1 INTRODUCTION

In the first years of the XIXth century, the French revolutionary army conquered all continental Italy, either acquiring it to the empire (from Piedmont to Rome), or founding the new kingdoms of Italy (whose capital was Milan) and of Naples. That secular splitting up of the territory in a multiplicity of little states had seen the rivers as borders strengthened by nature, whose not numerous crossings -by ferry, simple timber pile bridges and pontoon bridges- had to be controlled and sometimes interrupted with very little expense. The new political condition, similar to that already existing in France, required easy and safe connections, practicable in every season, both for the administration and for the commerce. While in the city the great bridges of the past subsisted (Rome, Florence, Pavia, Verona…), the renewal of the territory road system reflects Napoleon’s will, that declared “J’ai fait consister la gloire de mon règne à changer la face du territoire de mon empire. L’exécution de ces grands travaux est aussi nécessaire a l’interêt de mes peuples qu’à ma propre satisfaction” (Fig. 1).

The short existence of the Napoleonic empire didn’t allow the conclusion of the main part of the works, only conceived or really undertaken, but it started the progress of knowledge and modernization as realized in the following decades. The realization in north-western Italy of some great arch bridges in freestone or in masonry, connected to the restructuration of the alpine roads and to the opening of new ones between Italy and France, occurs in this context.

1.1 Territory condition and “state of arts”

The main passes between Italy and France were Moncenisio and Monginevro already in use from the ancient times. These two roads, entirely renewed for the passage of wagons, armies, artilleries, converged to Turin, already capital of the Savoy kingdom, and then they spread: the first towards Lombardy and Venetian, the second towards Rome and central Italy coming out of the city, respectively the torrent Dora Riparia and the river Po. The Dora was crossed by a ford and by a wooden toll bridge; the Po was crossed by rests of a strengthened medieval bridge, whose collapsed arches were mainly replaced by wooden planks.
Differently from what happened in France in the two previous centuries, when the traditional knowledge and the indications of the classical treatises were compared and developed through the experience of the modern buildings - experience systematically compared in the XVIIIth century thanks to the Corps des Ponts & Chaussées and the institution of the related École - the lack of occasions of remarkable experimentations consolidated the practice in Italy in that of the Renaissance treatises; in spite of the progresses in the field of statics and of hydraulics after the affirmation of the Galilean method and of the physical-mathematical sciences. Matters as the theoretical behaviour of the vaults or of the river course and of the water action were known; but the lack of experimental occasions didn't make possible to find correspondence in the innovation of the architectural types and of the constructive techniques.

Figure 1: The bridge on river Po and the Cours Impérial, as symbols of the renewal of the Piedmontese territory in early XIXth century (watercolour, G. Bagetti, 1814).

Figure 2: The Piedmontese territory, elaborated from J. Arrowsmith, A new Map to illustrate Broke don's “Passes of the Alps”, London, 1825:
- Bridges: I, on the Po (fig. 1, 3, 4); II on the Trebbia (fig. 5); III on the Taro (fig. 6); IV on the Dora Riparia (fig. 7, 8, 9); V on the Dora Baltea (fig. 10); VI on the Ticino (fig. 11, 12).
- Rivers: 1 Po; 2 Trebbia; 3 Taro; 4 Dora Riparia; 5 Dora Baltea; 6 Ticino.
- Cities: T Torino; N Novara; M Milano; A Alessandria; P Piacenza; Pa Parma; C Chambéry; G Grenoble.

1.2 The engineers and the architectural types

The alpine passes and the Italian road network renewal program, whom the new bridges constituted the characterizing elements of, started both by French engineers of Ponts & Chaussées, and by some Italian associates of the pre-existing local institutions, that continued it in the years after the Restoration, assimilating by experiences, techniques, composing models and administrative procedures, adapting them with originality to the reality of the places and of the resources. In about twenty years, the evident gap in comparison with the more recent experiences has been filled, and the Italian technique had to face another hard comparison: that with the industrial revolution technology, founded on raw materials of importation (iron, coal). Consequently, the technique has even more indissolubly interlaced in the political and commercial evolution, confirming the historical necessity of the processes that founded the buildings here indicated.

A fundamental role had the theory and practice diffusion through manuals and reports, at first in the French original editions, in the XIXth century even in their Italian translations, as in general about architecture of the Rondelet’s treatise, and more specifically about bridges the works of Belidor, Gautier, Perronet and Gauthey. In particular, the text and the tables of Perronet’s works constituted the undisputed principle which report the motivations, the
typological choices, the composing models, the constructive processes and building yard organization.

The Italian constructions adopt the French models, adjusting them both to the local hydrographic conditions, and to the demand of technical simplification and of cost reduction. The prodigious lightness, the great lights of vaults, that characterized the last works of Perronet, remain unsurpassed references, that guarantee the technique and typology’s diffusion in the numerous new realizations even in the annexation territories.

Particularly, the freestone bridge technique developed also where it was never used, as in the case of north-western Italy. In the same way the strongly reduced vault’s rise, polycentric or with circular arch ring, are commonly used as the different solutions codified in France in the second half of the XVIIIth century about foundations, piers, road profiles, relationships between cutwaters and flood levels, and generally about their composing characters, synthesis of art and of science.

2 BRIDGES OF THE NAPOLEONIC ROADS

2.1 The napoleonic roads in north-western Italy

The great bridges here illustrated are placed along two of the main Italian roads renewed during the Napoleonic empire, attested in Turin: the Grande Route de 2 e classe n°99 de Turin à Naples par Alexandrie et Parme and the Route Impériale de Turin à Milan that correspond respectively to Strada Statale Padana Inferiore (to Piacenza and then to part of the Roman Via Emilia) and to the western feature of the Strada Statale Padana Superiore (Fig. 2). On the first we can find the bridges on the river Po in Turin, the bridge on the river Trebbia near Piacenza and the one on the river Taro near Parma. On the second, we can see the bridges on the river Dora Riparia in Turin, on the river Dora Baltea near Rondissone and on the river Ticino, near Boffalora. They are all out-of-town bridges, enclosed the Vittorio Emanuele I bridge, also known as the “bridge in stone”, on the river Po and the Mosca bridge on the river Dora Riparia.

Actually, the city of Turin started its development beyond them a century and half before, so that they are usually considered as urban bridges. Their typological characters are already those of the urban bridges, in width, sidewalk presence, abutment and wing wall drawings. Their position, out of the ancient centre of the city, but aligned in perspective to two principal urban roads, was able to make them inevitably attractive elements and city growth guide lines. Already in the XIXth century, as a matter of fact, the guides and the illustrations of Turin showed them among the more remarkable architectures of the modern city. This condition, yet, shouldn’t make us forget the affiliation to more extended territorial systems and then the necessity to understand them, appreciate them, safeguard them in the context of the remarkable constructions that it is possible to meet along the roads that cross them.

2.2 The bridges of the “Grande Route” from Turin to Naples

2.2.1 The stone bridge on the river Po in Turin

The stone bridge on the Po in Turin was decreed by Napoleon in 1807. The project charge was committed to the Ingénieur en Chef of Corps Impérial des Ponts & Chaussées, Claude-Yves La Ramée Pertinchamp, who followed carefully the principles ripened by the Administration through a continuous experimentation during the last decades of the XVIIIth century (Fig. 3). The bridge entirely in freestone, a gneiss coming from quarry placed at about 30 km from the city, is 150 m long and 12 m width. It is composed of 5 equal polycentric arches with 11 center, traced with the geometric construction suggested by Perronet in the proportion of 1/3. Also the centres were of the same polygonal type used by Perronet, with a precise calculation of the bending and of the wedges position before and after the arrangement. The piers with semicircular cutwaters are 5 meter thick. The foundations are on wooden piles into the ground, the road surface is perfectly horizontal. The rain waters were eliminated in surface and under the cobbled paving, on the waterproofing coat modelled as a level roofing in lime mortar and crumbled tiles, and carried in cast iron gutter on the keys of the vaults. The rigorous lack of every ornamental element, except for the cornice that turns around the wing wall, the
elegance of the proportions, the perfection of the stone hangings, the symmetrical ramps that descend to the river, characterize the bridge, the first of its type and the only one finished in Italy under the Napoleonic administration (Fig. 4). During the construction, between 1810 and 1814, the engineer Charles-François Mallet, succeeded in the role to Ramée Pertinchamp, brought a meaningful change, placing the voussoirs without interposing the mortar joint as in the French models, and stiffening the centres to minimize the settlement (this innovation was however object of an hard censure by the inspector Defougères and of a debate at the Conseil Supérieur des Ponts & Chaussées in Paris).

The bridge was included in a wider urban project, stretching out over the river one of the principal urban axes and symmetrically organizing the interposed area, released from the ancient fortifications, in the shape of a great square en patte d’oie, able to join to the bridge the principal east-west roads of the city. This scenographical disposition was prepared but soon modified: at the bridge-head it was built the votive temple for the king’s return; and the area was reduced in rectangular shape of arcade square. The bridge is yet the original element on which it has constituted this important example of neoclassic urbanism. Some transformations, as the substitution of parapets in stone with railings in cast iron, placed on the edge of the cornices, and the increasing of the road level caused by the installation of the rails for the horse tramways service, have partially damaged the bridge image, which however preserves all its historical and aesthetical value, as basic moment of the art progress in Italy.

![Figure 3: Cl. Y. La Ramée Pertinchamp, Ch. F. Mallet, Stone bridge on the Po, Torino, 1808-1813.](image1)

![Figure 4: Anonimous, view of bridge on the Po in Turin during the construction, winter 1811 (oils on glass).](image2)

2.2.2 The bridge on the Trebbia near Piacenza

The construction of the bridge on the Trebbia, in the west of Piacenza, was decreed in the 1819 by the Maria Luigia duchess of Austria, wife of the emperor who was in exile. The project was entrusted to the Ponti e Strade engineer Antonio Cocconcelli, already official of Ponts & Chaussées under the French government, who was building at the same time the bridge on the river Taro near Parma. The bridge, in brick masonry - finished in the 1825 abandoning the first project that had proposed 11 wooden beams in sequence, 36 meters each, on masonry piers - crosses the wide riverbed with 23 vaults realized on 17,50 meter diameter circle arch reduced of about 1/6, for a total length of 460 meters, anticipating the model of the railway viaducts, as that built soon after not far from this site (Fig. 5). The bridge is still in use in its original width, however deprived of the original parapets, replaced by overhung benches with iron handrail.

![Figure 5: A. Cocconcelli, Bridge on the river Trebbia near Piacenza](image3)

![Figure 6: A. Cocconcelli, Maria Luigia bridge on the river Taro near Parma 1819-1825 (from Cocconcelli, A. 1825).](image4)
2.2.3. **The Maria Luigia bridge on the Taro near Parma**

Also the bridge on the Taro, built for the duchess’s munificence and begun in the 1816, was designed by Cocconcelli. Conceived as the monument of the reconstituted and illuminated dukedom of Parma, it unites a strong commemorative intention, with inscriptions and statuary groups at its ends, with mere utility (Fig. 6). Even in this case, the bridge crosses the very wide riverbed of a still torrential waterway. The hydrographic calculation had suggested to Cocconcelli the forecast of 17 arcades; then brought to 20 after further consultations. The bridge is in brick masonry, with half-oval 3 center vaults set up at the ordinary level flood and spandrels relieved by cylindrical voids, so that to direct the static stresses and to give passage to the water of exceptional flood. This kind of bridge interprets freely the French examples (with a declared reference to the writings and works of Belidor, Perronet, Gauthey, Boistard, Sganzin) and it anticipates the eclectic characters of the nineteenth-century constructions. The bridge where the ancient Emilia road transits is substantially intact and in use.

2.3 **The bridges of the “Route Impériale” from Turin to Milan**

2.3.1 **The bridge on the Dora Riparia in Torino**

The first project for the bridge on the Dora Riparia was designed by the Corps Impérial engineer Charles-François Mallet in the 1813, while he was directing the construction of the bridge on the Po, in the place of the old wooden bridge, located upstream. The bridge axis, chosen for regularity reasons in the configuration of the territory, intersected slantewise the river with an angle of about 22°. The problem will found an optimal solution only some years later, when it became an ordinary matter in the lay-out of the railway bridges. Mallet adopted a disposition with 5 oblique full center of about 11 m diameter vaults with, in the limits imposed by the poussée au vide (Fig. 7). It was a mixed structure: the cutwaters and the lower parts at the flood level were made in freestone, the parts out of water in brick masonry, with an unusual disposition. The project was stopped in Paris by the inspector Defougères’s contrary opinion, who proposed a more regular solution with 3 polycentric vaults, similar to those of the bridge on the Po and of the recent bridge on the Arve in Geneva, which need a previous divertion of the river so that to make the intersection orthogonal.

After the Restoration, the Piedmontese engineers found the question still open, object of long discussions. A sketch of an oblique bridge with three lowered vaults, maybe set in the French way, has been found among the preliminary designs of Carlo Bernardo Mosca - ancien élève at the École Polytechnique -. His final project prevailed and he proposed one great freestone lowered vault, with a span of 50 meters, then reduced to 45. The project is very similar to that unrealized of Perronet for the Melun bridges on the Seine. The choice of the type was determined by prestige reasons more than functional ones (its excessive height on the level of the water for the setting up of the vault at the flood level was the object of censures), in order to state the reached art mastery of the Piedmontese engineers (Fig. 8). The bridge was built between the 1823 and the 1830, and it is still intact and in use (Fig. 9).
2.3.2 The bridge on the Dora Baltea near Rondissone

The renewal of the Route Impériale foresaw the realization of all the bridges in stone or in masonry, allowing yet as provisional solution the construction of wooden bridges, to be gradually replaced afterwards. Omitting the examples of bridges built in wood on smaller rivers, it is interesting to analyse that on the river Dora Baltea, descending from the Aosta Valley, where it was decided the construction of a masonry bridge 9 m wide, without sidewalks because it was situated in the open countryside, with 7 polycentric vaults with 11 centers of 20 m span and piers 4 m thick with foundations in concrete thrown within a sheet-pilings. The first project (1809) of the French engineer Jean-François Mariés proposed a mixed construction: piers and tapered arches in freestone; superstructures in brick masonry with stone finishes, with a vivacious chromatic effect, imitating the project of La Millière for the Pont of Eln. His successor in the charge of Ingénieur en Chef, Alexandre Cavenne, preferred a more conventional construction in freestone, similar to the bridge in Turin. By the defeat of Napoleon, only the foundations and the piers have been build. The vaults were built only after the 1817 under the direction of the Piedmontese architect Benedetto Brunati, who completed the bridge according to the project (Fig. 10). Nowadays the bridge is intact and in use; but the lowering of the riverbed has discovered the foundations that have been mend with bearing piles and encapsulate in rough concrete casting. This is an improper condition, for a bridge that - with that of Torino- testifies this typology in Italy and an important phase of the art progress.

Along the Route Impériale going westwards, it is possible to reach the Sesia river, which was border between the Empire and the faithful kingdom of Italia during the Napoleonic period. Here it was realized a great wooden bridge, designed by the engineer Coudère, that was replaced in the 1843 by a masonry one, it was afterwards transformed in a railway bridge and nearly rebuilt in concrete after the second war.

2.3.3 The bridge on the Ticino between San Martino and Boffalora

The bridge on the Ticino was built between the 1808 and the 1826, following the project of Stefano Ignazio Melchioni (1765-1837), Luganese by birth, graduate at the university of Turin, and departmental ingegnere di Acque e Strade of the kingdom of Italia, under viceroy Eugène de Beauharnais, Napoleon’s adoptive son. The site of the bridge was very suggestive, not only for the landscape of the wide riverbed, but also because it had been the border among territories unified in the “pax Napoleonic”. A bridge of fundamental importance for the communications, but also a symbol and an occasion to compare with those French references known through the treatises and the engravings (the text of Perronet is one of the most important), but never experienced in Italy.

The bridge was realized as it was planned: 11 arcades 24 meter wide, lowered to 1/6, ordinary flood level springer, while the pier cutwaters, 4 meter wide and with mixtilinear triangular profile, are lifted till the highest flood level recorded in history. It is 10 meter wide (Fig. 11). The bridge is entirely covered with white granite from the near Montorfano on the Lago Maggiore, and it was carried on rafts floating on the river. There were two serious difficulties: the bridge axis traced out following the direction of the road was slightly oblique as regards to the course of the river and the ground firmness required a strong and deep piling for
the foundation. While the course of the river was patiently diverted with a constant series of interventions, the piling was an enormous enterprise, for its realization was only possible during the low water periods, that is in the short and misty winter days. About 4000 piles were plunged, with 540 kilo mauls, operated by 46 men, to reach the amount of about 1000 men operating in the yard. During the work management, that any contractor hadn’t accepted, Melchioni improved the work consistence. From the forecast of uniform thickness brick vaults, the bridge was realized with granite voussoirs vaults, integrated by masonry tapering. As a consequence, the bridge seems entirely granite made, particularly appreciable.

While the vault construction was going begin, the fall of Napoleon stopped the works, and the border between the states of the kingdom of Sardegna and of the Austrian Lombardo Veneto was again fixed by the Ticino. The construction started again only seven years later; the Austrian government placed the engineer Carlo Gianella side by side to Melchioni, who stayed in Piedmont. Gianella was born in the Canton Ticino, and had already realized the Sempione road and its bridges in the Italian part. Their co-operation was quite difficult, because the project had been completely defined by Melchioni, but Gianella wanted to take the merits for himself (nevertheless the building yard documentation, preserved in Novara, doesn’t leave any doubts). The bridge was finished in the 1828 (Fig. 12) and four customs pavilions were added at the two heads. A part from any immediate metaphoric connotation, the bridge shows a remarkable architectural and historical value, as the first great modern bridge built by an Italian engineer. Repaired from the damages brought by the II independence war in the 1859 and the second world war, the bridge is today entirely used by the Turin-Milano railroad. It replaces the single track line realized in 1860.

In spite of all these events, it hasn’t undergone further transformations and preserves its architectural identity and it is still a characterizing presence in the landscape.

3 CONCLUSIONS

The appreciation of the ancient bridges is often subordinated to functional demands not otherwise solvable, but their interest in the construction history and their importance in that of people and territories confirms the statement of Perronet, that they are “monuments fit to convey the greatness and the cleverness of a nation”. Consequently, any intervention that concerns them should respect the principles of conservation, compatibility and sustainability, so that their complex values aren’t sacrificed to sometimes utilitarian and contingent objectives.

The intervention on the historical bridges should firstly consider the theoretical and practical “state of the arts” that produced them, trying to limit - as far as it’s possible - the alterations in accordance with a principle of “re-treating” (even in consideration of the quick transformations of our times).

The critical evaluation about bridges, as regards the other art works of the territory, not only remarkable for their own architectural and technical values, requires a similar evaluation of their historical and territorial context. The merit of these works consists both in the their exceptionality and in their contribution to the characterization of coherent and meaningful systems.
REFERENCES

Cantalupi A. 1884. La costruzione dei ponti e dei viadotti. Milano.
La Ramée Pertinchant C-Y. 1809. Ouvrages d’art pour la construction d’un pont en pierre sur le Pò à la sortie de Turin (manuscript in coeval copy). Politecnico, Torino.
Mosca C.B. 1823. Capitoli d’appalto per la costruzione d’un ponte ad un sol arco sulla Dora Riparia. Torino.
Perronet J.R. MDCLXXXXII, Description des projets et de la construction des ponts de Neuilli, de Mantes, d’Orléans, de Louis XV etc. Paris.
Vittone B.A. MDCLXVI. Istruzioni diverse concernenti l’ufficio dell’architetto civile. Lugano.