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The Restoration of the Chapel of the Shroud in Turin

Interview by Kim Williams. Edited by Sandro Caparrini

Guarini's Chapel of the Shroud in Turin, a major monument of the Italian Baroque, was devastated by fire in 1997. Plans are now underway for its restoration. An important initial phase of the restoration project is to understand Guarini's original design process and the construction techniques used. In this interview with Mirella Macera, Paolo Napoli and Fernando Delmastro, coordinators of the restoration project, the nature of the damage caused by the fire, the steps taken thus far to stabilize the structure, and new discoveries about the Chapel as a result of the fire are examined.

Fig 1. From left: Architect Fernando Delmastro, Architect Mirella Macera, Engineer Paolo Napoli. Behind: the photo of Guarini's cupola in the Chapel of the Shroud, taken just before the 1997 fire (photo/Kim Williams)

Kim Williams: Guarini's Chapel was in need of restoration even before the fire of 1997. The Chapel was closed on 4 May 1990, the holy day dedicated to the Shroud. What kind of problems were there? Were they structural, or primarily aesthetic, or of the kind of maintenance-related problems that one would expect for a building 330 years old?

Mirella Macera: As time went on, the restoration, which ended tragically with the fire, turned out to be a substantial intervention of maintenance. The restoration had begun as the result of a piece of stone having fallen from the cornice to the ground.

Kim Williams: Were you involved in the first restoration?

Mirella Macera: No, that was undertaken by my colleague Franco Ormezzano, who passed away shortly before the restoration was completed. The story of the Chapel isn't a very happy one for those of us who have worked on it, either professionally and personally. This piece of stone fell to the ground, and we feared a problem of a structural nature, so first we erected a small, temporary, scaffolding and then later a more substantial one. There turned out to be only a deterioration of the stone, which is the marble of Frabosa. It has white veins of various materials running through it, and which constitute weak points in the stone. So, for lots of reasons—water infiltration, age, vibration—maintenance was necessary. Nothing was necessary from a structural point of view, but by hitting with a small hammer and identifying where the stone sounded hollow, we were able to “sew” together with injections of resin and steel pins the pieces of marble that were loose, anchoring them to the parts that were sound. And then we undertook a thorough cleaning and polishing of the stone.

Kim Williams: Discovering at the same time the frescoes of the cupola.

Fig. 2. Interior of the Chapel before the fire. At left, at the lowest level of the rotunda, Bertola's altar. At right, the cupola

Mirella Macera: One of the most interesting elements of that first restoration was the discovery of the fresco of the cupola, but I would say that it was one of the many results that came out once

the cleaning was completed, another being the difference in the marbles that were used. There are two kinds of Frabosa marble, black and gray. The black marble was used predominantly in the lower part of the Chapel, while the gray was used in the upper parts. After the stone was cleaned, the emphasis on the verticality of the Chapel was revealed: as the Chapel rose, the stone became ever lighter in color and, as a consequence, the effect of verticality increased in a spectacular way. Unfortunately, only a few of us were able to see this.

Kim Williams: What caused the fire of 1997?

Mirella Macera: Since the judiciary process is not yet over, I can only say the cause of the fire was given as an unspecified electrical problem. Several expert witnesses testified to causes other than this during the hearings, but I think that it is probably that the electrical problem will be accepted in the end as the cause, unless there is a surprise ending. The district attorney says that it was an electrical problem and has asked that the persons responsible be sentenced.

[**Editor's note:** On 29 September 2004, the hearing on the cause of the fire reached its conclusion, with the judgment being that the fire was partly due to negligence on the part of the firm that was in charge of the restoration, and partly to the failure of the custodian to recognize the fire and give the alarm in a timely manner.]

Kim Williams: An article in *La Stampa* of 18 March 2004 reported that, according to the district attorney, a light or something similar was left unattended near flammable materials.

Mirella Macera: If this was indeed the case, then it was an accident of fate, because, as I said when I testified at the hearings, this was not a construction site that was disorganized, disorderly, or badly managed, of the kind about which one felt that something was bound to go wrong. It was a construction site that had gone forward for a number of years, one that was supervised by a responsible firm, and that had many technicians on site. There had never been any previous incidents. Work of this kind necessarily takes place at a certain height above the ground and so accidents can happen, not only to materials but to people as well. This was a construction site that had dealt with many problems of a technical nature, but certainly none that regarded safety. So how such a tragic accident could have occurred on the night of 11-12 April will probably always be something of a mystery.

Kim Williams: In terms of materials and load-bearing elements, what is exactly the structural system of the Chapel?

Paolo Napoli: That is a really good question, and it is difficult to give an adequate response, because in this monument, as in other buildings by Guarini, the structural system is somewhat hidden. Some elements are visible, but very probably there are others that are hidden from view. In terms of materials, the massive masonry walls in the lower portions become increasingly lighter as they go up, and then there is the stone.

Kim Williams: Guarini came to the Chapel when it was already at the level of the cornice.

Paolo Napoli: Guarini found the Chapel already begun. He re-shaped it in some way, but we don't know exactly how he modified the lower part, though he certainly used it as a base in order to go up. So there is masonry, and there is stone. What exactly is the relationship between the load-bearing capacity of the masonry and that of the stone is difficult to determine. Certainly in the lower parts the masonry is load-bearing and the stone is more or less a veneer, although it is never a thin layer, but is always substantial. In the upper parts of the Chapel, the stone appears to take on a more substantial role. I say appears to because when you investigate the sequence of

arches in the cupola, which are substantially arches in stone, although there is always a masonry support, they appear to form a structural system by transferring the loads through the keystones from one to the other. In all probability, however, this is not the case, because tests run to record the compression present in the arches even before the fire gave a reading of zero, that is, there was no compression present in the arches. In fact, in some cases the stone joints were completely open.

Kim Williams: The joints at the top of the arches?

Paolo Napoli: No, there was a gap between one stone and the next in the arches, let's say; often there was no mortar in the joint, so these arches play a secondary role in the structure. But it isn't easy to say what the key structure is and what plays the primary role. It appears, from as much as we have been able to verify, that a very important role is played by the large exterior ribs, which are very closely tied to the arches because each stone bracket is inserted into the full thickness of the ribs, and they bear the load of the arches.

Fig. 3. Detail of the cupola of Guarini after the 1997 fire. In the lower part of the photograph are visible the arches and brackets of the cupola, while in the upper part are the point of the twelve-pointed star (photo/Kim Williams)

Actually, even the calculations for simulations that we have made confirm the very important role of the ribs as external arches that sustain the system. However, this explanation, which, I repeat is the most probable at this moment, has its questions marks. The biggest question concerns the arrangement of the bricks that make up the ribs, which aren't in the form of an arch, as they ought to be, but rather in horizontal courses, while for an arch they should be inclined (Fig. 4b).

This is very strange, especially because Guarini knew perfectly well how arches should be constructed. This is one strange thing. Another is that there are old prints of drawings which show the Chapel without any ribs. They were an addition.

Kim Williams: Or a development.

Fig. 4a. The exterior of the cupola, showing the ribs

Fig. 4b. The bricks of the ribs with the two phases of construction distinguished by color.
From *The Architecture of the Shroud* by John Beldon Scott

Paolo Napoli: And so there are many unanswered questions. But if we leave aside for a moment the history, and look at the measurements we have taken of the Chapel, and at the simulations on the finished elements, it appears in effect that the fundamental load-bearing elements are the ribs, in as much as, at the time of the fire and the breaking of the cables at the large windows, these ribs were among the first to develop significant signs of damage. Practically no cracking was observed in the arches, but the ribs showed significant cracking.

Kim Williams: The arches of the cupola, even in though they suffered damage to their surfaces, remained integral?

Paolo Napoli: Yes, they are sound enough from the point of view of direct damage from the fire. But the fire broke the cables, that is, the metal belt that goes around [the exterior] of the Chapel, and so the Chapel began to open outwards. Opening in this way, the whole structural system became distorted, even if it wasn't directly damaged by the fire, and it was certainly the general distortion due to outwards movement that damaged the arches, which were the first elements to lose their equilibrium, although it was the ribs that showed the most notable damage. Thus, even this points to the fact that they were damaged because they bore most of the load of the Chapel. We can therefore say that this is a monument with a predominantly masonry structure, to which the stone contributes in some measure, but we don't know just how important a contribution this is. At least for the upper part of the Chapel, which is the part that is most visible, we can say that the ribs play a very important role in the load-bearing system. But we don't know if this was Guarini's original intention, or if it was a successive development.

Kim Williams: What structural interventions on the Chapel and its dome were necessitated by the fire?

Paolo Napoli: In order to understand what interventions were necessary and why I have to tell you the story of what happened. A few days after the fire we saw that new cracks were getting ever larger.

Kim Williams: This was visible on the exterior?

Paolo Napoli: On the exterior. It was the firemen who saw them, because it wasn't possible for us to get close enough to see them, so the firemen told us...

Mirella Macera: Fortunately!

Paolo Napoli: ...about the cracks. At first we didn't believe them to be all that important, but videos were taken and then we were able to see that what was happening was that in the course of a matter of hours the cracks were growing in both number and size.

Kim Williams: Those must have been frightening hours.

Paolo Napoli: Crucial hours, because seeing the cracks it was possible to understand that one of the cables that resisted the outwards thrust of the arches had broken.

Kim Williams: Where are those cables located?

Paolo Napoli: There is one at the level of the large windows in the drum, but they are very difficult to see because they are hidden by the mullion of the window: it seems only a part of the window, but in fact it is also part of the cable. So our first idea was that one of the cables had broken, whether because of the heat or because of the water used to put out the fire, or because of the change in temperature. At first, the firemen weren't able to see the cable, but then finally they

located one which was in fact broken, so an attempt was made to repair it. It seemed that repairing the chain was the quickest way to stop further damage, but it turned out not to be possible because the steel couldn't be soldered (some steels can't be soldered because the alloy contains too many impurities). So it was decided that the very first thing to do was to place encircle the structure with cables at the level of the drum. This was the first intervention, and probably the decisive one, the one which stopped further progress of the impending collapse and allowed us to undertake further steps in a calm manner. It was also completely reversible because it was undertaken on the exterior: it serves the same function as the broken chain, but it can be removed at any time without leaving a trace. Next, more cables with steel plates were placed at the level of the dome; this too serves to preserve the dome without leaving any traces when removed. So, as it now stands the Chapel is stable on its own, as it was structurally conceived. The only thing that we have done is to repair the damage to one broken chain, and then to place other cables where breakages in other, hidden, cables were possible (at the base of each small arch is a chain that is hidden in the masonry). Some cables were broken, and others could be broken that we don't know about, so external cables were placed. These were the two steps taken to guarantee the safety of the Chapel. As regards the Cathedral, a step was taken—more functional than structural—to close the opening between the Chapel and the Cathedral, in order to separate the two buildings so that the Cathedral could remain functional. A minimal structural intervention was necessary because the arch between the Chapel and the Cathedral was damaged, but in essence a separating wall was built.

Kim Williams: The large window wall between the Chapel and the Cathedral was destroyed?

Mirella Macera: Yes, almost completely destroyed.

Kim Williams: Will it be reconstructed?

Mirella Macera: This is one of the most important subjects of the restoration, when all the rest is completed. In the Cathedral you can now see the painting on the screen that shows how the view would appear without the window wall and which shows effectively the relationship between the Cathedral and the Chapel without the window (Fig. 5).

In actual fact, there is a big problem, even if today's technology has made great strides in the field of heating, and so there is some possibility that this problem could be handled successfully. This was one reason why the Chapel suffered such great damage from the fire: the Chapel functions as something like a chimney with respect to the Cathedral, so that leaving the opening means that the Cardinal couldn't celebrate mass inside the Cathedral! We need to come up with some kind of barrier, because otherwise the Cathedral would have to face huge heating bills, which probably couldn't be borne.

Paolo Napoli: Another important intervention was this "castle" of interior buttressing. A steel structure was built inside the Chapel, starting from the foundations of the Chapel, with three columns that go up, arriving at the level of the drum, at thirty-four meters above the pavement of the Cathedral.

At this level there is a steel grating, and then the buttresses that support all the arches of the dome from below. Actually, the scaffolding doesn't really support anything, because it is placed extremely close to the arches but doesn't actually touch them. We don't want to support the Chapel, which stays up on its own, with its own structure and with the protection of the new cables. But we do want to be sure that, if something bad should happen, since there is always that possibility, support is in place. Periodically we verify the situation—it is possible to pass a piece of

paper between the masonry arches, the stone arches, and our scaffolding. Should any settling occur, it would be immediately stopped. This scaffolding serves another purpose: thanks to it, at the time when the process of restoration starts, it will be possible to take out individual blocks of stone without dismantling the arches because the supporting system is in place. The scaffolding will stay there until the restoration is completed, and then naturally it will be taken down.

There is one last important intervention: there are more than fifty instruments in place to measure and monitor control the Chapel constantly. These were extremely useful during the initial phase because they provided us with a measure so that we were able to intervene, above all by adjusting the resistance of the cables where cracks were opening in an alarming manner. Practically, since the end of 1998, that is, something over a year after the fire, the situation has been stable and there has been no need for alarm, but in any case the system is still functioning, and all is under control.

Kim Williams: There aren't any other alarming factors? Are you in an earthquake zone?

Paolo Napoli: No, there have only been very small tremors. We have three seismographs in the Chapel that signal all tremors, but there have only been small ones.

Fig. 5. The painted screen that is now in place between the Duomo and the Chapel of the Shroud.
(photo/Kim Williams)

Fig. 6. The interior of the Chapel at the level of the pendentives, with the “castle” of scaffolding (photo/Fernando Delmastro)

Kim Williams: The foundations are sound?

Paolo Napoli: The foundations are sound, as far as we can see. We have investigated, but here in Turin in general we are very fortunate: we are near the mountains; the glaciers have deposited detritus and gravel and the subsoil is stratified and stable, except for some areas around rives where there are veins of lime and clay, but not much. Generally, Turin is founded on a very stable layer of sand and gravel. What happened, and unfortunately is still happening in the Chapel, is that the thermal variations between day and night and season and season is that the parts of the stone that were damaged in the fire, were detached, but remained in place, are continuing to fall. We can't say that they are beginning to fall, because they've been falling since the beginning, but we believed that it would stop and instead it is still happening. We are continually finding fragments of the stone on the floor.

Fernando Delmastro: We were able to determine that one of the most diffuse types of damage is the detachment of flakes from the main body of the stone, not necessarily that they fall. This is particularly common in the moldings, which are raised with respect to the rest of the stone block from which they were carved, and under greater tension. There are flakes that were detached during the fire but which have remained in place in an unstable equilibrium. It only takes a little dilation to destroy that equilibrium, and the piece falls.

Paolo Napoli: So that the damage continues to take place.

Kim Williams: Will the restoration be able to remain faithful to Guarini's original structural system, or will it be necessary to substitute that system with modern materials, as happened in the restoration of the spire of the Mole Antonelliana after its collapse in 1953, when the original stone

spire was replaced by a steel one, or more recently in Assisi, where the vaults that collapsed as a result of the earthquake in 2000 were reconstructed in Kevlar®?

Paolo Napoli: We can say that the interventions undertaken up to this point, which weren't of restoration but only for security's sake, were all faithful to the original concept, and are in any case reversible. Just how the restoration will proceed has yet to be determined, but we believe that they won't be like what happened in the Mole Antonelliana, to use that as an example, but will aim to respect as far as possible Guarini's structural intentions. It may be necessary to reinforce the dome, but without disrupting its structural function.

Kim Williams: Can the fragments that have been collected be reused? The newspapers talked about more than a meter of detritus on the ground.

Fernando Delmastro: They have been collected according to archaeological criteria, according to stratification. The Chapel was divided into sectors, and it was possible to know in which sector every fragment fell, and by knowing at what level in the stratification it was found, it was possible to know the chronological order in which it fell. This doesn't mean, however, that if a fragment is found in sector 9 that it fell exactly there, because it could have bounced there, but as far as possible it is all documented. In a large warehouse in the courtyard of Palazzo Reale we have assembled a team that is identifying and inventorying all the fragments one by one, identifying even the profiles so that, along with the work I am doing together with other colleagues who are creating files on all the stone blocks used in the interior of the Chapel, we can recognize the profiles. At this point we can identify at least what kind of molding and the general location of each fragment that has fallen. Next in the project of restoration comes the task of deciding if, once recognized that the fragment comes from a given piece of stone or at least from a given architectural element, it can be reintegrated with the original or in another way. Architect Macera can say more about this than I can, but I did want to describe the methodology with which the fallen pieces as well as the great repertoire of moldings that Guarini used in the Chapel, are identified and catalogued. A first estimate was that there were 150 different kinds of moldings, as well as a great deal of variation in the details of the stone carving that were absolutely anomalous, given the dimensions.

Mirella Macera: This is the work that we are doing now. There is a group of architects and art historians who are creating files on the stones one by one.

Fernando Delmastro: Exactly. Each stone block is analyzed by means of two forms, one of which is more graphic and one more typological by the state of conservation, which identifies the location in plan and in section by typological element, for example, a lunette, for which there is a stereogrammetric photograph. For each individual molding a survey is made with metrological methods. This information is then transferred to a computer and compared with the fallen fragments. The next step is dedicated to a numeric, typological description of the state of conservation so that these spaces on each side, one of which is geometrically intact while the other is partly disintegrated, because sometimes they present are very different problems. Any given stone block has two faces; both faces can show different states of decay and require different cataloguing. This is all inserted into the database. This first "exploratory" phase to determine the current state of the stone blocks is being undertaken by a group of colleagues composed of Augusta Cyrillo Gomes, Clara Distefano, Stefano Faletti, Francesca Filippi, Maurisio Sola, Igor Violino, each of whom applies to the problem his or her particular skills.

Kim Williams: This is really a job for monks!

Fig. 7. Reproduction of the etching of the Chapel of the Shroud from *Architettura civile*

Fernando Delmastro: But it has to be done. In fact, even Guarini was a Theatine! Anyway, the mere numeration of the stone blocks required identification and elaboration of a kind of tag that has a precise number, and those of us who know the system knows what kind of element the fragment belongs to: “r” stands for “radius” and “l” for lunette, and so for example, this piece comes from one of the radii inside a lunette.

Kim Williams: Did the damage caused by the fire reveal details about the architecture and the structure of the Chapel that were previously unknown?

Paolo Napoli: I would say that more than the damage it was the investigations that we made inside that revealed traces of arches that lead us to believe that there is something not previously known.

Mirella Macera: When the plaster fell off because of distortion as a result of the fire, what appear today as buttresses with an arched form was revealed to be in fact an addition to the original

structure, which was stepped as it is in fact shown in *Architettura civile*. Not only, but we also discovered this corridor, or better, passageway, which isn't shown in the drawing, which indicates only a thin roof.

Paolo Napoli: As part of the investigations that we made after the fire, we carefully scouted out this passageway.

Kim Williams: Is it usable?

Paolo Napoli: Yes, with difficulty, but it usable.

Kim Williams: Is it for maintenance purposes?

Paolo Napoli: I don't think that anyone had gone up there in hundreds of years.

Kim Williams: Perhaps to lighten the structure?

Mirella Macera: This is one of the most singular elements of the structure, because it doesn't appear in *Architettura civile*.

Paolo Napoli: In *Architettura civile* the passageway doesn't appear, nor does it appear in the earliest surveys of the Chapel (Fig. 7). But in fact this is a passageway that forms a sine curve as it passes over the large windows of the drum, because every time it comes to a window it has to go up and over and then back down again. There is also a passageway in the drum, in which it is just possible to distinguish the faintest traces of arches, which then disappear. At this level there is a circular plan, which is what is visible on the interior, and a plan that is effectively square, the external one. In this passageway that goes around the Chapel, at a certain point you can see arches segments projecting out that then disappear. Only small segments of these arches can be seen because they are encased in the masonry, so that it is necessary to imagine the forms. The segments are visible because, since the plan is circular and the four arches are oriented according to the square, as the circle moves away, then the segments of the arches appear. So probably from here down the load-bearing system is composed of four arches and not three, as it appears. We hope that the phase of investigation that is about to begin will shed light on the materials used in these arches.

Kim Williams: Will the restoration have an effect on future Guarini studies?

Mirella Macera: Our hope is that it will help us to understand first of all how the Chapel works, since if we don't understand that we can't be sure that we have restored it correctly. It is necessary to understand the Chapel from a structural point of view in order to intervene in the correct way. I think that this will be the most interesting outcome from a scientific as well as a practical point of view. We will certainly know this long before the restoration is complete, in the sense that at the moment that the restoration is begun the question of the structure will have to be understood, because that is essential to the process. There are two other aspects that are certainly of interest with regards to this project, and which Prof. Giuseppe Dardanella and Arch. Delmastro are working on.

One is the original construction process of the Chapel, which is certainly important to understand with regards to the restoration. What was involved in the design of a building such as this? Was there a general design concept? How detailed was the design? Did a stereotomic construction dictate the dimensions, designs, cartoons, for each individual stones? How were the stones worked on the site, and how was it possible for the architect to control the construction process in such a precise manner? There are truly very few discrepancies. Of course, some discrepancies are present:

there are some additions here and there to make things work, but it appears evident that the stones were worked on site and then set in place. This means that the architect had to control the dressing of each of the 4000-5000 stones that make up the Chapel. He knew exactly what form and dimension and orientation of each of the faces and how the stones were fit to each other. Understanding how this process worked is extraordinarily important because it will clarify what construction technique was used. Not only, but it will perhaps also be the tool that allows us to integrate the collected fragments, if it is decided that this is possible, because in some way, once Guarini's construction technique is understood, even given the differences in modern construction techniques, we will reinterpret, not in a formal sense, but merely in a constructive sense, Guarini's construction process. In the reintegration there won't be any new inventions, but only a re-composition of what the architect did originally. The structure of the Chapel is intact, in spite of the damage from the fire. All of the stone blocks are in place, their forms are pre-determined; it is only necessary to reconstitute the decorated faces of the stones. If we understand the key that Guarini used to work the stones, then this allows us to intervene by reconstructing, by significantly integrating the existing without inserting anything modern except perhaps the choice of the materials.

The other interesting aspect is that of the geometry, of what that might have been. Architect Delmastro can tell us more about this, as we don't yet have a full understanding of this, since the scaffolding has only been in place for a short while and so we have only just begun to study the building from close up.

Fernando Delmastro: The starting point was a very particular and original study from the point of view of architectonic typology undertaken by Prof. Giuseppe Dardanillo, who analyzed the compositional elements of the Chapel, and identified and created a glossary for each of the constructive elements. With this as a basis, I inserted what I had learned from my own research into medieval buildings which I have been conducting for some time. I believe that geometry played a very particular role in the construction of sacred buildings, because at that time, especially because of neo-Platonic philosophy, the construction of a divine temple had to respect what was considered to be the geometry of the cosmos. Clearly we are in a minefield here, and I want to exclude any esoteric components. But surely when the architect conceived an architecture on the basis of Euclidean and Pythagorean mathematics, he created a system of proportions as well. In order not to venture into improbable and speculative interpretations, I believe that the first step is that of a metrological analysis. The decimal metric system was introduced in Piedmont in 1850, and certainly before that date the units of measure were various. By analyzing historic documents contemporary with the construction of the Chapel and with a detailed survey we will be searching for the unit of measure used by Guarini, even though the analysis is rendered more difficult by the fact that there exists today only one original drawing of the Chapel of the Shroud. There once were 900 drawings kept in the new wing of the Palazzo Reale together with a wooden model of the Chapel, but these have gone missing.

Kim Williams: Did the geometric forms of the Chapel (circle, triangle, twelve-pointed star) serve a structural purpose, or were they purely symbolic?

Fernando Delmastro: I think that in order to identify what may be the geometrical compositional organization, it is necessary to go through three stages, the final of which is the identification of the symbolism. As you said in the question, the symbolism can be analyzed on two levels. One is clearly immediately apparent visually, as are the forms of pentagons or hexagons, the numbers of the elements, etc. This is the part that is most evident but that is almost equivalent to a painterly message more than an architectural or geometrical one. The other level is that which could be,

and probably is, a constructive, spatial, geometry of the development of the whole building. Given the lack of original drawings, we have to be very careful to not create what I call “artifacts”, in the sense that when an architect or a lover of geometry sits down to play with a compass and straightedge on a survey, it is possible that, given enough patience, certain coincidences will be found. That isn’t to say that they will be the coincidences that Guarini intended. So, in order to have a minimum of security, and availing ourselves of a calculation of probability, the methodology that I propose is that of finding three successive confirmations on three separate levels of investigations, in the sense that a geometry can be confirmed by metrological analysis. For example, if we find an equilateral triangle, and the side of this triangle is a given whole number of feet or Roman cubits, then the probability that we are getting close to the real intention of the designer increases. If, successively, as a complex organization these geometries contribute to a whole that has a symbolic significance, three coincidences then perhaps form a proof, and that is what we are looking for in this case.

Kim Williams: With regards to the geometry of the Chapel, the equilateral triangle is often cited in plan as well as in section, as in the recent book by John Beldon Scott, *Architecture for the Shroud* (University of Chicago Press, 2003). This triangle is used more or less as a guide, but isn’t necessarily a visible element in the architecture itself. It brings to my mind the story of the Cathedral of Milan, when during the construction in the 1300s, there were signs of structural damage even before the structure was completed, and so various experts were called in for advice. The final judgment was that the form of the equilateral triangle was inherently the most stable.

Mirella Macera: There is one very interesting aspect to the geometry that is intriguing precisely because it came out in the course of the work. The supporting structure now on the interior of the Chapel designed by Prof. Napoli together with Prof. Vittorio Nascé, which we call the “castle”, was based on a triangular module, because it is evident that this is a stable form. Once erected within the Chapel, however, it was obvious that this was the natural, right, form. Up to this point we haven’t taken any definitive steps in the restoration of the Chapel, but only steps of a temporary nature. This triangular structure is one of these steps, and so the triangle has an impact on not only the form of the Chapel, but on the form of the structure meant to support it as well.

Paolo Napoli: It is only logical that we were inspired by Guarini: we designed a structure that takes the hexagon as its point of departure, because the Chapel contains the hexagon, and then this hexagon transforms itself into a triangle as it descends onto its three columns. Three columns is the minimum number necessary for stability, but at the same time it is also that which permits all the forces to be monitored: if a table has four legs, it can always have one that is shorter than the others, but if it has only three legs, then all the forces are known.

Kim Williams: With four legs a structure is always statically indeterminate.

Paolo Napoli: And instead with three all the forces are known. So Guarini in this case too played with this idea of 3, because the cupola is based on a geometry of 12, then passes to 6 in the drum, then apparently passes to 3 in the three arches.

Kim Williams: But only apparently, not in the structural system itself.

Paolo Napoli: Only apparently.

Fig. 8. Drawing showing the two orders of layout of the stones and the layout of the decoration in one of the pendentives (drawing/Clara Distefano and Francesca Filippi)

Fig. 9. Horizontal section at the level of the pendentives and lunette comparing the actual to an ideal circumference (drawing/Clara Distefano)

Kim Williams: One of the things that I find most interesting is the pendentive zone where there are two orders, that of the stones and that of the decoration. The execution of the sculptural detail was rendered still more difficult because the surface of the pendentives is a spherical segment, that is, it is curved in two directions. Do you have any idea how this was accomplished?

Fernando Delmastro: That's right, it is extraordinary. The stones joints aren't related to the decoration; they follow a different order. The arrangement of the stones themselves evidently follows a design. There is an order to them, even if the dimensions vary slightly from lunette to lunette and from pendentive to pendentive.

Kim Williams: This means that there was no standardization.

Fernando Delmastro: I would say not. I would think rather that the size of the stones was determined by the dimensions of the blocks that could be extracted from the quarry. For example, in the second level of the Chapel, some the radial stones of the lunettes constitute perhaps the largest blocks of the construction, after the monolithic columns.

Kim Williams: Who knows, perhaps the stoneworkers said to themselves, "Let's hope that in the future no one ever has to deal with these again! How we got this to work only the Lord knows!"

Fernando Delmastro: How this was actually carried out is very difficult to understand. It has already occupied us and will continue to occupy us for some time. Arch. Macera, Prof. Dardanello, Prof. Napoli and I are all working on it, and others will want to contribute as well.

Regarding the spherical nature of the surface, I can add some observations, while noting that Guarini's use of classical architectural elements, particularly the lunettes and pendentives, in an original way has been demonstrated by Prof. Dardanello. They appear to be true pendentives, but are not. The first observation is the result of an analysis by laser scanner that was recently undertaken. From the available information we can confirm that the "forms" of the pendentives are spread onto a truncated spherical bowl, and those of the lunettes are spread onto another bowl, concentric with the first but slightly larger. Practically, the nature of the basic surface of these two architectural elements, however different they appear, is substantially the same. The second observation is on the emphasis placed on their differences. This is obtained by means of an optical illusion caused by the decoration: hexagons and radial stars for the lunettes, and the crosses in horizontal courses for the pendentives. It is curious to note how this type of illusion is exalted even further when represented in a drawing of the vertical section. If we try to imagine the form of those elements by only looking at such a drawing, then it is easily possible to think that the pendentive is a cylindrical form with horizontal axes and the lunette is a conic surface. We have seen that the reality is completely different. Further, the small surfaces inside the individual hexagons, stars and crosses are spherical as well. This demonstrates that Guarini's Chapel is difficult to represent adequately by means of an architectural survey. We can therefore imagine and admire even more, given the complex scope of the Chapel, just how challenging it was to design the project, in terms of composition as well as execution.

Kim Williams: Will Bertola's altar be rebuilt?

Mirella Macera: Bertola's altar is perhaps one of the most important questions because the parts that were in wood were lost, destroyed, while for the rest of the Chapel we have surveys that we are putting together and which will give use the elements we need to solve the problems of reintegration, restoration and consolidation. For the altar we have not yet been able to find the necessary materials, drawings, to attempt a reconstruction.

Fig. 10. The remains of Bertola's altar amid the castle of scaffolding (photo/Kim Williams)

We are trying to assemble all the photographic documentation possible, but it is a subject that has been somewhat set aside at this time. It is not of the first importance, not least because of the scaffolding. We are rather trying to work on the [funerary] monuments, because for that work we have funding from "Specchio dei Tempi", a foundation connected to the newspaper *La Stampa* of Turin, which provided a significant financial contribution mostly for the monuments, so we are proceeding with those. Working with the monuments also allows us to begin experiments with techniques for consolidating, with glues. Immediately after the fire, after the structural work, we had to remove the iron parts that were all tangled of scaffolding from the interior of the Chapel, after which we could begin to collect the more than 100 boxes of fallen detritus from the floor, including all the pieces that had a decorated face, for which we are now trying to determine the original location. The most interesting fact up to now is that almost all the pieces that were missing from the monuments were recovered, so that we can reasonably hope to achieve a reintegration of the fallen pieces within a short period of time. In order to be able to work in a timely fashion and achieve results, we are thinking of working on the monuments that were at the base of the altar. Bertola's altar itself we have set aside for now, in part because we don't know enough about it, and in part because it is in the most inaccessible part of the chapel, inside the scaffolding.

Kim Williams: Are the bronze Passion Capitals in the lower portion of the Chapel intact?

Mirella Macera: Yes, they are. Since the fire developed at an upper level of the Chapel, you can see that the part that suffered the most damage is there. The lower part suffered damage that was mainly of a mechanical kind, that is, from pieces falling from above or from the scaffolding collapsing as it burned, but it suffered less damage from heat.

Fernando Delmastro: We thought that the Passion Capitals would be lost, but they are almost complete undamaged.

Fig. 11. One of the bronze passion capitals after the fire. Photo Kim Williams

Kim Williams: Since the Shroud can no longer be housed in its original place, what function will the Chapel serve in the future?

Mirella Macera: The Shroud can no longer be kept in the Chapel because it has to be kept unfolded, and so it requires a large space. I think that the function of the Chapel will remain a religious one, so that when it is finally returned to the curia at the termination of the restoration it will once again be part of the Cathedral. It was an architecture that was born with a dual function: royal chapel and a place to exhibit the Shroud. To insert it into the context of the Palazzo Reale would be to take away much of its value. Certainly it should figure in the context of a visit to the Palazzo Reale, to show a measure of the palace's organization, and in order to allow visitors to understand both roles so that the Chapel can be fully appreciated.