonal works. Thus the hypothesis has been put forward that the two arches had the diameter of 66 Roman feet, equivalent to 19.57 meters, while the biggest arch had the diameter of 104 Roman feet, i.e. 30.83 meters, and the fourth one – only 53 feet, i.e. 15.71 meters. (Fig.10). These measures would be perfectly congruent with those surveyed. The collapse of the second pylon, documented already in the Renaissance, together with the fact that the presence of rostral pylons were also documented, strengthens the hypothesis of the river Nera having originally been much narrower, reaching only the second arch. This would justify the erection of only one central arch. Following major geological modifications the bed of the river could have enlarged so that the second pylon came to be significantly lowered and exposed to the constant wear because of the currents – often rapid – of the Nera river. When the new riverbed stabilized, the need might have been felt to open another arch to guarantee the continuity of passage of the left bank and also to ensure and increased flow of water when the river was seriously flooded. The results of the study of the slope of the viaduct made it possible to put forward a hypothesis intermediary to that calculated by Eng. Riccardi in 1837 (objectively too steep for vehicles) and the one redesigned by Cecchi in 2003, incompatible in relation to Narni and, as to its extension towards the Terni valley and the cave, placed too high. While extracting information from these models, we did not limit our interest to the geometries of the whole work but tried to approach the detail as close as possible

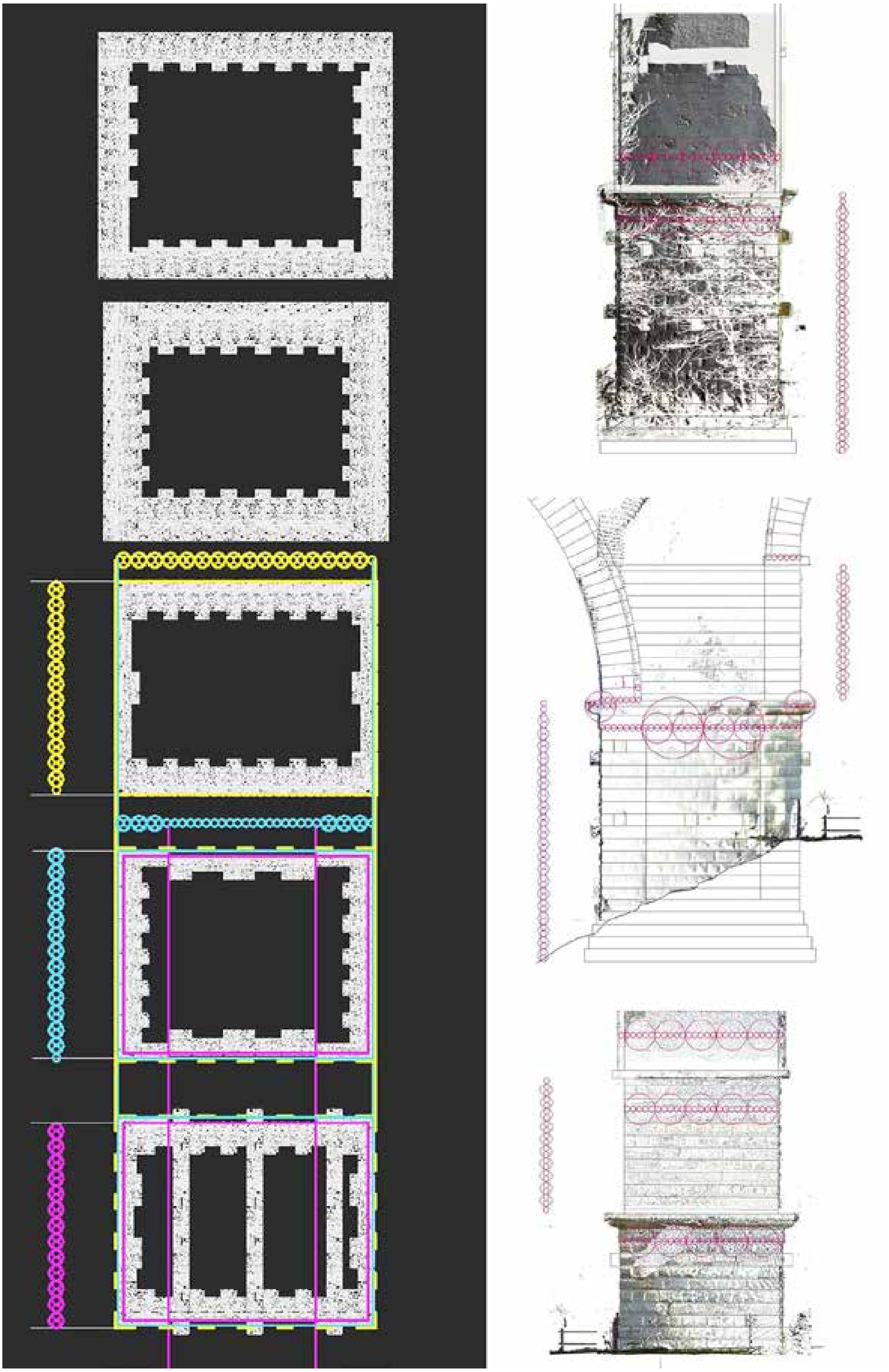


Figure 5. Analysis of ashlars of the first pylon in relation to filars modelled in a parametric environment and a discontinuous model: a) the river part, b) the mountain part, c) the road part.

and study directly the construction apparatus. As mentioned, already at first visual enquiries we have observed substantial differences between the first and the second span of the bridge: the first rounded arch has a constant intrados, just like the second and the third ones as the ruins and the iconographic apparatus at our disposal seems to reveal. The ruins of the fourth arch are completely different, the arch having been endowed with a non-constant intrados constituted by five reinforcement rings. This construction technique ensures equal structural value while cutting back on materials. This methodology prompted a hypothesis of the fourth arch having been modified in relation to the original design or constructed later than the others. Likewise, the support pylon of this arch has been found different, first of all by the first one - upstream and downstream - has frames and is generally narrower, 9.50 x 7.50 m. The third pylon is regular, has no frames and measures 9.90 x 8.00 m in section.

Also, this factor made us think that the structure was remade at a time later than its construction. Oddly enough, the second pylon has more aspects in common with the third one than with the second one: there are no frames and could have been regarded as regular in section measuring 9.90 x 7.50 m if it were not for some alterations at the base that make it reach the cross-section measurement of 9.90 x 8.00 m. The quoted data seem to support our hypothesis that the last arch was modified in time or was built after the others. Looking for the original form of a bridge with three arches when the first and the third one are reduced and the second one considerably larger, makes one seek a construction motivation that cannot be found in the composition rhythm A-B-A, but that would be functionally compatible with the environment of the bridge. It is not groundless to think, for example, that the river similar at the epoch when the bridge was constructed as it is today, and with the bed so much reduced in width, that it could pass easily through the span of the second arch.

The data acquired with the laser scanner made it possible to obtain not only the main general measures of the ruins of the pylon but also the minute details of masonry equipment. The study of construction equipment did not finish with the analysis of surfaces. Thanks to the condition of the second pylon, broken into three parts after it collapsed, we could have no uncertainties as to its structure and the technique of assembling and fixing stone blocks. So, the bridge is a robust example of rubble masonry with lateral surfaces in opus quadratum, with ashlars and wedges rusticated in local travertine while the toothing between blocks is effected with metal staples and the internal nucleus is made of concrete composed of lime, sand, pebbles and travertine chips. We have deduced from our analyses that there were rigid rules regarding the cutting and assembling blocks of stone. Each part is 2 Roman feet (59.3 cm) tall and they are arranged in the way that alternates the cuts (always in two modules) to obtain a square block 2 x 2 m. The fascia is of variable dimensions, but always conforms to the unit of measure. Evidently this rigidity in assembling stone blocks was respected particularly with the first pylon and not with the third one which was erected later on and is composed of reused blocks, which can be gathered from the signs on the blocks used to raise ones that are completely out of measure with the last pylon (Fig. 5).

In order to present the highest possible level of knowledge acquired so far, the decision was made to model the structure of the bridge by means of a parametric modeler, thus creating families that would evince precise characteristics imposed on the basis of rigid geometric and measuring rules identified to date (Fig. 6)

The application of this methodology generated a model in the way much similar to the proper construction of the bridge at the building site, creating blocks and filars one by one, all in the optimized way due to the fact that the blocks were adjusted to the imposed binds as well as to the possibility of generating cascading modifications starting with but one unique parametric variation (Fig. 7).

The construction principle of the pylon is developed starting from the regular monolithic volume of 33 feet + 1/3 (in Fig. 5, the measurement in yellow) equivalent to 9.90 m as measured immediately under the springer of the arch, which we invariably find in the third pylon. From these fundamental measure volumes, multiples of 1/3 of a Roman foot are subtracted. The frame plane (in cyan in Fig. 5) is placed at the distance of 1/3 of the upper one while the plane at the back (in magenta in Fig. 5) – at the distance of 2/3 from the one preceding it. Thus, we arrive at the minimum measure of 32 feet + 1/3 equivalent to 9.60 m. Finally, there are the basement filars that reach up to 1/3 of the Roman foot in thickness descending

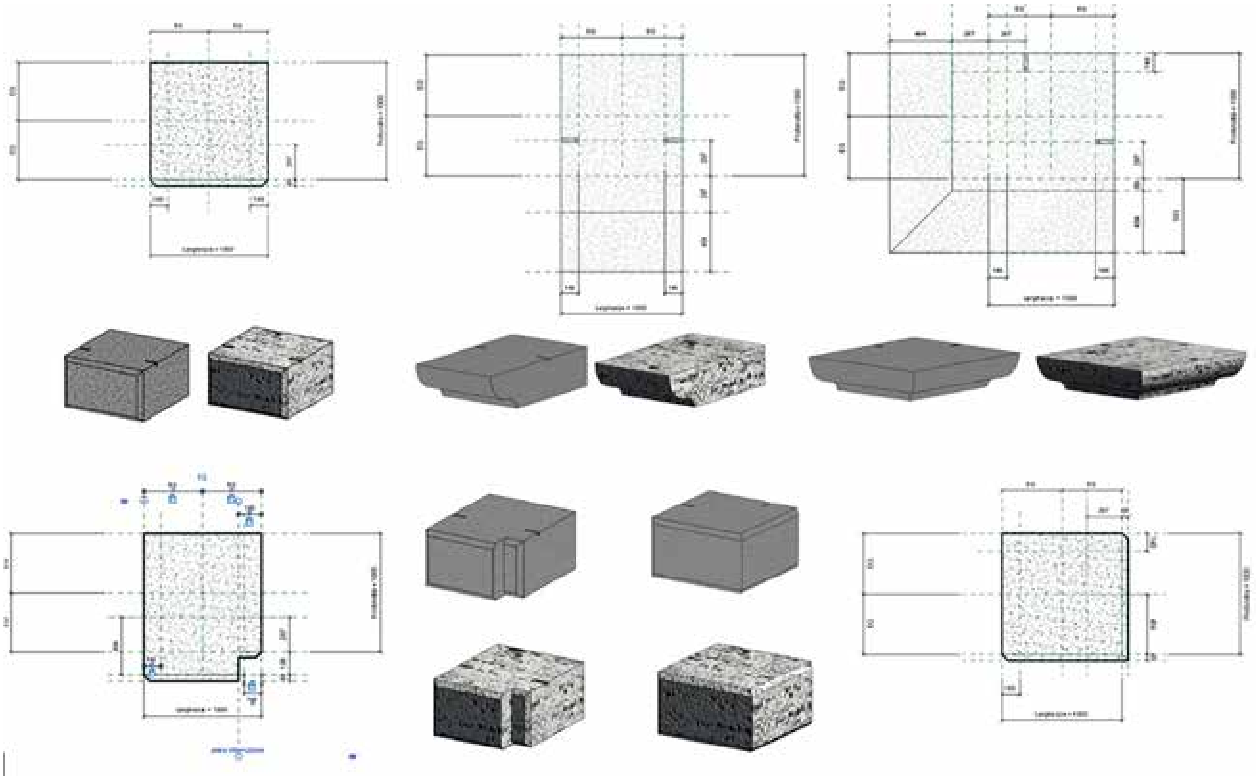


Figure 6. Creation of parametric families to form ashlars.

to the ground. In view of this evidence, the two pylons at the ends seem less different. Starting from an architectural project based on precise volumes and dimensions, the first pillar changes its volume according to the architectural logics just described, the third remains constant.The second is the pylon for which a number of disparate hypotheses were generated since has a constant pedestal at the base which makes us think that it was precisely the basement level. Yet it has been discovered at a certain distance from the springer of the arch that is shorter that the one of the first pylon. This is precisely why so many scholars have supported the hypothesis that springers were misaligned and the arch is not a rounded one. Nevertheless, it can be maintained with high degree of certainty that the arrangement of the blocks is similar to that of the third pylon and that it was erected later on. Moreover, we know that after the bridge had collapsed in 1053, a wooden gangway was built on the stone bridge to make it crossable. Thus, a hypothesis was put forward that when the terrain subsided, the second pylon was adjusted to allow the construction of the temporary wooden bridge. The structure of the pedestal has holes aligned with those of the first pylon, used to fasten the bar of the bow construction. This may lead to the idea that the two pylons were built in the same period, but the blocks are arranged in a completely different way (Figure 8).

It is also worth noting the presence of holes for the wooden provisional works on the right side of the third pylon and on the left abutment. If this technique had been used in the second arch to not engage the wooden works with the river water, it is also possible to think that the same technique could have been used for the construction of the fourth arch, during a period when the water level was much higher. The absence of housing holes in the first and third arches supports the hypothesis that these would have been built on a ground surface that was not submerged at the time (Fig. 9).

Results and Conclusions

This study proposes two hypotheses regarding the original shape of the Augustus Bridge: the first one – with four arches, for which the fourth outcome of original construction work established the rhythm of A-B-A-C (where the measures of A and C close to each other); and the second form with only three

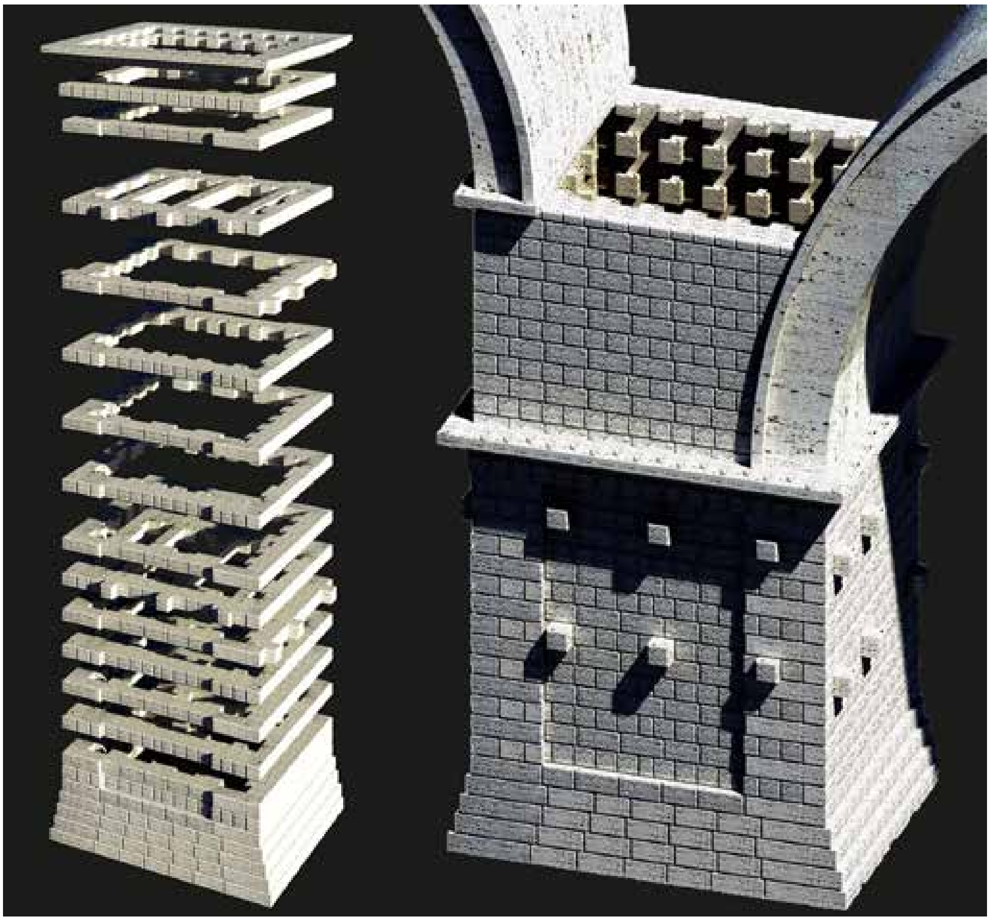


Figure 7. Model construction in a digital building site.

arches. For both the reconstructions, it has been established that the first and the third arches are identical with respect to the construction technique applied and to their dimensions, which had the advantage having the same ribs used at the worksite. The span of the second arch (the biggest one) can be explained by the necessity to span the river with a narrowed bed. Moreover, the distance between the springer line of the smaller arches and the keystone corresponds to the fundamental measure of the pylons - 33 + 1/3 roman feet. It was also observed that the distance between the springer of the first arch and that of the second one has exactly twice as big as that of the third arch.

The smaller arches are endowed with radial blocks of 3 degrees, as compared with two degrees of the bigger arch. According to our hypothesis, the slanting of the bridge is caused by the unity of the keystones in the first and the second arch and measures exactly 2 degrees in horizontal plane. The keystone of the third arch was not take into consideration in these calculation as it is positioned according to a measure derived from the first one. The hypothesis as to the construction of the bridge is that the two pylons must have been much similar as to their construction. (Fig.10)

The present study demonstrates that ruins of and ancient bridge frequently constitute strategic evidence of an environment which can evolve considerably with the passage of time. An ancient bridge, especially when it links two river banks, is often an object difficult to survey because of the specific nature of the environment into which it is immersed. Our research group was especially interested in ancient Roman bridges in order to identify a methodological procedure for the purpose of achieving homogeneous results and ensuring a comparative reading of these structures, keeping in mind their historical, architectonic and geographic differences. The ultimate objective was the analysis, preservation and promotion of cultural heritage starting with the initial design of the work, considering the labour organization at the building site from the beginning until the completion of the work of architecture.

Figure 8. Holes in first and second pylon.

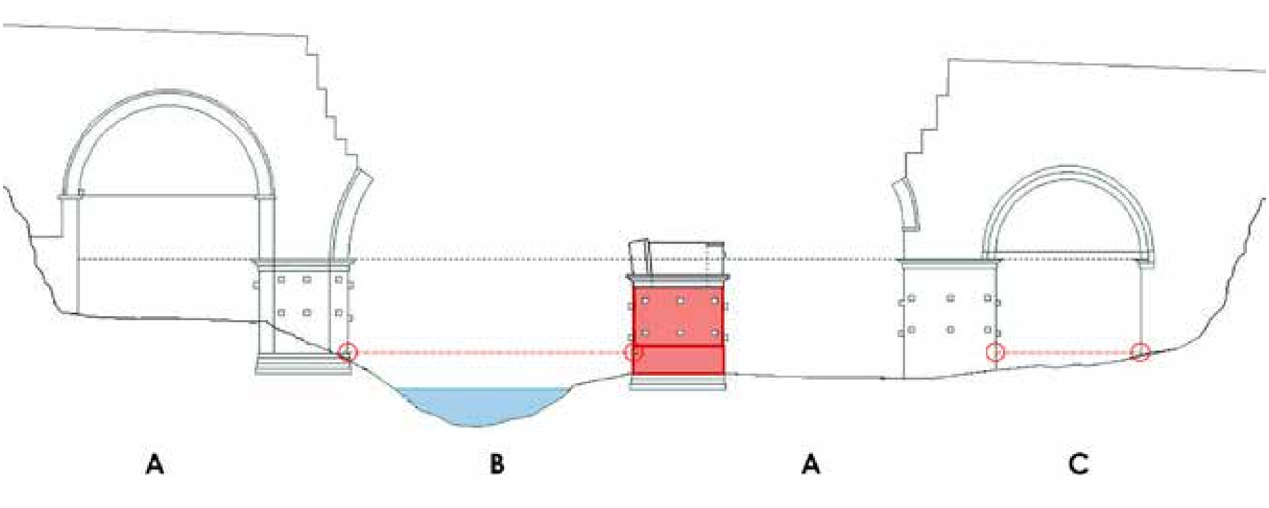


Figure 9. Alignment of holes for fixing wooden ribs demonstrates the corresponding misalignment of the two springers in the second arch.

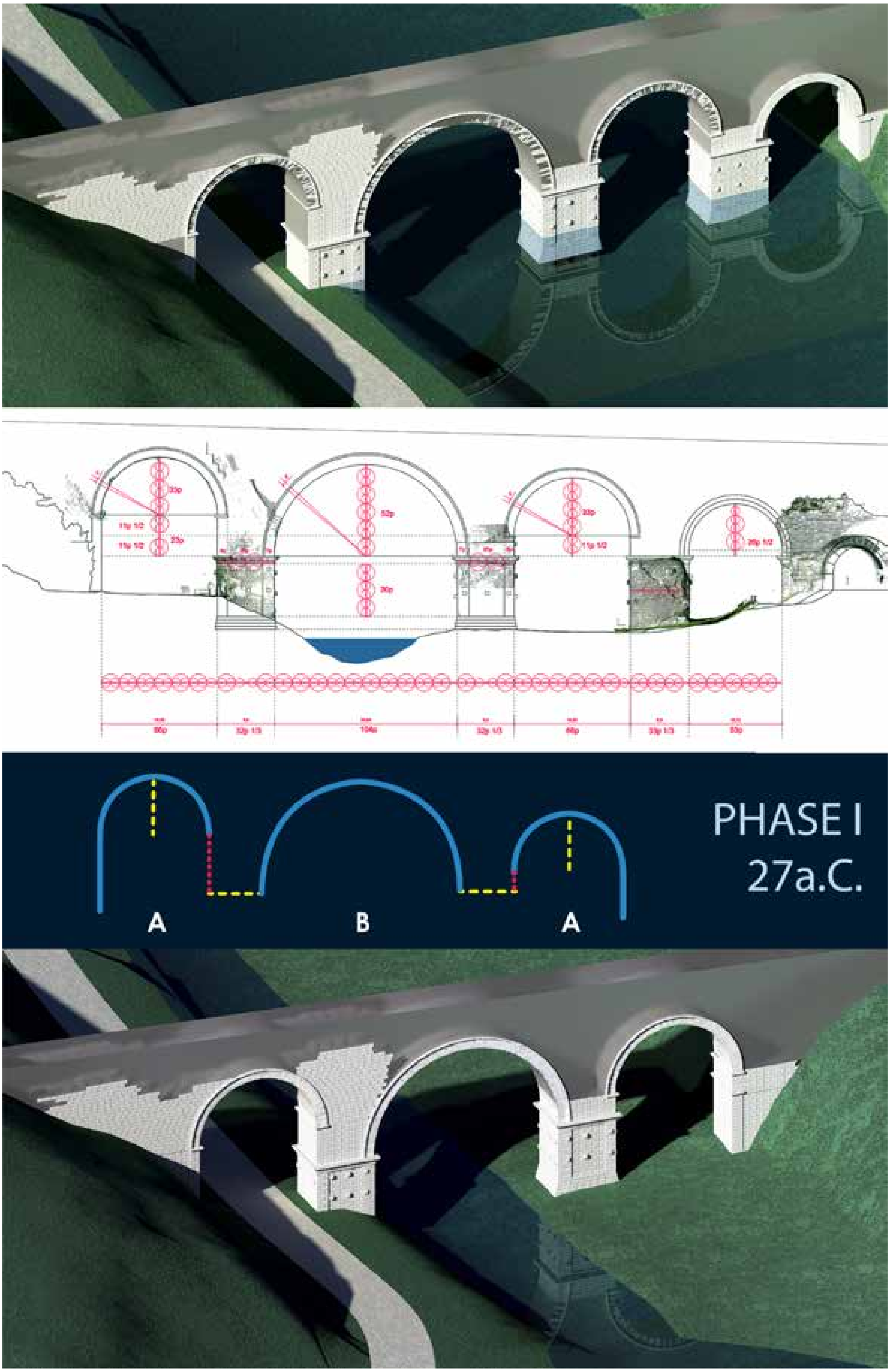


Figure10. Hypothetical reconstruction using the base point cloud. Proportioning and metric analysis in roman feet. Original form of with four and three arches.

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