

The construction history of the N2 motorway: Networking on reinforced concrete in the Canton of Ticino

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ABSTRACT: The N2 Chiasso–San Gottardo Motorway in Switzerland features the global use of reinforced concrete and is a symbol of the modernisation history of Canton of Ticino in the 20th century. This paper addresses the N2’s construction history (1961–86), discussing how the networked relationships among the various actors involved in the project (institutions, engineers, builders, and regional planners) were embodied in the N2’s conception, and shaped a shared technical culture of reinforced concrete design. The studies were conducted within the FSN project ‘Architecture in Canton Ticino, 1945–1980’ (www.ticino4580.ch), which was promoted by the Archivio del Moderno. The main archival sources were the National Roads Office in Bellinzona, the Renato Colombi (head of the National Roads Office), and the Rino Tami Archives at the Archivio del Moderno.

1 INTRODUCTION

The 300km of the Swiss N2 highway links the cities of Chiasso with Basel, crossing seven cantons. The construction of the Ticino Canton sector, which is more than 140km long, began in 1961 and was finished and inaugurated on October 23, 1986. Built over 25 years in segments made entirely of reinforced concrete, the highway is an extraordinarily unified work characterised by evident rigor and formal coordination among the structural works located along its route.

In 1961, the famous Italian critic Bruno Zevi (1918–2000), speaking about the Italian motorway *Autostrada del Sole*, attributed the realisation of an infrastructure that was non-uniform and inconsistent from an aesthetic point of view to a ‘fragmentation of the works’. He complained about the involvement of 18 companies and 27 engineers in the construction of the various viaducts in the motorway’s 84km Apennines section (Zevi 1961). In that same year, in Ticino, 25 engineering consultants and 25 construction firms (in addition to associations, committees, communities, consultants, and consortia) were involved in the construction of the first 10km of the N2 highway (Colombi 1961). Furthermore, along the entire route of the N2 and including its bridges, 78 structures were built between 1961 and 1968, and 115 between 1980 and 1986, 20 years after its initial construction. New structures incorporated technological advances that had occurred during that time.

It is clear that the N2’s formal, structured design is due to a design strategy that differed from the centralised one called for by Zevi, an efficient ‘coordination’ already personified by the architect Rino Tami (1908–1994) (Maffioletti 2008; Navone 2017), who in 1963 was designated the N2’s ‘consultant on

aesthetics’. This history of the project’s construction focuses on that different design strategy, investigated through the observational lens of the network of actors involved.

In the following pages, the organisation of and methods used by the ‘N2 network’ are reconstructed with the general aim of highlighting the network’s role in shaping a specific Ticinese culture in infrastructure design that has persisted in recent works (Navone 2017; Maffioletti 2018).

The analysis focuses on two levels, both conducted by material analysis of primary sources in the canton’s archives, which are as yet poorly investigated: the National Roads Office (USTRA) Archives, Bellinzona; the Renato Colombi Archives, Archivio del Moderno, Balerna; and the Rino Tami Archives, Archivio del Moderno (AdM), Balerna.

At the ‘macroscale’ level, with regard to the canton’s social and political framework, the network of actors involved and their respective roles in the design process have been reconstructed, beginning with the choices of politician Franco Zorzi (1923–1964) regarding ideation and promotion of the motorway project. At the ‘microscale’ level, the design effects of the network have been investigated by following Tami’s actions through a single phase of the project.

Finally, by way of comparison, the specificities of the operational strategy developed in Ticino are discussed and compared to those used in the Italian case, which is considered a direct counterpart of the N2.

2 ZORZI’S STRATEGY

In the 1940s, it was decided to complete the main road network in Switzerland by adding two major transit

routes, one from Sankt Margrethen to Geneva and one from Basel to Chiasso. In 1954, the Federal Council appointed a commission to develop this road network. The commission, which was responsible for defining the legal basis for and clarifying the financial aspects of the operation, remained in charge until 1958, when the commission published its first report. For Ticino, the proposal foresaw a predominantly two-lane road with no motorway tunnel through Saint Gothard. On April 5, 1959, the politician Franco Zorzi was elected councillor of the Department of Construction. Confident that infrastructure would play a crucial role in modernising the canton, he firmly opposed the federal programme, foreseeing the construction of a road that had four lanes and was complemented by the Gothard Tunnel. Following the March 8, 1960 'Federal Law on National Roads', the connecting roads of major importance and general interest for Switzerland were declared to be national roads and were divided into three classes. The Ticino section of the N2 national road was included in the first class, defining it topologically as a real motorway.

Two words, chosen by Zorzi, were key to the creation of a clear operational strategy for the N2 project: reinforced concrete and coordination.

2.1 Reinforced concrete

The choice for reinforced concrete was strictly linked to the canton's economic and productive development.

Inspired by the coeval improvement of the hydroelectric infrastructure, featured in large concrete dams from the early 1950s (Botter Balli 2003), the motorway construction would boost reinforced concrete supply demands and support the establishment of Canton cement production. In 1959, the project for a new cement factory in the Breggia Gorges, the SACEBA, was settled (Buzzi & Pronini Medici 2012). The factory, utilising the limestone resources of the valley, would ensure the supply of canton cement for infrastructural works. The construction of the factory began in 1961, and its activity started in 1963. In 1959, the Agglomerati di Cemento SA company, established in 1913, founded a new plant in Noranco for the upcoming N2 construction sites.

Within the same scope of fostering the canton building industry sector, the choice of reinforced concrete was accompanied by the preference for in-situ construction techniques that continued to be systematically applied in the N2 construction site from late 1979 onwards. For the other Swiss segments of the same motorway, prefabricated and industrialised systems were widely spread from the mid-1960s on, according to general European trends (Menn 1982).

2.2 Coordination

The choice for coordination was undertaken in accordance with the vision of infrastructure as a tool for modernising the territory, avoiding its aesthetical spoil (Zorzi 1959).

In 1959, Zorzi decided to set up an autonomous section of the Department of Construction that would coordinate the N2 project from its layout to construction on site. Thus, on May 5, 1959, one month after his election as head of the Department of Construction, he met with civil engineer Renato Colombi (1922–2015) (Colombi 1959), a graduate of the Federal Polytechnic. Colombi was employed in the hydroelectric sector of the company Blenio SA, and was an expert on large reinforced-concrete constructions. Zorzi explained to Colombi the intention to form a new team of technicians within the department that, under Colombi's leadership, would be entirely dedicated to the freeway project. This team constituted the 'National Roads Office', and was officially established on July 7 of that year (Colombi 1960). As the section's 'chief engineer', Colombi began recruiting technicians. On August 6, he met Zorzi with engineer Francesco Balli (1925–2015) (Colombi 1959), a graduate of the Federal Polytechnic who was also employed by Blenio SA, and a specialist in reinforced-concrete construction.

The National Roads Office began working unofficially on October 1, when Colombi's first collaborators settled in a small villa in Bellinzona (Grassi 1979). On October 7, examinations were held for drafters and to recruit eight civil engineering graduates of the Federal Polytechnic, who were employed by the office under private companies fees (Colombi 1960). The Office's activities officially began on January 1, 1960. The team numbered eight engineers, one technician, six draftsmen, and one secretary in charge of expropriation procedures. Despite its small staff, the Office was divided into three main services: 'design' (directed by Balli), 'geotechnical laboratory and materials testing' (entrusted to engineer Marco von Krannichfeldt), and 'administrative services' (directed by Renzo Sailer). In April, the 'works management' service was added, coordinated by engineer Glaucio Noll.

Between 1961 and 1963, three technical consultants were involved in supporting the Office tasks: the traffic engineer Jaques Richter (Sailer 1992), the geotechnical engineer Ezio Dal Vesco, and the architect Tami.

From its foundations, the Office represented the operational hub for the various actors in the project that ranged from the Federal Council (Swiss government) itself and the canton's municipalities, to engineering firms and contractors. The organisation of the different office section workflows that are reported in Figure 1 held a crucial role in structuring the network relationships between the involved actors.

The Federal Council established the annual loans, the general time planning, and the route layout. In accordance with the law of March 8, 1960, the office design section's first tasks involved design services for the route layout, which was proposed on a scale of 1:25000 by the Federal Council and was detailed in 'general plans' on a scale of 1:5000. During this phase, the office design section drew up the 'general plans' of the individual sections according to a list of priorities (Colombi 1960) and then shared them

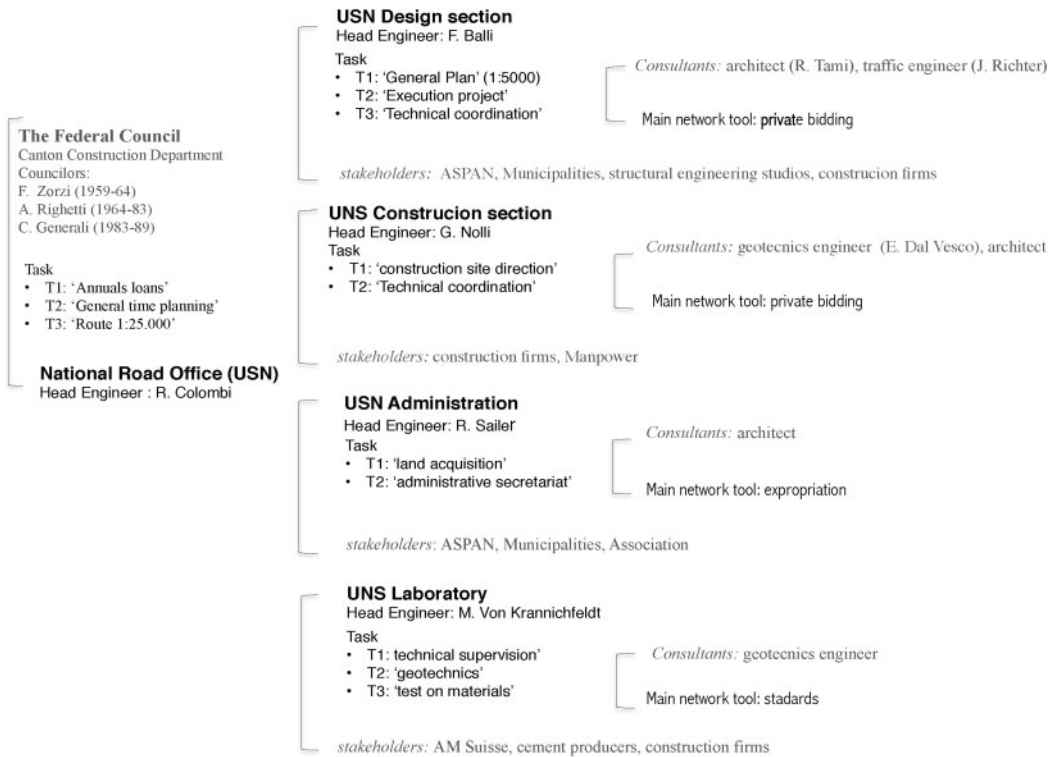


Figure 1. Diagram of the National Road Office workflow and its stakeholders.



Figure 2. Colombi explains the N2 design, 1966 (ETH-Bibliothek Zürich, Bildarchiv, picture by Josef Schmid, Com_L15-0896-0001-0001 / CC BY-SA 4.0).

with the municipal administrations so that they could be examined and commented on by the municipalities (Figure 2). After being modified, the plans were submitted, once, to the Federal Council for approval (Colombi 1961).

While the 'general plans' were under review by the municipal administrations, the design section was working on the final execution drawings of the sections for which the approval process had already been completed. Given the design section's limited staff, the network expanded during this phase to involve professional engineering firms that were already active in the Ticino region. As represented in Figure 2, between 1961 and 1968, while about 25% of the freeway was being built, the Office's staff increased from 14 in 1960

to 168 in 1968, and the number of consulting engineering firms involved in the execution phase increased from 3 in 1961 to 38 in 1968 (Colombi 1968).

2.3 The operational tools: Private bidding

At this stage, consistent with its general objective of 'coordination', the Office used an effective operational tool that was valid both in the design and tendering phases: private bidding competitions. In particular, extending the practice of private bidding competitions to the design execution strengthened the relationship between the Office and the other professionals involved, and enabled the Office to formally control the individual products in accordance with the overall vision for the motorway.

The first private bidding competition for design was announced on January 4, 1961, for the Melide viaduct. Analysis of the jury and its participants clarifies the operational aims of this tool. Five engineering firms (Hans Eichenberger, Gellera and Lombardi, Losinger and Cie, A. Casanova, and Conrad Zschokke), all Swiss and mostly from Ticino, were invited. Among the jury members were Zorzi himself, representing the Department of Construction; Balli and Colombi, representing the Office; Luigi Pini and Amedeo Marrazzi, representing Ticino's professional engineering firms; and architect Tami.

While the inclusion of professional firms on the jury ensured that the Ticino Canton's professional

community was committed to the N2 project, Tami's inclusion was the key element in the public's perception of the motorway as a project that would enhance the region (Maffioletti 2008; Navone 2017). Indeed, Tami was already the director of the motorways section of (Swiss Association for Territorial Planning) ASPAN, of which Zorzi himself was president (Maffioletti 2008; Navone 2017). The jury's reports indicate that the projects were judged from two perspectives: 'construction' and 'aesthetics' (Figure 4). Although it was unusual for infrastructural designs, the aesthetics perspective called for the projects to be verified using photomontages explicitly requested by participants to enable them to check architectural aspects of the designed structure in relation to the landscapes in which they were being built.

Thus, in the Melide competition, Eichenberger's viaduct was awarded the contract because it was considered 'valuable' for its 'lightness and unity of rhythm of the structural elements' (Ufficio Strade Nazionali 1961). Even before the solution was presented, it had also been judged 'excellent' in terms of its construction concept.

Following the successful outcome of the Melide competition, a continuous dialogue was established between Tami and the Office, aimed at the 'harmonious' integration (Maffioletti 2008) of the new road with the canton's landscape. In 1963, when 'the freeway works entered the execution plan' (Colombi 1963), Tami was officially designated by the Council of State as an 'aesthetic consultant for the motorway works', a role he held until 1983.

Zorzi died in a tragic accident in 1964, when the motorway construction was at the very beginning. Both the defined structure of the Office and the organisation of its workflow, with Tami's institutionalised role, allowed the extension of Zorzi's strategy up to the completion of the motorway construction in 1986.

3 TAMI'S ROLE

From the very first construction sites, Tami charged his young collaborator, architect Aurelio Galfetti (1936-), to compile some 'albums of errors'. These albums used photographs and annotations to document the main formal errors made in the design of the various structures and their relationships to the landscape.

These errors were identified, classified, and transformed into a series of 'standard solutions' to be adopted moving forward. Tami elaborated these standard solutions in a series of dense drawings of 'standard bridge abutments' and 'standard overpasses'. In the early 1970s, the Office translated these drawings into a series of 'standard plans' (Ufficio Strade Nazionali 1974), which were execution drawings that included details of the reinforcements for various dimensional hypotheses. They described, for example, inclined walls featuring standard bridge abutments or profiles of the retaining walls to be used on the entire route.

Tami's accurate aesthetic coordination on the structures—explicitly translated into the Office's 'standard plans' after 10 years of work—were introduced in the project's three main phases, from the preliminary drawings to the execution drawings. They were used to train the various actors involved in the design process to ensure a shared practice.

3.1 *Coordination and corrections*

Aesthetic coordination had already been implemented in the 'general plans' drawn up by the Office as the basis for the private bidding regarding design.

During this phase, the dialogue between Tami and the 'design service' technicians focused, beginning with the first sites, on the road profiles. In this way, unique structural figures took shape, both for the substructure viaducts and the road overpasses. In accordance with the global use of reinforced concrete, the substructure viaducts conformed to the image of high-pier girder bridges featuring 'sliding and profile' decks (Figure 5), while the overpasses conformed to the image of 'overpasses with sliding decks and inclined piers' (Figure 6).

The coordination also extended to the control of the final projects that had been developed by engineering firms in the competition phase. By participating on the jury, Tami directly influenced the individual viaducts within the overall view of the sequence of structures. During this phase, Tami designed the special viaduct abutments, as 'inclined connections to the ground', and, to architecturally define the relationship between the viaducts and the tunnel entrances, elaborated the novel figure of the 'tunnel portal' (Tami 1984). Tunnel portals were designed, one by one, by Tami himself, featuring the whole route as a series of architectural artifacts overlaid to the road (Maffioletti 2008; Navone 2017).

During this phase of the project, the most interesting collective effects of this project strategy were suggested in the design of the standard structural bridge type—the high-pier viaduct with a continuous box-section beam—developed by the canton's engineering studios following Tami's indications. For example, the Bisio viaduct (1962–65) and Ruina viaduct (1977–84) projects indicated, on one hand, the continuation of Tami's 'coordination' and, on the other hand, the establishment of a specific competence acquired by Ticino engineering firms regarding this approach to the project.

The Bisio viaduct's design was developed by the Ticino engineering firm Bernardi-Gerosa for a 1962 competition. Five engineering firms (four of which were from Ticino) were invited to bid privately: Bernardi and Gerosa from Mendrisio, Marazzi and Pini from Lugano, Lombardi and Gellera from Locarno, Augusto and Alessandro Rima from Locarno (consortium with Elektrowatt) and Emil Schubiger from Zurich. In addition to Tami, the jury included Zorzi, Colombi, Balli, and engineers Hermann St'ssi, Edmond Rey, and Eichenberger. The Bernardi-Gerosa

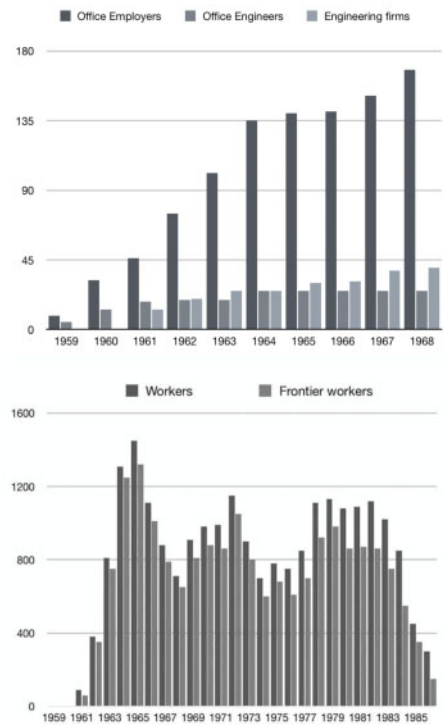
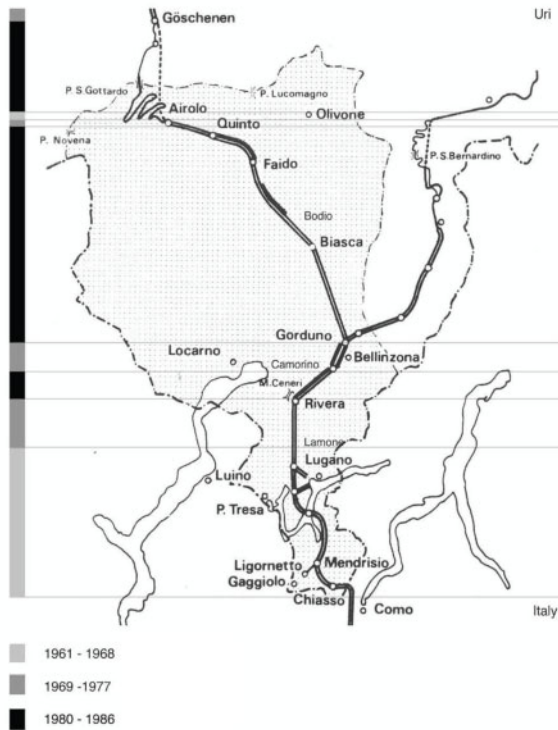


Figure 3. N2 construction periods; numbers of the Office employers and stakeholders (1961–68); numbers of N2 workers (1961–85).

firm won the contract, thanks to its design of a viaduct that was considered of ‘excellent formal appearance’ (Giannetti 2020). After the competition, at Tami’s suggestion, the viaduct’s appearance was further improved by the addition of inclined abutments designed to connect the deck line geometrically with the terrain’s slope.

In the execution phase, the invitation to focus attention on the viaduct’s architectural lines was further reflected in the elegant solutions developed independently by Bernardi and Gerosa. The inclined sections of the deck’s beam box and the strong overhang of the carriageway platform contributed to the elimination of the traditional structures that supported the freeway’s twin roads. Furthermore, the head of the two-cantilevered carriageway was emphasised to create a ‘light band’, which contrasted with the ‘corresponding shadow effect’ created by the overhang. Finally, the design was completed by original commuter devices placed at the foots of the piers and between them and the deck. They were entirely made of reinforced concrete and featured the use of crossbar hinges.

The Ruina viaduct was built in the Biaschina gorges between 1976 and 1984, designed by the engineers Balmelli and Filippini. After a private bidding competition (Ré 1977) that involved five engineering firms from Ticino, Balmelli and Filippini’s proposal won the second prize. Then, their bid was combined with

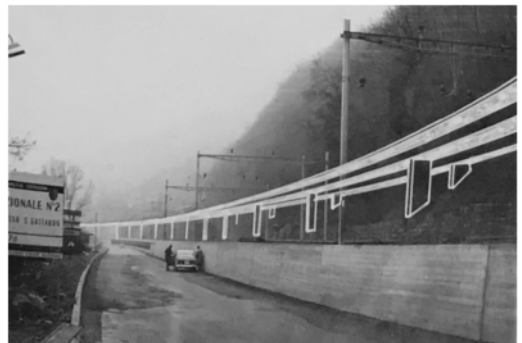


Figure 4. Photomontage for the viaduct study (Ufficio Strade Nazionali 1961).

Kessel and Blaser’s, and thereby won preference in the execution phase. According to the jury’s report, the competition was characterised by a variety of proposals, including those based ‘on solutions that have been widely tested’ and those characterised as ‘new and original’, confronting the jury with a ‘real choice’. Kessel and Blaser’s project, which presented a mixed solution in concrete and steel and was characterised by special Y-shaped supports, was judged the best in terms of aesthetics for ‘the degree of lightness and transparency it offers as a whole’. Balmelli and Filippini’s

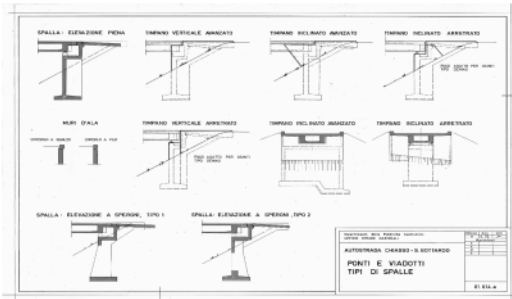


Figure 5. Picture of the Bisio viaducts and viaduct abutments ‘standard solutions’, execution drawings by the Office, 1974 (USTRA, Archive).

viaduct was also judged well for ‘aesthetics’ because it was ‘formally valid’ in accordance with ‘tradition’. In fact, the latter proposal’s deck ‘flowed harmoniously’, and the rhythm of its high, slender piers was described as ‘almost regular’. While its appearance conformed typologically to the vision developed by Tami in the 1960s, in terms of structural design, the viaduct presented a particularly innovative solution. According to the jury, ‘the parts’ sizes responded well to the forces ‘flows’, and the viaduct differed from all other structures on the route because of the design of a unique box deck made of prestressed reinforced concrete that included both of the road’s pathways, thanks to two cantilevered side decks of 7.5 metres.

3.2 On-site corrections

Tami’s influence also extended to the construction phase, engaging in dialogue with the engineering firms, contractors, and more broadly, the Office’s two sections: design and construction sites.

During the first two phases, if the architect’s conception had affected the engineering project, stimulating those professionals to reflect on the overlap between Tami’s formal themes and the structural design, in the third phase, the architect’s influence extended to the construction site, directly involving the contractors and workers in the creation of tailored solutions. One example is the case of the Capolago viaduct, built in 1964 by the Zschokke Company. The project involved building a structure that had spans of 20 metres and slender rectangular piers on which rested, with transverse lintels, the longitudinal beams of a prestressed reinforced-concrete deck, completed with slabs cast in situ. The beams, with T or double T sections, were composed of two prefabricated elements, each 10 metres long, coupled on site with longitudinal prestressing cables, which provided both a productive and constructive advantage. However, the appearance did not comply with Tami’s ‘shaped’ and ‘profiled’ vision set out for the N2 viaducts. Therefore, during the execution phase, Tami corrected the viaduct by designing a new deck cross-section and shape for the connections between it and the piers. By inserting a continuous lateral ‘edging’ in the form of an inclined wall composed of small,

prefabricated reinforced-concrete elements (Figure 7), Tami reconstructed the deck profile to create a continuous longitudinal band that inclined outward. While the viaduct was under construction, the execution drawings, developed between 1964 and 1965, called for the 495 prefabricated elements. They were one metre long and different through the valley from on the mountain, to be assembled on site into the new reinforced-concrete enclosure. In 1968, Zevi appreciatively noted ‘the profile of the prefabricated viaduct of Capolago’, which had been completed slightly more than a year before, for its ‘value of lightening the figurative weight of the roadside’ (Zevi 1968). He thereby culturally validated, in comparison with the much-criticised Italian project, the coordination strategy developed in Ticino.

4 ON THE N2 METHOD

As mentioned, the Italian project was the most direct reference, both productively and technologically, for the construction of the Ticino motorway and therefore is a useful point of comparison in the quest to fully understand the N2’s operational specificities. In Italy, a 1955 law enacted a freeway-development plan with a 10-year timeline. In addition to strengthening the pre-war freeway segments, the plan called for two new highways, the Adriatica and the Sole, which would connect Milan to Naples using 800km of new road. The highway was completed in only eight years, establishing itself as the most daring feat of the Italian ‘economic miracle’ years. In 1959, at the very beginning of the N2 project, the *Autosole* construction sites provided clear proof of the technological success of the reinforced concrete construction in the artisanal dimension of the construction site. In October 1959, Colombi, Balli, and some other engineers directly involved with the Office made a study trip to these construction sites in Italy (Colombi 1959). As they reported, the Italian strategy was based on subdividing the work into small segments and entrusting their completion, on a contract/competition basis, to various construction firms, while *Società Autostrade* supervised the bids (Iori & Poretti 2015). This subdividing strategy was considered effective to the Ticino productive and economic system and, thus, suitable to be successfully re-used.



Figure 6. Extract from the 'album of errors': study for the architectural details of the overpasses; picture of the Soresina over-pass designed by Tami and the engineer Ervino Kessel (AdM, Tami).

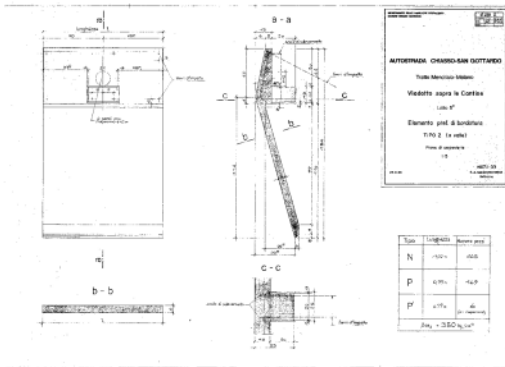


Figure 7. Capolago viaduct, detail of the "edging" elements, 1964 (USTR, Archive).

Over 25 years, the construction involved more than 100 construction companies, many workers (2200 at peak), and more than 40 Swiss consulting engineers. Anyhow, the network- and coordination- strategies adopted in the two countries, differed by two crucial correlated aspects: the organization of the bids, and the role of the contractors. In Italy the bids were dedicated to the one phase of design and construction, while in Ticino were divided into two subsequent steps: the design bid, thus, introduced the possibility to formally coordinate the works. In this way, while in Italy, the contractors played a crucial role in the design of the works, establishing a direct relationship with designers, in Ticino the designers established relation with the 'coordination team', enhancing a network cultural 'training' on infrastructural design. Furthermore, while in Italy the execution phase was 'governed' by the contractors and designers, in Ticino, the Office held a solid directive role in this phase, allowing the coordinate design strategy to extend over the entire time-span of the project.

5 CONCLUSIONS: THE N2 LEGACY

This article discusses the working methods of the network of actors involved in the design and construction of the N2 motorway (1959–86). As a consequence of Zorzi's strategic choices, the structure of the network of actors and their respective roles in the design process were analysed at the 'macroscale'. The effects of the network's working method embodied by the design and

construction processes used for the N2 were analysed through the narrative of the individual works.

In conclusion, it is thus possible to report some findings of the N2 construction history through network-based analysis. First, the network-based analysis shed light on the direct effects of the choice of reinforced concrete as the only structural material used in the N2 on both the productive and economic system of the, and, more specifically, on the design approach. Regarding the productive and economic system, the reconstruction of the Zorzi strategy focused on the fundamental role of N2 planning in the development of canton cement production. Moreover, the related choice for the cast-in-situ solutions proved to be fundamental to enhance the artisanal nature of the construction site, taking advantage of the large numbers of non-skilled workers available (Figure 3). Regarding the N2 design approach, the global use of reinforced concrete allowed Tami's formal coordination to be extended to the under-construction works.

Second, the network-based analysis highlights how the N2's formal unity has been achieved through the Office's operational strategy that, established by Zorzi, was pursued over the years, after his death in 1964, thanks to the crucial roles of Tami and Colombi. In addition to Zorzi's choices in favour of cement and coordination, the Office ensured success by played a lead role in selecting the actors involved in the project and, above all, in their commitment over the years. In this way, a community of technicians that spoke a common design language was established, leading the N2 artifacts to effectively illustrate Tami's best-known writings: *Problemi estetici dell'autostrada* (Tami 1969), and *L'autostrada come opera d'arte* (Tami 1984).

Third, the network-based analysis reveals the cultural training of the N2 constellation, conducted during the 25 years of the motorway construction, as the direct reference of the recent reinforced concrete infrastructural works of the canton (such as the Transjurane). These works, though the intervention of the architect, clearly integrate structural and construction functions with 'artistic directives' (Maffioletti 2018).

ACKNOWLEDGEMENTS

The studies were conducted within the FSN project 'Architecture in Canton Ticino, 1945–1980'

(www.ticino4580.ch) promoted by the Archivio del Moderno. The author would like to express her gratitude to engineer Marco Fioroni and archivist Davide Campana for their collaboration in research conducted in ASTRA's historical archives in Bellinzona, and to anonymous reviewers of this article for their suggestions.

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