Pier Luigi Nervi and the School of Italian Engineering: Science or the Art of Building?

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Abstract. The recent and painful event of the collapse of the Riccardo Morandi bridge in Genoa has brought to light in international debates what, in the second half of the 1900s, was recognized as the School of Italian Engineering. The sixties mark a pinnacle in the relationship between technical and scientific studies, the evolution of infrastructural networks, and a specific attention to the importance of form in the final result of engineering works. The Stadio Flaminio, designed by Pier Luigi Nervi (1891-1979) on the occasion of the 1960 Olympics, internationalized an engineering approach that can be identified as made in Italy. This paper aims to analyse, starting from a charismatic figure like Nervi, what the characters of this identity are and if, in light of recent failures, we can talk about a school.

1. Introduction
Around Nervi, personalities of the caliber of Morandi, Sergio Musmeci intertwine, who contribute, through sharing or through contrasting positions, to interpreting this heritage. The realizations of the bridge over the Arno to Incisa by Silvano Zorzi (1962) and the cable-stayed bridges by Riccardo Morandi on the Maracaibo lagoon in Venezuela (1962) and on the Polcevera in Genoa (1964), mark the highest moment of this art of building and of the Italian research on prestressed reinforced concrete, consecrating the great structure as an identifying element of Italian engineering. This route at some point follows a descending path.

On June 30, 1964 the exhibition entitled "Art in a Changing World: 1884-1964: Twentieth Century Engineering" was inaugurated at the MOMA in New York, which enshrines the leading role of Italian engineering. Next to the already known works by Nervi, Morandi and Zorzi, a number of works by some of the protagonists of Italian construction were presented, unknown to the general public such as: Carlo Cestelli Guidi (1906-1995), Franco Levi (1914-2009), Arrigo Carré (1919 - 2004) and Giorgio Giannelli (1918 - 1985).

The gradual loss of centrality of the prestigious Istituto Sperimentale Modelli e Strutture (ISMES) where many tests and experimental models of constructive works were carried out, sometimes impossible to calculate with the usual rules of construction science and the Vajont disaster (1963), mark the point where the decline of this engineering parable begins, on which an inexplicable silence still descends today.

In 1997 at the Center Pompidou, a retrospective was set up named L’art de l’ingénieur, in which there still are to this day the admirable works of Nervi and Morandi to represent the Italian contribution during the twentieth century. The organization of the exhibition suggests that this heritage is not collected by any future generation, a victim of a failed process of historicization and therefore incapable of representing contemporaneity, represented instead by the tensile structures of Frei Otto or by Richard
Rogers high-tech and Norman Foster, and the constructive professionalism of the Ove Arup & Partners. [1]

Again in 2014, an exhibition inaugurated at MAXXI in Rome, offered a selection of studies, projects, models, drawings and photographs from a collection of 20th century engineers at the MAXXI Archives. On this occasion, among the various conferences, the "Scuola italiana di Ingegneria" by Sergio Poretti and Tullia Iori stood out, among other authors of the SIXXI research. Twentieth Century Structural Engineering: The Italian Contribution, in which they presented some results. [2].

2. The School of Italian Engineering
The protagonism of Italian engineering on the international scene has become lost over the years: the school of engineering has been somehow excluded from a historical perspective. Yet the extraordinary research on structural prefabrication, the testing of systems in pretensioned reinforcing tendons and the realization of slender vaults had led to a lasting success based on the expansive potential of the resulting structures.

To be able to resolve this issue, we should take a few steps back. The success of Italian engineering is undoubtedly based on the long experimentation and use of reinforced concrete, during the period of autarchy and until the Second World War. Reinforced concrete has almost completely replaced metal structures since the beginning of the 20th century. The pioneers in the scientific study and in the technical application of reinforced concrete structures are Camillo Guidi (1853 -1941) and Silvio Canevazzi (1852 - 1918), and then Arturo Danusso (1880 - 1968) and Gustavo Colonnetti (1886 - 1968). The latter collaborated with the major Italian representatives of the Hennebique system. The collaboration between Danusso and Nervi, for example, has given rise to a whole series of applications on the slender vault, whose structural system gave the possibility of fulfilling the problem of low resistance to the breaking load of cement.

Danusso created the laboratory for models and constructions at polytechnic of Milan in 1931 and Ismes in Bergamo in 1951. From the collaboration with Nervi, the first celluloid model was released for the hangar project for the Air Force in Orvieto (date). In the same years, Nervi developed what would later be called Sistema Nervi, a new method for the production of reinforced concrete structures. The system offered a double advantage: on the one hand, to significantly reduce the use of construction formworks, on the other a respect for the material, based on prefabrication, assembly on site and ferrocement. This system, in its application variants, was perfect for large roofs. Still, the studies on prestressing gave the possibility to arrive at solutions that minimised the use of iron in the construction of reinforced concrete. Another researcher is associated with the use of this system Colonnetti, to whom we owe the projects of the first prestressed concrete bridges, between 1949 and 1951. These constructions were the final outcome of his research, first during the autarchic regime, then in exile in Lausanne, and finally as president of the CNR (National Research Center). [3 p. 120].

In the years that followed the Second World War, Italian engineering could apply much of the experimental research carried out up to that point on real structures. This constructive enthusiasm actually arose from a profound need for physical reconstruction and identity. These occasions gave the opportunity to introduce to the general public and not just a series of capable designers, who constituted a real generation: Nervi, Morandi, Krall, Cestelli Guidi, among the veterans and Zorzi, Musmeci, Carè and Giannelli, Galli and Franciosi, among the youngest. L'Autostrada del Sole, with its high number of bridges and viaducts, has given space for experimentation to the various personalities of the Italian School. In the same period Nervi, with his engineering and construction firm Nervi & Bartoli, imposed himself on the international scene with works designed and realized for the Olympic Games in Rome in 1960. On the other hand, in the same years, Riccardo Morandi developed an equally unique and characteristic design path.

This school has left a great deal of quality works, but apparently no heirs. Probably the first reflection on this decline should be looked for in the shipbuilding setting that has characterized the same Italian construction tradition, strongly artisan and traditional building. In fact, when the energy crisis of the seventies arrived, Italy’s construction engineering witnessed a profound lack of preparation in the face of an increasingly conspicuous presence of high-tech engineering.
The tradition of the Italian shipyard is not associated with light materials and techniques, such as using glass and steel, a characteristic that has automatically excluded it from dialogue with contemporaneity. It will return to the fore only after a long time when, on the occasion of some great contemporary yards (the Roman church Dives in Misericordia by Richard Meier (1998-2003), the MAXXI by Zaha Hadid (1998-2009), the Italian Pavilion at the 2010 Expo in Shanghai) the need to demonstrate high competence in the cement and shipbuilding sectors applied to large structures returned. [1]

3. Intuition or science: the legacy of Nervi

Nevertheless, in this parable of oscillating dialogue with the contemporary and the definition of a trend or school, Pier Luigi Nervi continues to represent an incontrovertible model, even today. Its modernity, more than in the results, lies in the method, in which structure, form and space represent a unit. His contemporaneity lies in his constant, though sometimes unconscious, dialogue with the Italian cultural design past. Ernesto Nathan Rogers, in outlining a portrait of the engineer Nervi, compares it to Maillart, saying that as the latter he was able to give realism to the problem of tekne, bringing it back to its correct and original meaning. The work of these two engineers, Rogers continues, offers a new synthesis on the distinction between "science and art, between use and medium" which until then had always presented itself as a dichotomous binomial. It is the same synthesis that characterized creativity in the medieval architectural construction, in the hands of unconscious artisans, or that defined the architect in the Renaissance through the recovery of the classical approach, making it aware. Rogers goes on to say that in that synthesis the artistic vision of form and its material content must not be a twofold concept that generates divergent paths but rather an intense process in which both are interchangeable. When this process is the fruit of two opposing forces, the architect must solve them in a synthesis. Rogers stated that the word ‘tekne’ returns here to its original meaning and that it does not refer only, as in modern usage, to a coherent interaction of technique and execution at the service of science and art but, as the Greeks intended, to a synthesis of art, science, knowledge, craft, skill and profession. [4]

In an article in the magazine “L’Ingegnere” published perhaps fourteen years before Scienza o arte del costruire?, Nervi began to lay the foundations for reflecting on the empirical method of structural design, concepts repeatedly taken up in his later writings. The question that concerns the whole reflection is whether there can really be a true science of engineering, and how much truth exists and how much adherence to reality, in the numbers with which one dialogues with the resistance of materials and the forces acting on structures. He continues pondering what value these numbers that can be obtained after processes and formulas, which deal exactly with inaccurate things, can have. This need to transform approximation with accuracy leads to results that in one final phase require interpretation and how can we make this interpretation if not with a personal criterion, where the judgment parameter can only be intuition and feeling. In his view, the most serious damage of the scientific illusion of engineering lies in the consequent drying up of the imagination and of constructive intuition, which only, can create a beautiful, economic and stable work. And finally, he concludes in the text by saying that in the evaluation of non-measurable factors lies the true essence of engineering, but in this light it is no longer science but art. And when it refers to the latter term, it does so according to the meaning that Aristotle gave of it, namely meche, which means ability combined with the capacity to grasp the physicality of reality, a characteristic of the practical intelligence (metis) of the engineer. If this does not get used to thinking and feeling the structure, and not simply to calculate it. [5]

You will continue to think that there will always be an incurable contrast between the mathematical mentality and the intuitive mentality, rich in aesthetic sensibility and creative imagination. [6] Nervi has represented for Italian culture, building a milestone. His teachings have influenced, directly or indirectly, a vast culture of building. Around a kind of empiricism applied to engineering, a real school was established, although there never actually existed a conscious sense of belonging to a trend. Giorgio Morandi or later Sergio Musmeci, have participated in building a design attitude that very often makes us really reflect, looking at their constructions, if we are faced with works of "genius" or works of "art". It is in this dichotomous vision of construction that we should read the traces of Nervi's inheritance on his successors, who in their specificity have continued the work. (Figure. 1)
Musmeci, for example, as soon as he graduated he worked at the firm of Nervi & Bartoli, between 1949 and 1951, and then, in 1952, together with Antonio Nervi, started the studio di Architettura e Tecnica edilizia, with Nervi’s father as a consultant. [7 p. 290]

Musmeci’s attitude towards this diatribe between ingenuity and a work of art is clearly expressed on the occasion of the drafting of the text that he will write on the occasion of the death of the master. The great legacy that according to Musmeci, Nervi left to the culture of building were not so much its brilliant solutions but the problems left unresolved, because it is from here that one can start again and reflect on the “relations between the act of building and architectural culture on the one hand and the science of engineering on the other”. [8 p. 12] Musmeci believed that, when it comes to sizing the sections of resistant structures, we have very sophisticated tools, when it comes to making the basic design choices, on which almost all of the result depends. It is in the same conditions as a Renaissance architect: "intuition, experience, static sense, but nothing that puts me in a position to choose (...) with awareness and responsibility". [9 p. 40]

This condition which for Nervi is an incontrovertible fact for Musmeci is unacceptable. For Nervi, this gap can contribute to shaping designers who, alongside the cold, impersonal formulation of the construction sciences, can combine intuition and imagination, giving life to a real "art of building". [10 p. 30]

If for Nervi the rigor coming from the highest mathematical procedures inhibits architectural invention, for Musmeci it is a question of inversion of terms. (Figure. 1)

That is, he maintains that the engineer must not start from the given form and limit himself to determining his tensions, but on the contrary he should be able to fix the acting forces and one or more performance parameters and consider the final shape of the structure as unknown. His design path, in fact, will always be set on finding the minimal form, in which each part is equally necessary. Obviously there is no single minimal form, but a set of possible forms that we could call structural organic forms; and it is within this circumscribed although rich group of possibilities that the intuition and creativity of the engineer are measured. [11 p. 2]

When Riccardo Morandi (1902-1989) began his professional career, Pier Luigi Nervi is already a famous engineer. Their relationship focuses on parallel paths that only cross a few occasions. Both are engaged in university teaching, the first in Florence, the second in Rome; both have their studio in Rome. They meet on some occasions like when in 1962 they were awarded by Aitec (Italian Association of Concrete Economic Technician). In 1960 they competed for the awarding of the works for the Olympics in Rome, but Nervi will build the Palazzetto dello Sport, the Corso Francia viaduct, the Flaminio stadium, the Palazzo all’Eur in the Olympic area, (Figure. 2) while Morandi will build the overpass of Corso Francia and Fiumicino airport (in collaboration). [12 p. 262]

The works of the Olympics will make him a personality known internationally, while Morandi will remain on the fringes of fame, even when he built the 9-kilometer bridge on the Maracaibo lagoon in Venezuela in 1957. When Nervi passes away, Morandi entrusts his memory to the pages of the magazine “Industria Italiana del Cemento”. It is in this essay that one can understand the deep bond that bound the two professionals. Referring to Nervi, Morandi describes him as one who has always influenced his professional life with the example of such coherent activity. Morandi states that he feels the need to analyse the reasons for his long spiritual bond with a man whom he has personally met only occasionally and with whom he has often been a competitor and sometimes also in polite controversy, this more or less clearly expressed. [13]

For Morandi, therefore, Nervi represents a model of professional ethics and coherence, an influence that will accompany him for a long time, despite their obvious distance in research and applications in the construction field. But despite a clear difference, there is a design attitude that unites them: leaving room for an unpredictability that can be solved through ingenuity and intuition.

When both are awarded the Aitec Prize by the Minister for Industry and Commerce, Emilio Colombo, in the hall of honor of the Palazzo della Civiltà e del Lavoro all’Eur, an exhibition is also set up of the awarded works. The judges reward the two masters for their unanimity, recognizing them as creators of an increasingly daring technique, to which concrete allows new processes, new dimensions and new architectural expressions, with a typical contribution to life, work and man's well-being. Colombo states Pier Luigi Nervi and Morandi have well deserved this recognition from their country because they have
honoured it in various world competitions, thus giving authority and prestige to the Italian stylistic and construction tradition. [12 p. 265]
When Morandi receives the telegram telling him that he was equally placed with the engineer Nervi, his satisfaction is doubled by the fact that he is united with a great personality like Professor Nervi.

4. Conclusion: a reflection as a new beginning?
The story of these correspondences, although limited by information available, opens up a series of questions not only linked to the success and decline of a School, but also to the broader concept of the transmission of knowledge and the recognition of a master, of a template. To this, we must add reflection whether or not there is a model of Italian knowledge. The characteristics of both the training and professionalism of Nervi, place him in a sequence of models recognized as emblematic for their typicality in the Italian tradition of building, but also of theoretical reflection around building. Rogers states that Nervi's secret lay in his ability to extract the essence of things and communicate it by expressing the truth. He does not create from nothing, but invents, giving accuracy and consistency to the term, used in its original meaning of invenio. Rogers states that it is like a medium that invokes the spirit of statics leading it to materialize; a spirit that others express all too often as incomprehensible mathematical symbols. The relationship between thought and creative activity is inextricably linked in his mind, continues Rogers, even if, in reality, there is nothing more difficult than expressing complicated things in a simple way. [4 p. 115]

Figure 1. Sergio Musmeci, Ponte sul Basento (Potenza), 1969.  
https://focusarchitettura.wordpress.com/2014/07/27/strutture-romane-montuori-musmeci-nervi/

Nervi combines the two mental attitudes that distinguish those who create and construct spaces: the mathematical, analytical and synthetic, intuitive and artistic attitudes. These two models of being in the world complement each other, do not oppose or cancel each other out. [14]. And this makes it similar to a shared idea, even in an international context, that of Italianness. His example is not sectorial, but interdisciplinary and helps to overcome the ancient diatribe that poetry is entrusted to architects and prose to engineers; this fracture was partly overcome thanks to a way of making history that owes credit to Carlo Giulio Argan and Manfredo Tafuri.

But when a work of engineering like a bridge, recognized worldwide for its importance and for the ability to mark a surplus in the theory and building practice collapses, what does it drag with it? A personality, a profession, a model of knowledge, a cultural tradition?
A first reaction, from those who give a voice to culture, has been that of defense: defending the personality of the design engineer, removing responsibility, showing the absolute specificity of a modus of knowledge that has made us famous throughout the world, and to validate the validity of a tradition that comes from the distant Renaissance.
Now, with the silence of a memory that has already lasted a year, reflection brings to light a theme that increasingly belongs to the contemporary: that whatever object or thought is produced, the recipient always has the task of understanding its absolute preciousness and specificity, and to protect it and then be able to entrust it again.
What we can conclude is that, as Argenti states, the Italian School of Engineering was not born as an ism and was eclipsed before the next formalist drift infected it. It was able to project itself forward, to be also a visionary, without ever having to sever its roots. And perhaps in the elegant sobriety of its structures, in the ability to connect technical knowledge to the creativity of design lies the most vivid and current part of its lesson. In this sense we can speak of a School. [15 p. 1]

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