From Porta alla Croce to Piazza Beccaria

The evolution of Florence from city to Capital

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Abstract: The object of this paper is the study of an area in Florence, the Mattonaia Quarter, with the intent to analyse its transformation after the proclamation of Florence as Capital of Italy in 1865. In the end, the analysis will reconstruct the quarter through a graphic representation and the construction of a 3-D model. The result will be a "photograph" of the area in two separate moments: 1855, just before the master plan designed by Giuseppe Poggi started expanding the city, and the years following 1870, as the work progressed. Piazza Beccaria, once known as Piazza alla Croce, is particularly studied because it is the focal point of the transformations made by Poggi. This reconstruction is based on the analysis of several fonts, among them being historical maps, documents and drawings by Poggi, photographs and landscape paintings by artists from that period. They enabled the distinction of the documented parts from those which are fruit of a procedure of deduction and hypothesis because of lack of detailed information. We can see the transformation of this area, from an expanse of vegetable gardens, fields and gardens, surrounded by the bordering streets and to the North by the ancient walls, almost like a rural area, in an extension of the city center, with a dense mesh of new roads which creates a series of residential blocks. Finally, two plastic figures were constructed by means of a 3-D printer to the scale of 1:1,000 which reproduced the two situations of the Mattonaia Quarter, maintaining the differences described by using a different level of definition in the 3-D model. The two plastic figures are now shown at the Archivio di Stato exhibit Una Capitale e il suo architetto, in Florence, with the intent to make people see clearly and concretely how the city changed.

Keywords: Piazza Beccaria, Giuseppe Poggi, Mattonaia quarter, Florence, 3d printing

The Mattonaia quarter

The area of interest in this process of reconstruction is the Mattonaia Quarter, located in 1855 north-east of Florence (Fig. 1), bordered on the north by the present ring road Viale Giacomo Matteotti, originally occupied by the city walls, up to Cimitero degli Inglesi, where the ancient Porta a Pinti once was. Borgo Pinti forms the northwest border. From Borgo Pinti to Piazza Beccaria the neighborhood is bordered by Via dei Pilastri, which continues with Borgo la Croce, crossing Via della Mattonaia, which originally extended only north of the district. After the work on the enlargement of Florence, the street continued to stretch to the south: overlooked by the market of Sant’Ambrogio and the complex of Santa Verdiana. The analysis then extended to the area of this block, to highlight the development of Via della Mattonaia and further changes in neighboring spaces, still important for the city. The edge of the area is Via dell’Agnolo. (Fig. 2) Taking into
analysis various historic documents, such as plans, drawings, paintings and photographs, the evolution of this neighborhood could be traced up to the situation closest to changes in the project by Giuseppe Poggi.

Fig. 1 – Map of Present Florence: in red we can see the Mattonaia quarter.

Fig. 2 – Map of present Florence: in red we can see the outline of the Mattonaia quarter, in green the added part.
Sources

Historic maps

The search began with the identification of a series of historic maps from the late 1500s to the mid-1800s. The first source, a map by Stefano Buonsignori, dates back to 1584. It is a perspective view, which has already provided some important information about the shape of Porta alla Croce including the city walls, the subdivisions in gardens and courtyards and the various elements of fortification towers and ramparts. The neighbourhood appears underdeveloped, with an expanse of fields and orchards in the interior, bordered by a series of houses and buildings with their courtyards in Borgo la Croce and Borgo Pinti. The convents of Santa Verdiana and of Santa Teresa and the whole of Sant'Ambrogio are already present in this map. Some of the elements mentioned are still the most representative of the neighbourhood. The current Cimitero degli Inglesi is represented as an accumulation of land, next to Porta a Pinti. The other maps by Francesco Magnelli and Cosimo Zocchi, dating back to 1783 and 1832, were processed using the surveys effected during the rule of Ferdinand III that are in the cadastre archives. They show the ongoing development of the area. The complex of Santa Verdiana and Sant'Ambrogio, and the convent of Santa Teresa are clearly visible here. The square outside Porta alla Croce is, in this case, named "Market Square of the Beasts", which confirms the original function of the square.

The map closest to the state of the district before the works of Poggi, is one by Giuseppe Pozzi (1855). It is assumed that in the period between 1855 and 1865, in which Giuseppe Poggi's masterplan was drawn up, the changes were quite minimal and therefore negligible. It is precisely from this map that large amounts of information have been drawn for the purposes of the 3-D reconstruction of the area. (Fig. 3)

As for the reconstruction of the state after the changes, it was decided to reproduce a situation that describes the construction phase, during the works, and then as it appeared in the 1870s. This choice was made because the area in subsequent years has been expanded and prolonged so substantially that it would require an enormous quantity of elements causing it to become too difficult to manage and demand a lot of time. For the study of this second situation, a map dated 1873, by the Military Geographic Institute was chosen (Fig. 4) It was used for comparing the data with the drawings and the plans of Poggi and then used to study the current state of the district.

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Fig. 3 – Giuseppe Pozzi, map of the city of Florence, 1855. Scale 1:5,700. (Copyright: Istituto Geografico Militare, Florence).

Fig. 4 – Map of Florence, 1873. (Copyright: Istituto Geografico Militare, Florence).
Drawings, paintings and photographs

Giuseppe Poggi and his colleagues have produced a series of drawings about the project that are very clear and helpful for understanding the transformations. These, along with numerous paintings and some photographs, were very important sources for realizing how the city was before the works. They furnished mostly general information but also much detail about individual elements.

For example, an accurate drawing of the square, showing a superimposed state of the square before the intervention of Poggi and his project, was the starting point for identifying the area. This documented drawing provided information about individual demolished buildings and those which remained, the streets and boulevards, and the shape of the square. (Fig. 5)

The above mentioned drawing was compared to the plan of 1855 by Pozzi and the knowledge gained from these has allowed progress from a general reconstruction to one with further details.

According to available sources a distinction was made, crucial to the graphic rendering, highlighting all the buildings for which documentation was available, compared to others in the area of which there was no clear information. From some of these elements, paintings, plans and sections, it was possible to obtain nearly complete data, including the directions by Poggi regarding the portion of an individual stable to be expropriated. For the rest of the area information was obtained from the data offering the most approximate values. For example, only some maps or only some perspective drawings served to reconstruct the number of levels, the size, the types of building, some of the facades and the purposes of the buildings.

It was not possible to find information regarding the other buildings, especially concerning the state before the work; so, rehabilitation operations have been adopted based on a process of deduction and hypothesis. In Piazza alla Croce and in Borgo la Croce, for example, knowing that the destination of the buildings was mainly residential, it was assumed that the buildings were homes, establishing size, number of floors and roof shapes fairly approximate according to the type of adjacent buildings or their surroundings. Along the way to the outer wall towards the Arno River, where some documents illustrated stables and storage, lower and larger buildings were indicated. Depending on the type of reconstruction, buildings were divided into: TYPE A, TYPE B and TYPE C. (Fig. 6)
In the study of the buildings during this research, however, the procedure was based mainly on the observation of the current situation in the area, assuming that many of the buildings constructed in those years have remained virtually the same. Distinction of what is certain and what it is only suggested has been kept in mind. In fact, another document that gives a general idea of what the square was like before the work is, the report Sui lavori per l'ingrandimento di Firenze where Poggi describes accurately the area, providing some details about the types of buildings, the slope of the land, the use of the square, the intentions and motivations of the project, especially with regard to the next stage of the project. In particular a photo of 1865-66, showing one of the first buildings constructed by Società Anonima Edificatrice has been taken as a point of reference for the general reconstruction of the district during the project. (Fig. 7)
Fig. 6 – Some examples of reconstructed buildings, divided in TYPE A: higher number of fonts and more precise informations, so more details and higher level of definiton of graphical representation; TYPE B: lower number of fonts and less precise informations, so less detail and lower level of definition of graphical representation; TYPE C: no fonts or not enough informations, so basic and simple representation.
Regarding the aspect of the ground, the situation before the project was very different from what it is today. Thus it was necessary to reconstruct a very irregular and bumpy ground. To do so, the only accurate sources used were, once again, the drawings of the architect. Some of these show longitudinal sections respectively: along the new boulevard from Porta a Pinti to Zecca Vecchia\(^3\), along the street outside the walls and along the way inside the walls. These drawings are superimposed on the state before the work and status of the project. There are also a number of cross sections, more or less equidistant from each other, that cut the strip of land between the street inside the walls and the outer one dissecting the walls, from Porta a Pinti to Porta alla Croce.

All these drawings are in scale and have provided accurate data about the height of the walls in that stretch and the inclination of the ground, in addition to the shape of some ditches and mounds near the walls. By crossing the data of the various sections, both longitudinal and transversal, it was possible to fairly accurately rebuild the strip of land occupied by the walls and the two-way internal and external views which would later become the space for the new avenue. Furthermore, the drawings also present paths that indicate the inclination of the new road. So it was possible to reconstruct the lay of the ground after the work, always making a comparison to the stretches of the level curves of the area in their current state.

\(^3\)Zecca Vecchia is a tower (Torre della Zecca) that closed the walls of the city to the Arno east.
The Mattonaia quarter before the works

The Mattonaia quarter around 1855 was an underdeveloped part of the center of Florence. It was inserted at the edge of the old town, which was well established and widely built, towards the walls in the north east of the city. Historic maps demonstrate the contrasting density of buildings in the center of the city against the expanse of gardens and courtyards as they gradually approach the walls. In particular, the district had a series of terraced buildings along the streets that bordered Borgo la Croce, Via dei Pilastri and Borgo Pinti, which appeared to be the least built-up, with some buildings interspersed with courtyards, and led to one of the two city gates that access the neighbourhood, Porta a Pinti.

The other gate in this neighbourhood was Porta alla Croce, inserted in the center of Piazza alla Croce. This space towards the outside of the city appeared as a square not well defined, surrounded by some buildings. Thanks to the sources, it was found that there were houses, a building with an outdoor area for the weekly market and other buildings, not clearly defined; but, mostly warehouses, stables and stockyards. Many of them, in whole or in part, would be expropriated and then demolished to make room for the new square.

According to the plans Porta alla Croce was destined to enter in Borgo la Croce, a road lined with mostly residential buildings with terraced houses on 3 or 4 floors. On the back of the houses a courtyards were often present, on both sides of the street. Here too, the first houses of the street were demolished under the provisions of Poggi in the following years. The road widened into a small square, Piazza Sant'Ambrogio, with its homonymous church. Continuing the way that took the name of Via dei Pilastri, with a conformation similar to the previous one, the only street that crossed Borgo la Croce was Via della Mattonaia, a fairly secondary street which gives its name to the entire district because of the presence of brick kilns in the area.

It was almost a country road, because it crossed the district reaching the walls and meeting virtually only vegetable gardens, justly called Orti della Mattonaia.

This parkland was largely owned by big convents and some Florentine aristocratic families, and was divided into crofting plots of vineyards, orchards, vegetable gardens and gardens. For example, the Convent of Santa Teresa that was in Via della Mattonaia included a large vegetable garden, surrounded by high walls bordering Borgo la Croce.

The area taken into analysis also extends south of Borgo la Croce, limited by what was called Via della Fornace, the current Via dell'Agnolo. This zone contains the convent of Santa Verdiana. The convent has been subjected to numerous interventions and restorations over the centuries, becoming first a slaughterhouse and, after the abolition of the convent in 1865, was transformed into a women's prison. Today it houses the headquarters of the Dipartimento di Architettura of the University of Florence. (Fig. 8)

Along the walls, especially in the north of the district, the ground shows great differences in height. On the inner side of the walls there are large bumps of ground, and more precisely, in Porta alla Croce and on the stretch of wall to Porta a Pinti, it’s reported that the ground rose up to 5.5 meters compared to the floor of

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Porta alla Croce. It is supposed that these accumulations of earth were placed next to the walls on the inside as a reinforcement of the city in case of an artillery attack. Finally, to all this must be added the masses of debris and waste products accumulated as the city pushed outward to create this irregular situation\textsuperscript{6}.

Giuseppe Poggi's Masterplan

In 1865, Florence was proclaimed capital of The Kingdom of Italy. The city was surrounded by walls, with the focal points on the dome of the cathedral and other monumental buildings, in a centuries-old balance between built areas and open spaces, gardens and orchards, especially near the walls, as in the district of Mattonaia. In a short time the city underwent a change of role and function, highlighting a number of functional inadequacies of its urban fabric, without a distinction between areas divided in public functions or private. The town urgently entrusted the architect Giuseppe Poggi with the implementation of a plan to expand the city. That plan was delivered on February 18, 1865.

The project had to answer a number of pressing issues, such as how to provide new housing and services for the population increase caused by the arrival of employees for the offices of the Capital. The customs station had to be moved to the one formed by the walls. The city needed a new defence from the floods of the Arno River. The plan also needed to give the city a celebratory, modern and bourgeois face, in line with contemporary trends in other European cities. One of the key elements of the plan was the demolition of the walls on the north side of the Arno, to create the new boulevards.

With the disappearance of the walls, the city lost a fundamental element of its structural, functional and formal definition. The distinction between an inside and an outside disappeared, and a new relationship began between the various parts of the city and between the center and the periphery quarters.

This happened right in the Mattonaia quarter. A neighbourhood inside the walls, but almost comparable to the countryside, was transformed into a dense set of isolated housing. The figurative presence of vertical walls contrasts with the horizontal design of the countryside, replacing the section of the tree-lined avenues interposed between the internal development of the new districts and the external expansion along the whole circuit.
The Mattonaia quarter after the works

The northern part of the district was divided by a series of streets perpendicular to each other to form blocks of buildings in the course of the following years of great growth. In the center of this quarter a large central garden square was built: Piazza d'Azeglio. The protagonist of this process was the Società Anonima Edificatrice, founded in 1848, which built accommodations for more than 700 families. One of the first buildings dates back to 1865-66, when the area was still under construction. The building is located on Via della Mattonaia at the corner of Via Niccolini, one of the new roads built by Poggi. The main landmarks of the neighbourhood, like the church of Sant'Ambrogio, the convents of Santa Verdiana and Santa Teresa, that

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were already present in previous years in the work, remained almost intact, in some cases changing their use. The perpendicular mesh of orchards and gardens in the neighbourhood before the works was thus replaced by that of streets and blocks.

Three-dimensional modelling

3D modelling for graphical display
The aim of the reconstruction consists in the creation of two models in scale 1: 1000. To do so, starting from what has been possible to study and understand about the area, it was important to adopt all the information to the operations of digital modelling. The main elements to be played were the buildings and soil, carried out separately and in parallel. Based on the amount of information and details that have been collected for each part of the reconstruction, distinctions were made for their graphic representation, and then later for the plastic figures. Two types of modelling were distinguished: one intended for graphical display, such as renderings, the other for the production of the plastic figures. In fact, the very small scale of the model did not allow inserting a number of details, and also because the 3-D printing demanded a series of measures and adaptations that had to be made to the original digital model. With regard to the neighbourhood of Mattonaia, modelling has focused more on Piazza alla Croce and the surrounding buildings, such as changes in Borgo la Croce demolished later, and consequently Piazza Beccaria and its avenues.

For all other parts of the area a decision was taken for allowing a more approximate reconstruction that is reflected in the modelling and in plastic figures, both because of the large amount of items, and because the part most involved in the changes of Poggi was indeed that described above. For convenience the model of the quarter before the works will be called before, and the one after the work after.

For buildings, both in the before model and in the after one, as already mentioned, a distinction was adopted between those that had complete sources or sufficiently comprehensive ones and those reconstructed on assumptions. The number of details in this case is proportional to the number of the collected data, such as for the TYPE A: maximum accuracy in design was adopted. Mouldings, arches, niches, decorations, steps and other types of secondary elements have been reproduced, as in the case of Porta alla Croce and the adjacent galleries. For Type B fewer details have been placed, reporting windows, roof overhang, shadows and more generic elements. As for the other buildings located near Porta alla Croce, of which there is little or no information, TYPE C, was the option calling for a more bare graphic, with no elements in the facades, without overhang of the roofs, but still respecting what sources have described and making assumptions quite realistic about the number of floors and the roof shapes. The same approach was taken for all buildings in the neighbourhood, on Via dei Pilastrì, Borgo Pinti and in the inner portion. (Fig. 10)

For the after model the distinctions are the same, regardless of the fact that many of the buildings in the model before which have a high level of definition are those that were demolished as a result of the works, and then in the second model virtually all the buildings of Borgo la Croce are represented in the most approximate ways (Type B and C). A higher level of accuracy was chosen for Piazza Beccaria, thanks to plans and sections. In this second model, a further distinction was made, for the development of the district, as previously described. Only a few buildings, which more or less were present in the 1870s were
represented as they were during the work. As for the others that gradually arose in subsequent years, the model represents them only with their shape, to make it clear that they would soon be built. This operation was mostly aimed at the realization of plastic figures.

3D modelling for plastic figures

Since the goal was to print a number of elements in scale 1:1000, the modelling was adapted to a different level of detail. So even those buildings that had been treated with higher definition, in this case, have been deprived of elements in the facade, stairs or small shelters and decorations to adapt the models to a scale so small. To highlight these types of buildings the roof overhang in front remained. The only expedient that has been adopted, in addition to always maintaining the overhang at 1 meter, is to give a thickness of 1 meter to the ground level in the most extreme part of the projection rather than leave it at zero, so that it proves 1mm in the plastic figures. Even the gate has been deprived of some accessory elements, while maintaining the openings in both layers. All other buildings appear as simple blocks topped by two sloped roofs. (Fig. 11)

Fig. 10 – Some examples of buildings in 3D model for graphical display, divided in the three types.
Fig. 11 – Some examples of buildings in 3D model for plastic figures, divided in the three types.

**Soil**

The soil of the *before* model, as already explained, appeared to be very irregular originally; but then, through the sections by Poggi and combining the data obtained from all drawings observed, a network of points in proportion to different levels was created in the places on the strip occupied by the walls. Based on the point which represents the threshold of *Porta alla Croce*, taken as a reference, it joined this set of points with those derived from shares of the contour lines of the plan of Florence as it is today. In this way it was possible to build a course that combines information taken from different sources and maps throughout the whole neighbourhood.

By this point network a three-dimensional sinuous surface was built. Thus it included peaks near the walls, due to uneven ground.

Once the surface had been divided, "slicing" it through level curves, about 30 cm apart from one another, so that in the scale of each plastic would have been 0.3mm, the surface composed by the superimposition of layers that had to be quite homogeneous and continuous could be created. For the *after* model the project was easier to define because the ground appeared much smoother and cleared after the work of Poggi. Then, by comparing the coordinates of the points taken from the sections of the project with the contour of present-day Florence, noting that they were very similar, the ground surface is constructed according to the interpolation of these points. (Figs. 12, 13)
Fig. 12 – Stages of the construction of the soil surface before the works.
Preparation to printing and laser cutting

Before the printing stage, the individual parts had to be organized to be ready for production. A code number was given to each single piece, with a letter according to the type of element that it represents and the sequence number. For example, a portion of the walls was called 01.W, with W for Walls, and so on for all other pieces of walls, or building 01.B, with B which stands for Buildings, with the assigned numbers starting from the before plastic until the after plastic. In this way all the components were classified and subsequently divided before printing.
This was made for reasons of practicality, in order to send more pieces at once to print and save time. This also allowed some parts, due to their small size, to be preserved, and be more easily located for their positioning during assembly.

After defining the curves, the laser cuttings were projected all on one floor, overlaying the entire plant area, roads, paths of the gardens and templates included. The next step separated the curves from each other, retaining in its interior the respective portion of the map, so that each bend could be treated as single and independent. Next they were cut one-by-one and the laser engraved each segment in its interior. In this way, once it printed all the curves and they were mounted one-over-the-other, it was possible to reconstruct the documentation of the district.

**Plastic figures**

The printing process, which was made by machines in the Laboratorio Modelli di Architettura of the Dipartimento di Architettura in Florence, is formed by two different mechanisms: the 3-D printer, which produces the buildings, the walls, the gate and all other similar elements, and another machine dedicated to laser cutting, with which all the curves of level for the ground were obtained. Then it was possible to assemble all the elements together.

First, the material used for the construction of the buildings is PLA, or polylactic acid, a plastic made of renewable starches, such as corn or sugarcane, which comes in the form of filaments of various thicknesses. The material is placed in a coil which is connected to the machine. The printer, in this case Maker Bot Maker Bot Replicator 2 and Maker Bot replicator fifth generation, works through a printing head, which receives data via a normal USB key, and plays on Cartesian coordinates x and y. The z coordinate is given by the base plane that is gradually lowered during printing, so that the material develops vertically. The PLA is melted by the machine at a temperature of around 230 °C, and it forms a fairly liquid paste that goes into creating the object, layer after layer, respecting all coordinates. It creates a design made of overlapping, also visible on the surface of the printed product. In addition, the printer produces a base for each piece or group of pieces, which serves as a support. Each element must then be detached from its base.

The production process of a component, such as a cube, is to create the envelope as previously described, and fill the inside with what is called *infill*, a kind of mesh honeycomb, wide and light, which serves as a fill volume to reduce the time of printing and gives less weight to the object. Also, for any openings in the model or protruding elements, the printer produces a mesh to support the protruding portion or the hole as it proceeds during printing. This is done so that the parts will not yield. The support material must be removed after the printing process is completed.

It is necessary to respect some rules in design so that the machine is able to correctly read the data transmitted, like closing all sides of the model. Openings cannot be left as holes, double sides must be eliminated and many-fold corners cannot have folds that is more than two faces on the same edge. The program that manages the print data creates X3g files, which are then transmitted to the machine, sending information about the printing temperature and the type of geometry. The printer has a resolution quality of the average curve of 0.2 mm in height that is a proper relationship between the model size and printing times.
Laser cutting is done by a machine that cuts many types of materials with extreme precision. In this case it was used to cut and engrave a series of contour lines on a white cardboard with a thickness of about 0.3 mm. The machine distinguishes the different layers that are set in the input file: one for cutting and one for the incision. The result is a curve with a slightly dark edge, due to burning by the laser, with a series of incisions of the same color in its interior.

The process that leads the digital modelling to 3-D printing made numerous attempts at troubleshooting, with continuous updates and adaptations of the digital model, based on the results of the printed object. The mounting of the plastic figures was started from the contours of the soil. Curves were superimposed one above the other in their numerical order, with very thin glue, to obtain throughout the entire surface the floor plan of the neighbourhood. Once all the pieces were printed, each element was cleared of excess material, often by simply pulling it away and, in more complicated cases, using a precision instrument. Then each building or group of buildings was put in place using the drawing engraved on the surface as a reference point. (Fig. 14) The distinction that can be noticed in the plastic figures regards the buildings, which are all those reconstructed and divided into the three basic types described, only those engraved on the surface, representing the future buildings and some blocks that are not part of the neighbourhood of the Mattonaia, are just hinted at through a layer of cardboard which highlights the silhouette of those buildings.

Finally, the two models were displayed at the exhibition *Una Capitale e il suo Architetto* organized by the *Archivio di Stato di Firenze* to celebrate the 150th anniversary of Florence the Capital of Italy, from February 3 through June 6, 2015. (Fig. 15/16)
Conclusions
The aim of this analysis was to reconstruct two past situations of the city, showing the changes and understanding how Florence has grown thanks to the intervention of Giuseppe Poggi. The goal was achieved with the creation of the two plastic figures, which help understand the historic events better. We can see how the city was literally opened and how it absorbed some territories that were not even part of the town, creating a dense mesh of blocks full of buildings. Those buildings in the following years began to house a large number of new citizens.
This was a very interesting job, not only from the historic path, but also because of the processes from the study of the sources to the construction of plastic figures using the innovative technology of 3-D printing. That technology allowed every single piece of the models to take shape. Finally, the exhibition of the State Archive of Florence allowed the two plastic figures to be displayed, so the result of this process could be observed and understood by people visiting the exhibition; thus, giving sense to this work and at the same time celebrating such an important event in the history of Florence.

References