ANCIENT AND MODERN RESTORATIONS
ON THE COLUMN OF MARCUS AURELIUS

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ABSTRACT

In 1589, on the occasion of a complex intervention on the Column of Marcus Aurelius, Domenico Fontana reconstructed an entire corner of the abacus resorting to a wise joint of blocks whose stability was simply guaranteed by their shape. The same corner was over again restored, in 1987, by Antonino Giuffrè because it was feared that the decay and fracturing of the material inserted during the sixteenth-century intervention could compromise the safety of the abacus.

Despite the seemingly unbridgeable distance that separates them, the two restorations share an undeniable affinity of method in which an essential role is played by the need not only of recovering the cultural and technical continuity with the historical architecture but also of correlating the different specialist contributions available within a unified approach. With respect to the latter aspect, both restorations discussed in this work constitute a suggestion for the current culture that, breathlessly running after the detail, often risks to lose sight of the entirety.

KEYWORDS

Column, abacus, mechanics, architecture, restoration.
INTRODUCTION

A drawing by Giovanni Antonio Dosio dated 1569 (Hülsen, 1921) depicts the Column of Marcus Aurelius as it appeared in the second half of the sixteenth century (Figure 1): there were vertical cracks all along the shaft of the column, a big fragment in the upper part was missing, the stylobate – six metres of which buried under ground, as from when it was first built in AD 193 – was in a precarious state, an entire corner of the abacus of the capital, facing the Pantheon, was broken.

Domenico Fontana, who was appointed by Sixtus V to restore the column, wrote that those who gazed at it were frightened¹ (Fontana, 1590) to the point that it was feared that the column was about to collapse (“stava per ruinare”) (ASV, 1984).

In a completely different condition was Trajan’s Column, built more than a century earlier, and still today practically intact, with the exception of some minor chips and a rare crack here and there.

It is precisely the comparison between the two columns that makes it difficult to give credit to Domenico Fontana when he claims that the Column of Marcus Aurelius was reduced to the precarious conditions it appeared in sixteenth-century prints because it had been burnt (“abrugiata”) by barbarians, ruthless (and unbiased) destroyers of Egyptian obelisks who had inexplicably vented their rage on only one of two columnae cochlides, leaving Trajan’s column undamaged. Neither could the damage be explained by earthquakes, although not uncommon on Roman soil, and in some cases, particularly violent, like the one of 1349 (Giuffrè, 1988). Perhaps an earthquake could have knocked down the second attic block and the bronze statue of the emperor above it, and as it fell it might have damaged the abacus; but it is difficult to think that earthquakes could have produced the cracks and missing chunks along the shaft, unless the column had already been somehow weakened, by being struck by lightning for example – which, on similar structures (obelisks, bell-towers, chimneys), produces vertical fractures similar to those seen in sixteenth century prints (Giuffrè, 1994).

¹ [la “colonna Antonina, ... parte per l'antichità, e parte per essere stata abrugiata da Barbari, ... in molti luoghi stava aperta, e crepata, e in molti luoghi vi mancavano pezzi di marmo grandissimi, a tale che spaventava chi la rimirava ...” / the “Antonine column ... partly because of its age and partly because of the ravages of barbarians ... was broken and cracked in many places, and in many places very large pieces of marble were missing, to the extent that those who gazed at it were frightened ...”].
Whatever the origins of the alarming conditions it was in at the end of the sixteenth century, the fact that the Column of Marcus Aurelius has survived intact to this day, along with Trajan’s Column, is certainly due to the timely intervention of Domenico Fontana, who dealt with every part of the monument – the stylobate, the shaft, the attic – even reconstructing, with a complex operation, the missing corner of the abacus using ancient marbles taken from Severan Septizonium that Sixtus V had dismantled three years previously.

Four centuries later, in the early nineteen eighties, in a new climate of interest for the seismic safety of the great Roman monuments, the appearance of new cracks in the column and the ancient damage that was re-emerging led the Soprintendenza Archeologica di Roma to undertake an in-depth study, resulting in a new static intervention to restore the abacus.

This paper gives a summary of the studies conducted on the stability of the top part of the Column of Marcus Aurelius, as a result of which, beginning with a thorough analysis of the sixteenth-century restoration ordered by Sixtus V, a new repair project was designed to consolidate the abacus, respecting not only static and constructive nature of the column but also the methodological approach on which Domenico Fontana based his extraordinary intervention (Giuffrè and Martines, 1989; Masiani and Tocci, 2010).

DOMENICO FONTANA’S RESTORATION

The sixteenth century work site

When Fontana undertook the task of consolidating the two columnae cochlides in 1589, the static conditions of the Column of Marcus Aurelius were alarming and the interventions he carried out concerned the whole monument. He reshaped the stylobate, lining it with new marble plates and opening up a new entrance to the internal spiral staircase. He repaired the gaps and cracks in the shaft with pieces of marble and fastened them with metal clamps. He pushed back in the parts of marble that jutted out, using a system of levers and winches, and had them chiselled. Finally he reconstructed the missing corner of the abacus.
All rather technically demanding operations requiring a well managed work site. We can in some way imagine what machinery and equipment was used – by analogy with those meticulously illustrated in the book celebrating the movement of the Vatican Obelisk (Fontana, 1590) – on the basis of a description in the abovementioned *Libro di tutta la spesa* (ASV, 1984), a concise list of materials, quantities and tools used for the two columns, something like what we would now call an itemised estimate.

Speaking of the work carried out on two *columnae* for Sixtus V, Domenico Fontana says that placing the statue of St. Peter on top of Trajan's Column had been an undertaking of some difficulty but the Antonine Column presented a far greater difficulty because, unlike Trajan’s Column, where lifting machines were placed directly on top of the capital, the restoration of the Column of Marcus Aurelius required the construction of a scaffold or – to use a term still in use until the middle of the nineteenth century – a *castello* that rose right to the top of the column.

The *castello* was used not only as a platform (in this sense it was similar to scaffolding), to reach any part of the shaft to carry out restoration work, but also as a support for winches to lift the marble blocks for the restoration of the abacus and to re-insert the broken parts of the drum jutting out of the shaft of the column.

For the *castello* and lifting machinery Fontana reused tools and materials (the so called "munizioni") from other work sites, especially the Palace of St John in Lateran and the Basilica of St Peter, following a practice that was usual at that time (Marconi, 2004), based on renting – more rarely buying – and justified by the difficulty of finding materials and the high cost of both timber for scaffolding and metal for construction equipment (the custom of loaning munizioni from the Reverenda Fabbrica of St. Peter's to other work sites started at the beginning of the sixteenth century and, towards the end of the century, was extended to other buildings where they were sold as well as loaned out).

The Lateran provided winches, pulleys, hemp ropes, metal tools and other things deemed necessary for the column ("argani e traglie, canapi, curli, ferramenti et altre cose necessarie per detto edifitio stimato" (ASV, 1984)) (Figure 2), while the use of materials from St. Peter's can be seen from the extraordinary similarity of the temporary structures that had been used to move the obelisk with those used for the restoration of the column.
The uprights ("antennae") of the support structure used to move the Vatican Obelisk (Figure 3) each consisted of four chestnut wooden beams (70 palms long by $2\frac{1}{4}$ palms squared: 1 palm = 22.34 cm), linked at intervals of about 12 palms by nailed metal strips and tied with ropes between one strip and another. Resulting antennae (123 palms long – about 28m – by $4\frac{1}{2}$ palms square – almost 1m) were then braced by horizontal beams arranged horizontally ("telari") and diagonally ("traverse") to create a rigid truss structure. The obelisk was connected to this structure by means of a complex system of pulleys that were attached to the shaft of the monolith, which was protected by wooden planks and ropes held together by metal bands (Fontana, 1590).

It would seem, from a reading of the Libro di tutta la spesa, that there is little doubt that the strong pieces of timber used to erect the obelisk were reused for the restoration of the column, and were joined together and braced in the same way ("per la fattura del castello attorno detta colonna per 4 faccie con suoi telari traverse inchiodate e ligate con 6 colonne di 2 travi grossi l’una, con haverli accomodato li cerchi di ferro attorno dette colonne di legnio per sicurezza inchiavate con le chiavi di ferro e ligate con le corde quale anno servito per lavorare e tirare li sassi dove s’è restaurata la detta colonna, quel castello era alto dalla cima della statua del S. Paolo sino in fondo canne 23, con haverli fatto un telaro di travi grossi sotto terra dove posava sopra il detto castello stimato") (ASV, 1984); "per haver fatto li ponti di piano in piano dove a bisognato tassellare detta colonna, tanto per li tasselli quanto per la scolitura, di palmi 8 di altezza l’un dall’altro, in tutto il detto castello ce ne sonno di 23" (ASV, 1984).

The difference, as we can see, is that the antennae of the column’s castello were made by assembling two (not four) beams, since they would be subject to less static stress, arranged in two rows of three (instead of three rows of four) on each side of the column; they were higher (about 50 m) and had platforms from where the column could be reached and restored.

The same system used to support the obelisk was re-employed to work on the three drums that needed to be reinserted into the shaft of the column ("per la manifattura di haver fatto fare 3 cerchi de fer-

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2 ["the scaffolding around this column had 4 sides and, for each of them, there were 6 columns, consisting of 2 large beams each, braced horizontally and diagonally; iron rings were placed around these wooden columns to make them safe and ropes were used to pull blocks of stone up to where the column needed repairing; the height of the scaffolding from the top of the statue of S. Paul to the bottom was 23 canne; the scaffolding stood on a frame of large beams sunk underground"). 1 canna = 10 palms = 2.234 m.

3 ["there were platforms at different levels to fix the column, at a height of 8 palms from each other, the scaffolding holding a total of 23 altogether"].
ro grossi delli ferri che havevano servito alla guglia fatti per mettere attorno alla colonna in più pezzi l’uno per tener stretto e forte la colonna mentre si lavorava attorno acciò non si aprisse in fora, qual ferri furno messi et inzeppati con zeppe di legnio e filarcie di corde sotto, acciò non guastassero la scultura di detta colonna quali furno levati e rimessi 2 volte secondo che si andava insù e sempre raccomandati nel medesmo modo⁴ (ASV, 1984)).

Finally, a gantry was placed on top of the *castello* to lift first the large blocks for the restoration of the abacus and then the bronze statue of St. Paul (“la capra in cima detta colonna di travi doppi di palmi 45, con haver puntellato al piè di detta capra al capitello e fattoci un telaro di travi inchiodato e ligato perché il capitello non patisse quando verrà addosso il peso della statua perché era tutto crepato …”⁵ (ASV, 1984)).

The *castello*’s two abovementioned functions had different dimensional requirements: slim wooden scaffolding would have been enough for the platforms but the need to create a support for winches clearly required a more robust structure.

To lift the pieces for the restoration of the abacus and to reinsert the dislocated parts of the shaft, the column itself could be used as a counterbalance: in the first case a gantry could be placed on the sound part of the capital, in the second case the ropes of the winches could be anchored on the two drums adjacent to the one to be restored from the side diametrically opposite the portion to be reinserted. In both cases, the *castello* would therefore not be required to withstand significant horizontal forces – as would have been the case to move the Vatican Obelisk – but only vertical compressions due to the deviation of the ropes being pulled down to the winches tied to the ground.

We can take a very rough guess about the amount of compression involved. This was undoubtedly associated with the portions of drum to be reinserted and not the blocks to be lifted to the abacus.

The largest piece to be lifted up to the height of the abacus weighed no more than two and a half tons (see below), and so just one of the winches that Domenico Fontana had used for the Vatican Obel-

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⁴ [“3 large iron rings, made with the metal used for the obelisk, were put around the column to strengthen it and hold it in place while work was carried out, placing wooden wedges as well as ropes under them so as not to damage the column; they were removed and replaced twice, in the same way, as the work went up in the higher parts of the column”].

⁵ [“a gantry was placed on top of the column made of double beams and measuring 45 palms; a wooden frame was made so that the capital would not be damaged when the statue was placed on top, because it was all cracked”].
lisk would have been more than enough, since, as Fontana himself tells us, it could handle about 7 tons (Fontana, 1590).

The load bearing capacity of the winches was evidently limited by the strength of the ropes (or hemp ropes) and the efficiency of the pulleys from which they were made. As regards the former, Nicola Zabaglia, a great builder of castelli in Baroque Rome (Marino, 2008), just a few decades after Fontana, states that the thick hemp ropes (canapi grossi), i.e. those with a diameter of three ounces (about 5.6 cm), had a capacity of about 6000 pounds (just over 2.0 tons). Such a figure is basically in line with what was reported half a century later by Rondelet, in his famous treatise (Rondelet, 1831), on 2-inch hemp ropes (about 5.4 cm) and also with the figures quoted by Donghi (Donghi, 1925) early last century (which gives an admissible stress of 100 kg/cm², slightly lower than the 120 kg/cm² indicated by Rondelet). Rondelet also gives us precise information on the efficiency of assemblages of pulleys, the Vitruvian polispastos, which were used in winches. Compared to the theoretical reductions that can be achieved by the multiple returns of pulleys, which could also bear up to eight times the load, because of friction – particularly where the rope touches the pulley, and greatly increased by any deviation of the ropes – the actual reduction would come to a ratio of roughly 1/3. Putting these results together we get capacities comparable with the 7 tons indicated by Domenico Fontana.

If the rope attached to the lifting machine at the top of the capital, passing through a first system of pulleys, came down vertically along the castello to then follow a horizontal path to the winches, passing through a second system of pulleys at the base of the castello itself, the antennae would have to support only the weight acting on the rope which, based on the bearing capacities mentioned above, could be no more than one third of the weight of the blocks (let say, less than one tonne) and, therefore, a weight that was essentially irrelevant. Furthermore, some marks on the marble of the first drum of the attic remind us of the antennae of a crane whose stabilization ropes ("venti") could well have been anchored to the abacus itself: which, even with the missing corner, weighs about 65t and could well have acted as a counterweight to the 2.5 tonnes of the piece to be lifted (less than 4% of the weight of the abacus).

A greater challenge, and for us somewhat more difficult to assess, was the reinsertion of the parts of the drum that jutted out from the column. This concerned three drums, as we learn from the pay-
ment requested by Fontana for having pushed back, with the winch, pieces of marble that jutted out in three points along the shaft ("per haver tirato dentro il marmo che avanzava fuora in 3 lochi e tirati dentro con l’argano, longhi ogniuno di detti pezzi palmi 7 per di dentro, e fuora in circa palmi 9, alti palmi 7 l’uno, grossi $2\frac{3}{4}$ quali erano usciti fuora del dritto della colonna palmi $1\frac{1}{2}$ …" (ASV, 1984)). The three parts that needed to be reinserted protruded from the shaft of the column by about 34 cm, affecting the full height of the corresponding drum (about 1.56 m), the full thickness (0.60 m) and a width of about 2 m, as measured on the outside of the shaft.

Even assuming that the friction produced in reinserting these pieces only involved the weight of the upper parts of the column vertically aligned with the displaced portion (and not the weight of the whole upper part), and considering the portion placed at the height of the eleventh drum, the weight would be more than 70 tonnes, which would require at least ten of the winches that Fontana had used for the obelisk. Although it is a figure that could have been handled by the *castello* that was built (a single $50\text{cm}^2$ *antenna* would have to support less than 30 kg/cm$^2$), it is still quite demanding from the viewpoint of the work site management and explains why, in some cases, Fontana was unable to completely reinsert some dislocated portions and had to cut them to shape to make them even with the shaft.

In any case, these simple estimates show that the problems Domenico Fontana had to face in the restoration of the Column of Marcus Aurelius were far broader than those traditionally considered part of an architect’s job. They introduce the issue, which we will briefly discuss below, of the problematic relationship between mechanics and architecture, "a clash between the worlds of knowledge and philosophy of art" (Curcio, 2003), which clearly emerges – perhaps one of the first examples in history – in the work of Domenico Fontana.

*The reconstruction of the missing corner of the abacus*

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6 ["for having pushed back the pieces of marble that jutted out in three points, pushing them in with the winch, each of these pieces being 7 palms long on the inside, and about 9 palms on the outside, 7 palms tall, and $2\frac{3}{4}$ thick, which jutted out from the straight line of the column by $1\frac{1}{2}$ palms …"]"
The south-west corner of the abacus may have been broken, perhaps during an earthquake, by the fall of the second attic block and the bronze statue of the emperor, which had taken with it the protruding part of the platform on which it stood, also chipping the *ovoli* of the echinus.

Thus the restoration of the column involved the need for restoring the band of the ovoli and the corner of the abacus where it jutted out most.

From archival documents we learn that Fontana used three large blocks of marble, taken from the ruins of *Septizonium*. Thanks to the survey carried out for the twentieth century restoration (see below), after removing the marble slabs on the abacus platform and the underlying light screed filling, it was possible to reconstruct the shape and arrangement of the three large blocks, and of a fourth of smaller size (Figures 4-7).

The first of the three large blocks was placed at the height of the ovoli of the echinus. It is a great truncated wedge, weighing about one and a half tonnes, which fitted into a cavity cut into the shaft of the column as far as the internal staircase (a “pezzo di marmo grande che fa l’ovolo del capitello di detta colonna qual piglia tutta la grossezza della sponda della colonna e passa da una banda all’altra”\(^7\) (ASV, 1984)). The two horizontal surfaces are flat and parallel. The small side is visible on the inner wall of the staircase and has the same concavity; the ornamental design of the three ovoli was reproduced on the large side, visible on the outside; the projecting part acted as a support for the two overlying blocks.

The two upper blocks have a more complex and articulated shape, almost symmetrical with the diagonal of the abacus (“2 pezzi de marmi messi intorno al cantone verso la ritonda del capitello detto longhi insieme palmi 12\(^{1/4}\) larghi palmi 10\(^{3/4}\) in tutto alti palmi 3\(^{1/6}\)\(^{8}\) (ASV, 1984)). They were placed next to each other on a vertical plane along this diagonal and reconstituted the part that was missing, from the outer edge to the edge of the attic. They rest not only on the overhanging shelf below but also on two recesses hollowed out in the ancient marble, as far as the dome underneath the bronze statue of

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\(^7\) [a “large piece of marble for the ovolo of the capital of the column with the same thickness as the side of the column and extends from one band to the other”].

\(^8\) [“2 pieces of marble placed around the corner of the capital, facing the Pantheon, which together were 12\(^{1/4}\) palms long, 10\(^{3/4}\) palms wide and 3\(^{1/6}\) palms high”].
St. Paul ("dentro la cupoletta che regie il S. Paulo"\textsuperscript{9} (ASV, 1984)), to a depth equal to half the original thickness and a length which reaches nearly to the midline of the square of the abacus. This arrangement allowed the two biggest blocks used for the restoration of the abacus to be partly wedged below the drums of the attic.

The block used to restore the west side of the abacus is the largest; it weighs about two and a half tons, and is wedged between the niche hollowed out in the ancient marble and the lower surface of the first drum of the attic. The block used to restore the south side, considerably smaller (about one and a half tons), is simply placed on the niche of the abacus and counterbalanced by the drum of the attic through two small pieces of marble. Both blocks are chiselled out where they jut out from their respective recesses to a depth of four fifths of the height of the abacus, so that the protruding part is much lighter than the part resting on the recesses since it consists only of the thin side edges of the two blocks and the slab that makes up the lower level (the new marble was “scarnato fuora per aligerirlo acciò desse manco peso alla cantonata”\textsuperscript{10} (ASV, 1984)).

The hole made to lighten the structure was later filled with light material and covered with thin slabs of marble to restore the platform. Similar considerations apply to the fourth smaller element of the Sistine restoration (weighing about half a tonne), shaped so that the part resting on the overhang is thinner and lighter than that resting on the recess.

The large blocks are shaped so that they can support themselves stably just by their own weight, and this also avoids the need for a temporary support structure during the delicate assembly phase. The long metal bars, placed parallel to the sides of the square on the extrados of the abacus, and which from the outside appear to support the two biggest blocks, are really just there as an extra precaution – as also the dovetail pattern of the vertical joints of the recesses between the large blocks and the ancient pieces, or the numerous metal clamps between the marble inserts – called into play only in exceptional circumstances (such as an earthquake).

\textsuperscript{9} ["inside the small dome that holds St. Paul"].
\textsuperscript{10} ["chiselled out on the outside to make it lighter so that there would be less weight on the corner"].
The sequence in which the blocks were assembled is quite clear. At first the broken surfaces were smoothed over, then the two support recesses were cut into the marble abacus, the ruined part of the echinus was removed, and a cavity was hollowed out in the band of ovoli.

After the lower shelf had been put into place, completely wedged into the shaft, the first of two big upper blocks to be placed was the one on the west side which, having to be wedged between the recess cut into the ancient marble and the lower surface of the first attic drum, needed enough space to be moved. The south side block was fitted in afterwards. It is not as high as the abacus so it could be more easily fitted below the attic, where it is counterbalanced by two smaller elements, and a large inclined metal bar could be used to join, more or less radially, the two large pieces (the upper part of the bar, which emerges from the platform, is pinned to the piece on the west side, covered by mortar fill and then hooked on the outside of the piece on the south side, about half way up, where there is the horizontal flute of the large letter "P" which Sixtus V had engraved on the facade). Then the fourth long thin piece that forms the edge of the abacus was placed on the third block, thus completing the restoration of the abacus on the south side. An eloquent indication of this sequence is the coarse bed of broken tiles and mortar placed between the south block and the shelf below, evidently imposed by the need to align it with the pieces already in place.

Domenico Fontana, therefore, in one neat operation – based simply on shaping and fitting the new marble inserts into the ancient marble of the column – resolved the architectural problem of restoring the appearance of the column, the static problem of the stability of the abacus, and the technical problem of actually carrying out the intervention.

As regards the damaged band of ovoli, he did not try to restore them but decided to completely remove the damaged area of echinus and replace it with a full-thickness insert, which also acted as a support for the blocks above. Meanwhile, the shape given to these and the seat where they rest – the former hollowed out beyond the supporting recesses to shift the centre of gravity, the latter cut into the marble as far as the first drum of the attic so that new pieces could be partly wedged in – not only ensures the stability of the reinstated part but also guarantees construction site safety and facilitates intervention operations.
A brief digression on the problem of mechanics

To verify the balance of his complex assembly of blocks Fontana could, by analogy, make use of the lever model, an ancient mechanical device but still used throughout the eighteenth century to verify, for example, arch structures. Archimedes’ solution to the problem of the lever was well-known; Leon Battista Alberti quoted it in his treatise (Alberti, 1485), and Fontana no doubt was able to apply it to verify the stability of the abacus.

But perhaps he used something much more recent than Alberti’s point of reference, and certainly more up to date.

Heir of a pragmatic approach to architecture, perhaps modelled on the tradition of the great Gothic builders, like all Lombards (he was born in Melide in Canton Ticino, in 1543 and died in Naples in 1607), and, in his case, supported by an exceptional inventiveness, Domenico Fontana also had a good knowledge of the theoretical aspects of his activities and the restoration of the Column of Marcus Aurelius provides eloquent proof of his interest in the more specialized developments of the art of construction.

There is documentation regarding his relations with Filippo Pigafetta from Vicenza – a tireless traveller and prolific author, interested in mechanics and its application to the art of war – who had translated into Italian, in 1581, Guidobaldo Dal Monte’s Mechanicorum Liber, first published in Pesaro, in Latin, and considered one of the first and most important books on applied mechanics of the modern era (Dal Monte, 1581). Pigafetta was in Rome in the years of the famous undertaking to move the Vatican Obelisk, and supported the young Fontana, publishing in 1586 the Discorso intorno alla historia della Guglia, a learned preamble to the undertaking that Sixtus V was about to begin (Dolza, 2008).

It may reasonably be assumed, then, that Fontana knew Guidobaldo Dal Monte’s Mechaniche. Some of the machines described in that book (scales, hoists, wedges) may have enabled him to rationally and facilitate work-site operations. But Fontana probably also drew inspiration from the Mechaniche to fine tune and effect procedures for verifying the balance of the blocks used to restore the abacus.
The *Mechaniche* may have suggested to him a simple system for determining the centre of gravity of the restoration blocks (and the consequent calibration of the holes to be made to lighten the structure) based on the lifting of the blocks themselves. In fact, if the centre of gravity of a block is to be located along a given line, it is sufficient to ensure that no rotation is produced when the block is lifted along this line. And it is precisely on the basis of a rotation equilibrium condition that Guidobaldo Dal Monte defines the centre of gravity: “il centro della gravezza di ciascun corpo è un certo punto posto dentro, dal quale se con la imaginatione si intende esservi appeso il grave, mentre è portato sta fermo, & mantiene quel sito, che egli havea da principio, né in quel portamento si va rivolgendo”\(^{11}\) (Dal Monte, 1581).

The theoretical problem of balance is therefore linked to concrete work-site operations, and the mastery of these is essential for the practical implementation, or just the calibration, of a project. The genius of Domenico Fontana, once more confirmed in his restoration of the Column of Marcus Aurelius and the success of his extraordinary technical undertakings, seems solidly supported by a mechanical competence that is anything but superficial and based on in-depth knowledge of latest scientific texts of the period. In this sense, his work can be seen as a decisive step in a process, then in its infancy, whereby knowledge of statics became more and more intimately tied in to architectural projects.

Incidentally, but far from being marginal to the topic of our discussions, it is worth noting that Domenico Fontana’s extraordinary technical expertise, in fact, represented, in the eyes of his contemporaries, a kind of atonement for a deficiency of some sort. Well-known is the cutting, and certainly not disinterested, opinion of Giacomo Della Porta, with whom Fontana had worked between 1588 and 1590 on the dome of St. Peter: “il Cavaliere della guglia e Giovanni suo fratello non li piacciono per architetti, che sono bravissimi muratori”\(^{12}\) (Curcio et al., 1989).

However, it is this technical expertise, coupled with the brilliance of his insights, especially in the field of work site management, which earned him his undisputed success, legitimized by the same

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\(^{11}\) [“the centre of gravity of each body is a certain point inside it, and imagining that the body hangs from it, the body does not move about when carried and holds the position it had at the beginning”].

\(^{12}\) [“neither the Knight of the obelisk nor his brother Giovanni are much liked as architects, but as builders they are fine”].
successive treatises that were to place his famous machines next to those of Vitruvius (Scamozzi, 1615).

And although in his case perhaps talent prevailed over theory, as can be seen in the spectacular failure of an attempt to erect the column of Antoninus Pius in the Campo Marzio in 1704 by his descendant Carlo Fontana (Marino, 2008), what is nevertheless significant for us is his indubitable methodological concern to confer the attributes typical of science on work site management – as is evident in the well-known undertaking to move the Vatican Obelisk, when he set out to translate his ideas on construction site management into a sequence of replicable, and therefore communicable, operations (Fontana, 1590).

THE MODERN RESTORATION

Reasons for the new restoration

In the early nineteen eighties the top part of the monument appeared to be rapidly deteriorating, especially the corner of the abacus restored by Fontana. Just below the blackish patina produced by pollution, deep cracks, still developing, were clearly visible in the marble taken from the Septizonium. Other cracks could be seen in the original parts of the abacus: some evidently ancient cracks repaired by Fontana with iron claps that had rusted and swollen, causing additional damages; some other cracks of a less certain nature and age.

The static situation at the summit of the Column of Marcus Aurelius in 1987 can be briefly described in these terms. The ancient part of the abacus had a number of local problems that were not too serious; large fragments of marble had fallen off, some rod housings were crumbling, rings around the attic were broken and the railing was seriously damaged. The ovoli had been consolidated in 1958, perhaps over enthusiastically, with brass studs and resins. The only potential risk to the monument as a whole was the condition of the southwest corner of the abacus, the object of the Sistine restoration.

The work of Domenico Fontana, excellent in all respects, had only one weak point, linked to the technology of the time and, in part, to the neglect of posterity: the iron clamps, inserted into the marble of the monument, had often done more damage than good, particularly in areas exposed to the atmos-
pheric conditions elements. A survey of the damage showed that the marble started breaking almost always at the points where the metal clamps were anchored, and this was caused clearly by thermal expansion and swelling due to the oxidation of the metal. Evidently the original lead seals were unable, over the centuries, to protect the anchorage points from moisture and to fully absorb the deformation of the iron produced by temperature changes.

This had produced different effects, some of the most serious involving the thinnest parts of two large corner blocks, which were beginning to split, and the long brackets on the platform of the abacus, which were no longer effective. In these conditions the assumptions that formed the basis of the Sistine restoration no longer held and the design criteria that followed from there were no longer valid: it was no longer possible to rely on the original integrity of the stone, a necessary condition for the stability of each piece and therefore the whole corner of the abacus.

The main purpose of the new static restoration was, therefore, to stop this deterioration and support the parts in a precarious condition restoring, for the stability of the abacus, a level of safety at least equal to that achieved by Fontana in the sixteenth century.

The intervention of Antonino Giuffrè

In the spirit of the Sistine restoration it was decided not to use glue or pins to fix the sixteenth-century reintegration blocks to the ancient marble of the abacus. And, just as Domenico Fontana had essentially relied on the shape of the individual pieces and counterbalances to ensure stability of a discrete assembly of blocks, so too the aim of the modern restoration, given the fragmentary nature of the whole, was to try to prevent any movement. The individual blocks remained separated, like they were in the sixteenth century intervention, and as in the original column the drums were simply placed on top of each other, but the support devices that had deteriorated were strengthened and new bonds were inserted where cracks and fragmentation could undermine the balance of the system.

The support recesses cut into the marble by Fontana were thought to be still efficient (the intervention, however, also reduced the stress on the recesses) but the iron bars were removed and replaced with titanium rods: nonetheless, some brackets, the biggest ones, were not replaced but left statically inactive, in situ, since for the past four centuries they have formed part of the iconography of the
monument. The potentially unstable portions of the large sixteenth century restoration blocks were on the other hand supported by a large shelf, also in titanium, which projected from the diagonal of the abacus, between the blocks, so that supports could be added for them. Titanium was chosen for the shelf, as well as to replace the iron parts of the old restoration, because of the material’s special characteristics: it is durable and, above all, its coefficient of thermal expansion ($\alpha=8.64\cdot10^{-6} \text{ C}^{-1}$) is similar to that of marble ($\alpha=7.00\cdot10^{-6} \text{ C}^{-1}$), thus not subject to stress from differential expansion (Stainless steel, which is also resistant to oxidation, has a very different coefficient of thermal expansion).

The large titanium shelf is housed, like an implant, in the vertical cavity hollowed out by Fontana in the two large blocks of marble which counterbalance the lateral instability of the shelf (Figure 8). Arranged along the bisector of the angle, it rests on top of the ovoli and is supported from above by a tie-rod anchored to a bolt inside the spiral staircase. It is big enough to support the whole weight of the corner, estimated at approximately four tons, by means of four pendulums whose ends protrude at the intrados from the gap between the two blocks. The pendulums are bolted to three external plates which press on the marble, with lead plates in between to avoid any concentration of weight due to surface irregularities. These three plates and four round nuts are the only visible parts of the entire intervention, from the base of the column, at the intrados of the south-west corner.

To carry out the intervention, the corner of the abacus was supported at the intrados, using screw jacks, by a beam hung, by means of tie-rods, from two articulated vertical triangles. These, resting on the lower part of the attic, channel all the weight to an octagonal ring bolted to the base of the block on which is placed of the statue of St. Paul. The temporary structure was easy to assemble and, above all, it was totally independent from the scaffolding surrounding the column, which because of its flexibility could in no way provide adequate support.

To put into place the definitive support structure, the tie-rod was first mounted. An 80 mm diameter horizontal hole was drilled into the ancient marble – the only irreversible action taken in the entire restoration – in a point that had already been deeply hollowed out by Fontana. The lower support recess was prepared and the following were put into place in sequence: tie rod, shelf, bolted end-plate, the four pendulums and the lower support plates fixed by round bolts. Each of the four pendulums was preloaded to counteract any deformations due to initial adjustments. Their stress state was monitored
by four electrical strain gauges, which were left in place connected to a control unit placed on the in-
ternal bolt in order to monitor and regulate stresses in the support structure (acting on the nuts at the
intrados of the abacus).

After the definitive support structure was in place, the fragments detached from the corners were
consolidated. They were glued with resins and supported by a system of titanium rods bolted, under
the marble slabs of the platform, to the upper edge of the shelf. The great sixteenth-century iron angle
bracket is still in place but has no static function, since it has no end hooks and is passively supported
by the shelf (Figure 9).

All surfaces under pressure between the marble and titanium have been protected with sheets of
lead, placing a Teflon sheet between the two metals to prevent the onset of corrosion due to differ-
ences in electrical potential.

When all the parts were in place, the temporary structure was removed. The hollowed out parts
were then filled with light mortar consisting of volcanic rock (lapilli), the titanium plate was isolated
in an air chamber formed in the cast, and the whole was sealed with a marble slab. The only new parts
left on the outside were the three lower support plates, virtually invisible at a hundred feet above the
ground, and the thin bands around the corner pieces (Figure 10). The intervention was of the type that
could be almost completely reversed. Apart from the hole for the rod in the shaft of the column, nei-
ther the ancient marble nor the sixteenth century restoration pieces were damaged in any way, since
care was taken to avoid removing the large blocks from their original position.

CONCLUSIONS

Despite the seemingly unbridgeable distance that separates them, the two restorations of the upper
part of the Column of Marcus Aurelius discussed in this work, share an affinity of method from which,
in a period of history characterized by the increasingly urgent need for a rational and philological ap-
proach to interventions on existing works of art, some interesting lessons may be drawn.

Firstly we may highlight the problem of continuity between the technical culture of those who
carry out restoration work and the original constructive context of the work concerned. Domenico
Fontana, whose scientific and technical culture had basically remained unchanged since the column was erected over a thousand years earlier, carried out a restoration implicitly consistent with the constructive and mechanical nature of the column. His techniques were more or less the same as those used to erect the column – somewhat improved but not different in substance from those of the ancient world – and the column’s static behaviour was, perhaps, for him clearer than it is for us, despite the fact we can count on much more powerful tools.

Today, we are dramatically removed from such close cultural and technical contiguity with the historical architecture but nevertheless the restoration carried out in the last century on the abacus of the Column of Marcus Aurelius is a convincing proof that we can still approach it with the same familiarity as the architects of the past. With the not negligible difference that what was natural for Domenico Fontana – whose cultural horizon was still basically the same as that of the architect of Marcus Aurelius – is much harder for the modern engineer, who has to design a project that involves conscious decisions in which modern day technical know-how, which is vastly superior to that of ancient engineers, must be adapted to the needs of the object concerned. Thus, although we have computational tools that a sixteenth century architect could never have imagined, the modern restorer has put them aside in the awareness that the assessment of safety implicit in the ancient art of building is no less reliable than an assessment resulting from the analytical procedures of modern mechanics of structures. And even though there was no hesitation in deciding to use previously unknown materials, work and monitoring techniques, this was always done respecting the static, construction and architectural reasons of the column and the restoration work carried out on it in the sixteenth century.

A second, equally important, aspect that emerges from an analysis of the two restorations is the holistic approach to architecture that underpins the sixteenth century work. Domenico Fontana skilfully employed building techniques and construction machines, had up-to-date knowledge of the mechanical problems that his profession involved, and managed the formal aspects of the static intervention with assured sensibility. In this case, the distance that separates him from modern times seems even greater, if not unbridgeable: the high level of specialization that now characterises any technical activity is an almost insurmountable obstacle to the unity of approach that emerges from the work of the
Sistine architect, since although we recognize the great disadvantages that stem from the fragmenta-
tion of knowledge, we cannot relinquish the clear advantages it also provides.

The question we have to face of, then, is that of correlating different specialist contributions which,
after a careful analysis of the problems involved, can be combined in a unified vision. From this point
of view, Fontana’s restoration sounds an alarm bell for a culture that is increasingly fragmented and, in
its frantic pursuit of detail, often runs the risk of losing sight of the whole.

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REFERENCES


Dal Monte, G. 1581. *Le Mechaniche dell’Illustrissimo Sig. Guido Ubaldo de’ Marchesi del Monte, tradotte in volgare dal Sig. Filippo Pigafetta*. Venice.


Hülsen, Ch. 1921. *Das ‘Speculum romanae magnificentiae’ des Antonio Lafreri*. Munich.


FIGURE CAPTIONS

Fig. 1 - The Column of Marcus Aurelius in Giovanni Dosio’s drawing (1569).

Fig. 2 – Tools (“munizioni”) from the work site of the Vatican Obelisk reused for the restoration of the Marcus Aurelius Column, in a plate from C. Fontana (left), and an example of gantry form N. Zabaglia (right).

Fig. 3 - The scaffold (“castello”) used to erect the Vatican Obelisk after having moved it (left). Wooden scaffolding used in the early nineteen century for the uplift of a statue in S. Peter’s Basilica.

Fig. 4 - Structural survey of the abacus: plans of the extrados (left) and intrados (right) (Drawing by M. Pelletti).

Fig. 5 - Structural survey of the abacus: the front views (Drawing by M. Pelletti).

Fig. 6 - The uncovered Sistine blocks used to restore the abacus: the various components can be easily recognized by comparing the images with the proposed reconstruction in figure 7.

Fig. 7 - Shape and arrangement of Domenico Fontana’s large restoration blocks. On the left, the projection of the centre of gravity is shown for each of the two biggest blocks resting on the two recesses.

Fig. 8 – Definitive support structure project (drawing by L. Fosci and M. Pelletti).

Fig. 9 - The restored abacus: the great sixteenth-century angle bracket left in place.

Fig. 10 - The restored abacus: the plates of the pendulums anchored to the titanium bracket.
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