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VOLUME 1

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and **Ana Paula Pires**

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History of Construction Cultures

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History of Construction Cultures – Mascarenhas-Mateus & Paula Pires (eds)

Problems of sources and bridges

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ABSTRACT: Where does the history of structural engineering fit into the great fresco of historiography? Who is the good historian of structures? What are that historian's sources? Are those sources "honest"? The collapse of the bridge over the Polcevera River in Genoa triggered a profound rethinking of historical research in the field of structural construction in Italy, briefly summarised in this contribution. The paper is an outcome of the Research Project SIXXI–XX Century Structural Engineering: the Italian Contribution, ERC Advanced Grant 2012, headed by Sergio Poretti and Tullia Iori from Rome Tor Vergata University.

1 INTRODUCTION

On 14 August 2018, the collapse of the bridge over the Polcevera River in Genoa triggered a profound rethinking of historical research in the field of structural construction in Italy. The bridge was one of the most iconic symbols of the Italian School of Engineering: it even inspired a construction game for children.

On the one hand, the many doubts about how the bridge collapsed imposed an urgent, scientific commitment to study and carry out precise historical research; on the other hand, the wide dissemination of SIXXI research results among students and professionals – who will inevitably be called upon to intervene in the future – was even more necessary. In Italy, the generalised unawareness of the value of structural heritage emerged from the debate after the collapse. The high level of building experimentation and the high average age of our bridges was not even known to those who had to preserve them. It was necessary to tell everyone about the cultural identity, the technical value and the historical significance of the Italian School of Engineering. This commitment, however, did not prevent the continuous brooding: relative to the way this research was carried out, so devoid of historiographical tradition.

2 THE ENGINEERING HISTORIAN

Is our research really historical research? And, if so, where does the history of structural engineering fit into the great fresco of historiography? In 2005, Sergio Poretti authoritatively included it in the history of construction. Poretti defined the history of construction as "the material history of architecture", quoting Eugenio Battisti who, in the 80s, indicated "the way of building" as "the new frontier of the history of architecture". Poretti recognised, however, that studies of 20th-century Italian structural engineering have never been part of the history of architecture, except marginally. When it happened that a historian ventured to deal with some engineer or bridge, he did so by remaining strictly external, looking from afar, without investigating the real built work, and without even trying to approach the other technical aspects of which that work is the consequence and that engineer is the interpreter: the evolution of scientific thought, techniques, materials, site solutions, regulations, and the lives of workers and companies. (Poretti 2005)

It's true that the history of structural engineering still needs an operation of essentially interpretative and critical synthesis that reconstructs the general picture, but this synthesis, as now consolidated in all the more mature historiographies, must be based on the "slow, patient accumulation of punctual investigations and specialist studies". These demanding, tiring micro-stories, however, struggle to find researchers interested in digging them out of the archives.

This is due to the usual old problem: the engineer is almost never interested in history, in the past. The engineer looks to the future. But training as an engineer, preferably a structural engineer, is indispensable to investigate the intricate carpentry of Morandi and Zorzi or to understand Musmeci's high mathematical reports (Figure 1).

The historian of structures must know how to distinguish a hinged joint from a fixed one, not because they find it written in the reports but because they intuit it from the geometry of the joint itself. In the designs of reinforcement rods, the historian distinguishes secondary reinforcement from prestressing cables and visualises the flows of energy, of opposite sign, flowing in a stay (especially when the steel tie rod is wrapped in a concrete sheet, prestressed by other cables). In the synthetic pages of calculations still carried out by hand, the perfect historian recognises the

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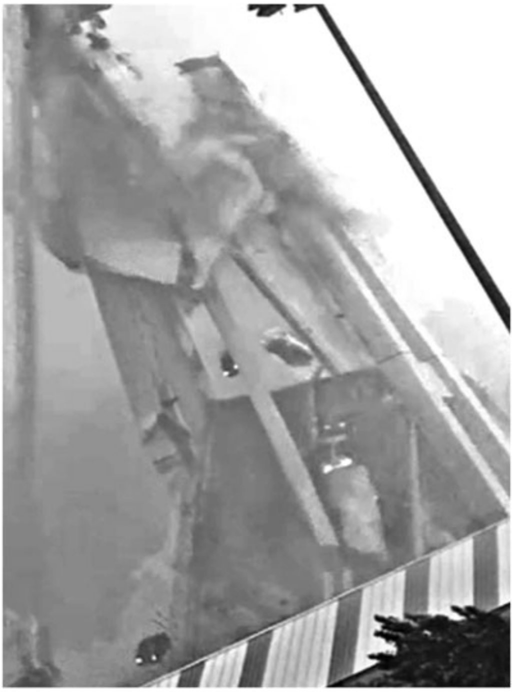

Figure 1. Photogram of the video of the collapse of the bridge on the Polcevera River, accidentally taken by a private camera, 14 August 2018 (SIXXIdata).

starting hypotheses, skips all the steps and understands the approximation of the conclusions. And, above all, they resist the temptation to redo the calculations using modern software: this is the most useless pastime for a historian (while it is a necessary exercise for those who have to verify and validate the current use of the structure – but this is another job!). The historian makes the effort to read the documents with the eyes of a pre-computer engineer, without judging the project with modern parameters. That is, they must renounce the actualization and "presentism" that often infect even traditional historiography. At the same time, the historian knows – and this is much more difficult – all the other stories: the history of the materials, of the construction site, of the companies, but also the political, economic and social history of the country where the work is carried out.

For this type of qualification, degree courses and related "Dublin Descriptors" do not exist. The training is entrusted to the few PhDs with dedicated scholarships, which must intercept and select this very rare figure of engineers interested in history. It takes a lot of luck!

3 THE SOURCES

Compulsory teaching for young, future historians should certainly be a branch of "Contemporary Diplomacy". What are the documents we are dealing with in historical research? Are they "honest", i.e. are they what they claim to be? And what do they really tell us? The dramatic events in Genoa have triggered a further reflection on this too (Iori 2020a).

The historical work I have carried out over the years has always had to do with peculiar documents that are rarely interesting for other research. Researching to study the history of reinforced concrete in Italy, for example, I examined the archives of patents from the origins to the Second World War. Not looking for this or that patent of a known author, but simply browsing through all of those pertinent to the construction technique. The history of the material has practically written itself. Yet the technique of reinforced concrete in Italy has not really been a sequence of commercial inventions. On the contrary: the material has instead been used very freely. But the variation in the density of patents dedicated to specific innovations has made the main steps in the evolutionary process evident. At first, in the pioneering phase, when the combined behaviour of steel and concrete was not yet clear, I found only privatives for fanciful designs of reinforcement. Then, when the technique stabilised around the Hennebique model, to lighten the floors, in Italy, pots were used: in this phase, the patent archive is full of inventions of pots of a thousand shapes. After the Messina earthquake of 1908, the filed patents only concerned anti-seismic frames. Finally, in the time of autarchy, designers spent all their energy to protect the inventions of alternative materials to steel to reinforce structures. Just before the Second World War, the first patents for tools to pull prestressing cables appeared.

The overview of patents that I lined up one after the other was really amazing. Perfectly unknown people, who had not played a role in the construction world, signed most of the inventions. Their patents have never been applied for in practice (Figures 2, 3).

Apart from the topic, which was very timely according to the historical context, many patents were mostly chimeras that could not be realised in terms of construction: e.g. houses hanging like laundry and therefore indifferent to the shaking earth; or the pots for the slabs, shaped like pieces of a puzzle, which, thanks to interlocking, should have become tensile strength, favouring steel savings. Patents are mostly dreams, even of paranoid people who, in order to protect their invention, do not talk about them to anyone, not even to those who can reveal the absurdity of their drawings in a few minutes. And yet, statistically, on the whole, they provide a very precise cross-section of the technological debate and the evolutionary path taken by the material (Iori 2001).

The patent is a peculiar document not only for this reason. The patents of Pier Luigi Nervi, so important for the history of the Italian School of Engineering, concealed more than they explained and generalised more than they specified. For Nervi, the patent served to protect rights, certainly not to reveal the recipe to those who wanted to copy the idea. Hardly ever do his patents help to precisely date the invention, because they were often filed after the first application, when

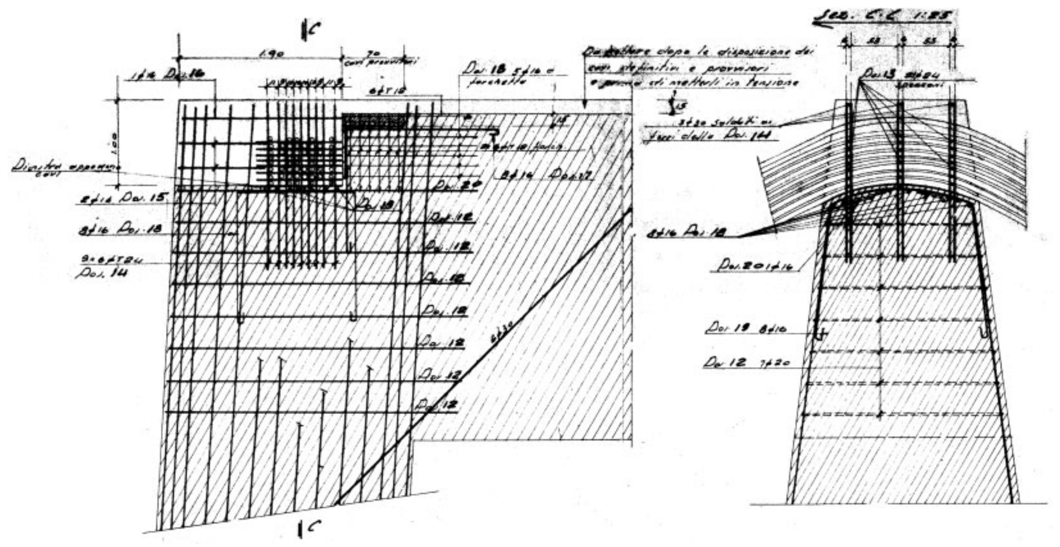

Figure 2. The bridge on the Polcevera River in Genoa. Drawing 299, executive design of pile 9 and pile 10, detail of the saddle, 19 February 1963 (SIXXIdata: Historical archives of the Autostrade Company).

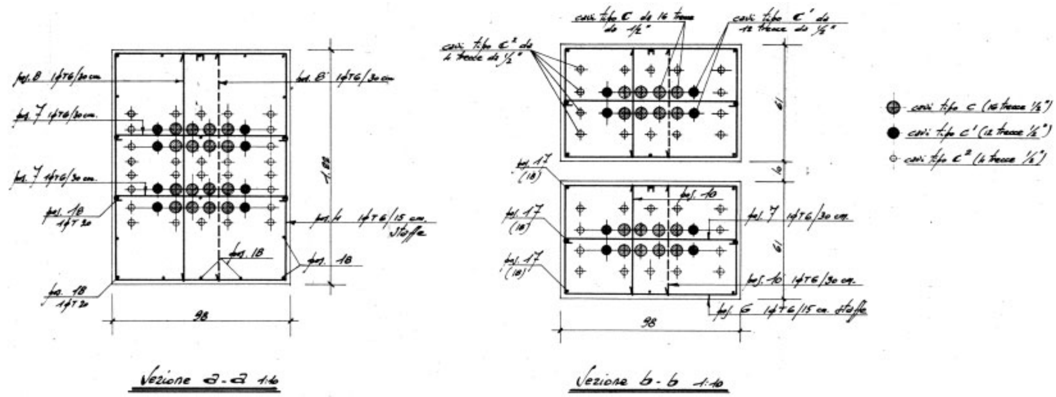

Figure 3. The bridge on the Polcevera River in Genoa. Drawing 327, executive design of pile 9 and pile 10, detail of the stay, 19 February 1963 (SIXXIdata: Central State Archive, Riccardo Morandi Collection).

Nervi understood its real potential, but sometimes before they could be applied, in the hope of finding application (Iori & Poretti 2010). Similarly, Morandi's patents ("M2" in 1949, "M3" in 1952, "M4" in 1955, "M5" in 1961) were not real new inventions: the text of the four patents is practically always the same while the diameter of the cable to be stressed increases from time to time (5 mm, 7 mm, half an inch). It is probable that the trick of re-submitting a new patent served to keep the claims and to prolong the request for royalties to those who used it (including the Condotte Company that built the bridge over the Polcevera) (Iori 2020b) (Figure 4).

For the engineering historian, however, the patent is a "solid" document. But it is essential to know all its limits and peculiarities.

Other documents that crowd this research are the official, possibly registered documents. In order to find a contract or a final static test, we historians are willing to crouch uncomfortably, in a semi-abandoned and dark archive, next to a dead mouse. For some particularly controversial works, even qualified technicians often said that the test certificate was never drawn up: as if this were possible for a public work.

The "Report, visit minutes and test certificate" for the construction works on the 24th lot of the Genoa-Savona motorway – 2.5 kilometres including the bridge over the Polcevera River – consists of 122 pages. They have been signed by the head of the construction company, Condotte, the director of works on behalf of Anas, Luigi Gambardella, and the three members of the testing commission, including the

Figure 4. The bridge on the Polcevera River in Genoa. Pile 10 under construction, detail of the tie-rod cables, 10 October 1966 (SIXXIdata: Archives of the Condotte Company).

expert for static aspects, engineer Carlo Greco. In the report everyone signed the statement that, compared to the contract signed in September 1961 (when, on the other hand, no one knew how to build the balanced cantilevers that overhangs from the pylons), the only project variants were the use of half-inch strands, instead of 7 mm cable, in all pre-stressing operations. With a few sentences, well weighed, the committee is relieved of all responsibility for the executive changes made on site with respect to the 20 preliminary drawings attached to the contract. There were more than 400 executive drawings of the viaduct in the end: a commission's feedback of a few more changes would have been more credible. Also in this case, the certificate had another function, basically an institutional function: it certainly is not used to explain to the historian what really happened during the construction (Iori 2020b).

As another example, during the SIXXI research, the story of the construction of the Risorgimento Bridge over the Tiber in Rome (1909–11) was carefully documented. It is now certain that the drawings attached to the contract had already been completely surpassed at the time of signature. The designer, Hennebique, and the construction company, Porcheddu, were already working on the new project, which was completely different, but could no longer delay the start of the work. Porcheddu had it written in the contract that he could bring variations to the project if these variations were for the benefit of static safety. Is the document with its outdated designs therefore a fake? Of course not: the variant in progress is a constant presence in our SIXXIdata archive. But whoever finds only those official drawings (and not those elaborated for the construction site, never validated by any formal act) could completely misunderstand the functioning of the real bridge (Iori & Savone 2015).

Finally, also in our sources, as in all the respectable historiographies, there are really false documents – not at the level of the "Donation of Constantine", but enough to condition successive episodes of the real history.

In the history of the construction of the Risorgimento Bridge, fake news left tangible consequences: the legend of the early loosening of the scaffolding. Let's remember it: Hennebique wrote to Giovanni Antonio Porcheddu asking that, once they had reached an advanced stage in the casting of the concrete of the bridge's longitudinal walls, in advance of the curing of the material, at night a trained team of workers should go and remove the wedges of the centring, one at a time, according to a precise sequence, and then reposition them but without forcing them. The bridge would be lowered a little, triggering a beneficial process, later called "a plastic adaptation in the most stressed sections". The secret operation was not carried out because a ferryboat crashed into the poles of the centring, broke one and no one had the courage to further disturb the temporary structure. But in 1942, the bridge's calculator, engineer Emilio Giay, told the newspapers that the loosening was done; in the meantime, both Hennebique and Porcheddu had died and could not deny it. Why did Giay do it? Why did Giay tell an "unpublished news" but false, thirty years after a letter he could not show? Perhaps because debate on the bridge had rekindled and doubts about its stability remained, many cracks had been photographed underneath it, and Giay wanted to defend the bridge from the risk of improper interventions, perhaps even demolition, revealing a "magic" procedure that justified the anomalous behaviour of the structure and its "indifference" to the elastic theory. And perhaps also because he wanted to be counted among the protagonists of that "magic"... (Figure 5).

The story of that nocturnal adventure, perpetuated for generations, became "one of the most vivid memories in the career of every engineering student" and certainly consolidated the scepticism of Italian designers towards analytical calculations and their preference for tests on scale models for decades (Iori & Savone 2015).

4 DESIGN VS CONSTRUCTION

There is another classic problem we are dealing with in our historical research: sources can be filtered. It's not necessarily that what we don't find in an archive what has never been there: maybe it simply disappeared. (It happened in recent years that agreements were signed with construction companies to catalogue their archives: in the agreements, the material that could be

Figure 5. The bridge on the Polcevera River in Genoa. Pile 11 under construction, the saddle in the foreground, 12 May 1964 (SIXXIdata: Archives of the Condotte Company).

consulted had to stop at 1992, the year of Tangentopoli, the investigation that unveiled bribes on public works contracts and overwhelmed Italian political life; if we had ever found any later document, we could neither read it nor reproduce it…).

This problem mainly concerns the queen of sources, the one that illuminates our eyes at the moment of discovery but that we had to learn to calibrate: the photos of the construction site. It seems a contradiction: the photos – or the video of the construction site if you are very lucky – would seem the most incontrovertible testimony of the way the work was built. And instead, even the richest collection can hide rather than show.

The scans of about 500 photographs of the construction site of the Polcevera Bridge are collected in the SIXXIdata: over 250 photographs come from the Condotte Company's archive. These photographs show the temporary tie rods and the thousands of work equipments from all perspectives – from the "harp" for the temporary deck prestressing to the cast-in-place form traveller – completely absent from the drawings. However, the photographs only document in detail the building of pile 11, the one closest to Genoa. During the research and before the collapse, it did not seem strange to us: pile 11 was the first to be built, there were probably more doubts to share and document. The pile was also easier to reach than the others, for the photographers charged by the construction company, without struggling to climb the scaffolding. The photos of the other piles are all from afar, panoramic, especially those of pile 9, the last one to be built, far from the Savona and Genoa sides.

And yet, in 2018, the day after the collapse, the American newspapers published a series of photos selected from their expensive databases, dated August 1967, taken by Mario De Biasi, the photojournalist, a paparazzo author of the famous shot, "*Gli italiani si voltano*" (Italians turn around). De Biasi had been commissioned by the magazine, *Epoca*, to produce a report for the August 13th issue (Red 1967). Early in the morning he arrived at the construction site, reached pile 9, climbed dangerously up the stays and reached the top of the antenna, maybe authorised or helped by who knows whom. From up there, he took some unprecedented images that documented the construction site a month before the inauguration. Five photos were then published in the weekly magazine. But not the one that, from the level of the deck, depicts a handsome worker, posing, working on one of the stays of pile 9, sea-side, on the Genoa side, the one that broke first in 2018. In the foreground, in the photo, we see a sheet metal casing wrapping all the half-inch strands. On the contrary, the executive drawings require the cables to be sheathed one by one. No document talks about this casing, no update of the drawings refers to this detail, no calculation considers this modification in progress.

Figure 6. The bridge on the Polcevera River in construction, the stay of pile 9. Photo Mario De Biasi, August 1967 (SIXXIdata).

And above all, why was this variant preferred? What made this simplification necessary? What made it necessary to overcome the sheathing of the cables one by one, as Morandi prescribed? (Figure 6)

The photos in our SIXXIdata database jump from July 7th directly to Giuseppe Saragat's inauguration on September 4th as if there was nothing to document in those two months of final acceleration of the construction site. Instead, the "missing" photos from the archives would be the most precious today. Not even the originals of the photos of the load tests IV, V and VI, which took place on 8 August 1967 on the balanced system supported by pile 10, the largest of the three, can be found today (photos published in the local newspapers). Even "the daily report", which the site manager, engineer Luigi De Sanctis Linotte, will certainly have filled day by day, especially at the end of July, is currently unavailable.

This is surprising, in a database in which everything has been saved: even the telegram that Loris Corbi, general manager of Condotte Company, wrote to Anas on 15 July 1967 to announce the "completion of the demanding viaduct on the Polcevera". That morning, in fact, finally, at the end of yet another 6-month extension granted in January, the Gerber beams that complete the entire deck were launched. (Iori 2020b)

5 CONCLUSIONS

In short, "the sources are traces that the past has transmitted to the present and that we, therefore, find in the present. They are not all we would like to know" (Di Carpegna Falconieri 2020). And for the rest?

In the case of the Polcevera Bridge, unfortunately, we have the autopsies of the ruins – the thin sections of the very cold "Exhibit 132" – which allow us to discover today all that has not been documented. However, we would obviously have all preferred that the bridge was still in place, perhaps after careful and timely maintenance that could have extended its life for many decades.

For all other chances, in chapter XIII of *I Promessi Sposi* (*The Betrothed*), Alessandro Manzoni explained: "*Del resto, quel che facesse precisamente non si può sapere, giacché era solo; e la storia è costretta a indovinare. Fortuna che c'è avvezza*" ("What exactly he was doing we can't know, because he was alone... History is doomed to guess. Luckily enough, it is used to that").

DEDICATION

To the victims of the collapse of the bridge over the Polcevera River.

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History of Construction Cultures – Mascarenhas-Mateus & Paula Pires (eds)
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Claudio Marcello and his dam

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ABSTRACT: The paper explains the role of Claudio Marcello (1901–69) in the history of Italian structural engineering, and in particular his contribution to the language of "Italian Style" dams. Marcello designed about 40 dams, in the Alps, Sicily, Sardinia and abroad, in less than 30 years as technical director of Edison (1937–63), working in the extraordinary period of post-World War II and Italy's economic boom. The unique character of its design is internationally recognised right from the start. In Marcello's works, the very characteristics of 20th-century Italian engineering are readable, as investigated during the Research Project SIXXI–XX Century Structural Engineering: the Italian Contribution, ERC Advanced Grant 2012, headed by Sergio Poretti and Tullia Iori at Rome Tor Vergata University.

1 INTRODUCTION

During the years of Reconstruction and the economic miracle, many dams were built in Italy for the production of electricity. As often happens in the history of Italian engineering, some of them take on a unique character and identity, recognised on the international scene: these are those designed by Claudio Marcello.

Marcello even gave his name to a type of dam. It rarely happens that a structural type is named after the engineer who invented it. We know the Maillart bridge, the Gerber chair, the Vierendeel beam: and then there is the Marcello dam, a hollow gravity dam.

Marcello is almost unknown among non-specialists, but his work was a world reference in the '50s and '60s and quietly contributed to the success of the Italian School of Engineering: he therefore deserves to be "rediscovered".

2 THE BEGINNING

Claudio Marcello was born in Forlì on 24 February 1901. In 1924 he graduated in Civil Hydraulic Engineering in Pisa and moved to Milan, where he started working in the design office of Angelo Omodeo, a pioneer in hydroelectric technology.

In those years it was increasingly clear that without energy there could be no development, but Italy was without coal and without oil. This is why "white coal", water, was the only valid alternative resource at that moment. It was necessary to use the many rivers of the peninsula: Omodeo was one of the first theorists of the "basin plan" which proposed the exploitation of several hydrographic basins, especially the mountain basins, in a coordinated way.

Marcello's apprenticeship in Omodeo's employ began abroad, in the Soviet Union, where the firm offered consultancy to exploit Russia's great water resources. Then, when the Italian friendship with the Soviets ended, Marcello worked on projects in Ethiopia. In 1937, the turning point: Omodeo retired for health reasons, closed the firm and Marcello was hired as director of Edison's Hydroelectric Plant Construction Office.

Founded in 1882, the Edison Company, with its subsidiaries, was the largest electricity production company in Italy in those years: it competed with Sade (Società Adriatica di Elettricità – Adriatic Electricity Company), Sme (Società Meridionale di Elettricità – Southern Electricity Company) and Sip (Società Idroelettrica del Piemonte – Hydroelectric Company of Piedmont).

At Edison, Marcello made his career until 1963, designing more than 30 dams in Italy in about 25 years and about ten abroad: an incredible number justified only by the parallel, enormous development of the sector, between the end of the war and the economic miracle, when the country started its industrialisation process and was hungry for energy.

Then, from 1 January 1964, with the nationalisation of electricity sanctioned by law in 1962 and the establishment of Enel – Ente nazionale per l'energia elettrica (National Electricity Agency), all private electricity industries were absorbed by the Italian State. Dams and power stations were expropriated and, with the compensation, the companies invested in something else: the Edison company merged with the Montecatini company creating Montedison, active in chemistry, Sip dedicated to telephony and Sme to the food industry while Sade was overwhelmed by the Vajont disaster.

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Marcello became Enel's operating consultant, then in 1967, he left due to age limits. He died two years later, on 9 January 1969, and with him the identity of Italian dam design (Figure 1).

3 THE "MARCELLO TYPE" HOLLOW GRAVITY DAM

The first works that Marcello undertook for Edison before the Second World War concerned the Agaro and Morasco dams, built by the Umberto Girola company: these dams were the most widespread "massive gravity" type. Later, Marcello also designed arched dams, including that of Santa Giustina, on the Noce River, in the Val di Non, in Trentino, built between 1946 and 1950, 152 metres high: the highest in Europe at the time of construction.

Figure 1. Valle di Lei dam on the Reno di Lei River, arch-gravity, double-curvature, preliminary model of wood at Ismes, scale 1:66, 1957 (SIXXIdata: Historical Archive of Ismes).

His curriculum also included double curvature dams such as the spectacular one in the Valle di Lei, above Chiavenna, right on the Italian-Swiss border, built between 1957 and 1960. The model, prepared on a scale of 1:66 at ISMES – the Bergamo Institute specialising in tests to verify the very complicated static characteristics – looked like a sculpture, with a dynamic and elegant line. In reality, it is gigantic: 690 metres long, 143 metres high, much higher than the Pirelli skyscraper in Milan and 10 times longer.

Paradoxically, however, it was not the arched dams or the double curvature dams, even so majestic, that made Marcello famous throughout the world, but those of his invention, the "Marcello type" dam and then the concrete block dam, patented in 1954.

What does a Marcello dam, a special version of a hollow gravity dam, look like?

When Marcello began to work for Edison in 1937, Italy was under Autarchy, that regime of self-sufficiency that was Fascism's response to the sanctions of the League of Nations for the invasion of Ethiopia (Figures 2, 3).

It was therefore, above all, necessary to save materials and Marcello imagined a gravity dam, like the classic ones, and to optimise the use of concrete he emptied it inside. Then, instead of using the classic rectangular triangle shape, his dam became an isosceles triangle. In this way, the water, which pushes on the upstream face, surmounts it and then stabilises it. Marcello had only played with geometry: his isosceles and hollow dam, however, was very advantageous, both from a static and economic point of view. Compared to a traditional gravity dam equivalent, concrete savings can reach up to 30%, with a savings of about 20% on construction costs. It was a little more difficult

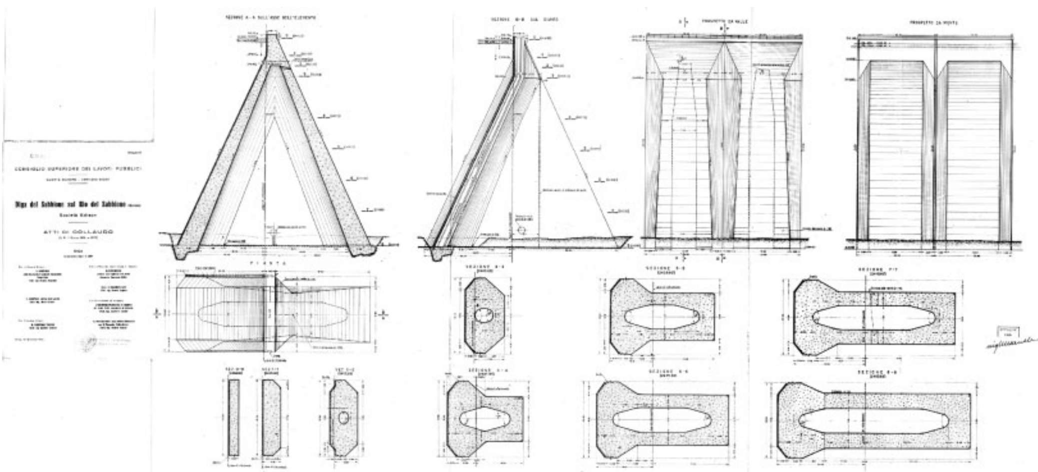

Figure 2. Detail of the hollow elements of a gravity "Marcello type" dam. Sabbione Dam in Val Formazza (SIXXIdata: Historical Archive of Ministry of Infrastructures and Transport, Dams repository).

Figure 3. (On the left) Hollow elements of a gravity “Marcello type” dam. Ancipa Dam on the Troina River, 1949–52; (on the right) Hollow gravity “Marcello type”, Bau Muggeris Dam for the Upper Flumendosa River plants, 1948–49. View from valley (SIXXIdata: Claudio Marcello Private Archive).

to do but it was better this way as the construction site employed more workers.

But that was not enough. Marcello trimmed everything carefully to reduce waste. His dam was made by placing, one after the other, many equal buttresses, each about 20 metres thick. Each buttress was shaped with the minimum amount of material and the walls were reduced in thickness – tilted and enlarged only where necessary. The side facing the mountain, then submerged by water, remains simple and smooth; the downstream slope, instead, is the facade of the dam. Marcello worked its image, sculpted it, and bent it: the result is the fortified wall of a city, with its bastions, towers, battlements. A fortress of water: it is a masonry image, powerful, saturated with history. But, in reality, it is also a futuristic form with a visionary flavour: in the sequence of the very high buttresses, Antonio Sant’Elia’s drawings materialise, in particular the 1913 studies for the power stations and dams, in which engineering, vision, energy and lyricism are mixed together. Futurism, in fact, was nourished by engineering, and engineering, with Marcello’s works, returned.

In the post-war period, before facing the most demanding works, Marcello made a “first test” of his invention in Sardinia, where the production of hydroelectric energy was still largely entrusted to the Santa Chiara Dam over the Tirso River, designed by Omodeo and Luigi Kambo and completed in 1925. Even before the war, it was decided to build a plant in the province of Nuoro, barring the Flumendosa River. Marcello retrieved the old projects for the plant but completely redesigned the dam, which became a hollow gravity Marcello type: the Bau Muggeris Dam, built between 1948 and 1949 by the Lodigiani Company.

Then he also designed one for Sicily, on behalf of Ese (Ente Siciliano di Elettricità – Sicilian Electricity Agency), a public institution founded in 1947, (Figures 4, 5) which had a concession for the hydroelectric exploitation of the island’s rivers. One of Ese’s most ambitious projects planned the exploitation of the Salso and Simeto basins, thanks to a series of dams: the first to be built was the Marcello dam at Ancipa on the Troina River. The work is much more monumental than the Sardinian one: 108 metres high. The construction site, complicated but very well organised by the Lodigiani Company, which specialised in hollow gravity solution, began in September 1949 and, despite the enormous workload, ended in November 1952.

In the same year, 1949, on the northernmost tip of Italy, the construction of the Sabbione Dam, this time entrusted to the Girola Company, also began. The dam is located at 2500 metres above sea level and bars the basin of a glacier that is always full of snow during the winter. The works could only be carried out during the summer season, between the beginning of June and the end of October. The construction-site houses for workers were so isolated that those were donated, at

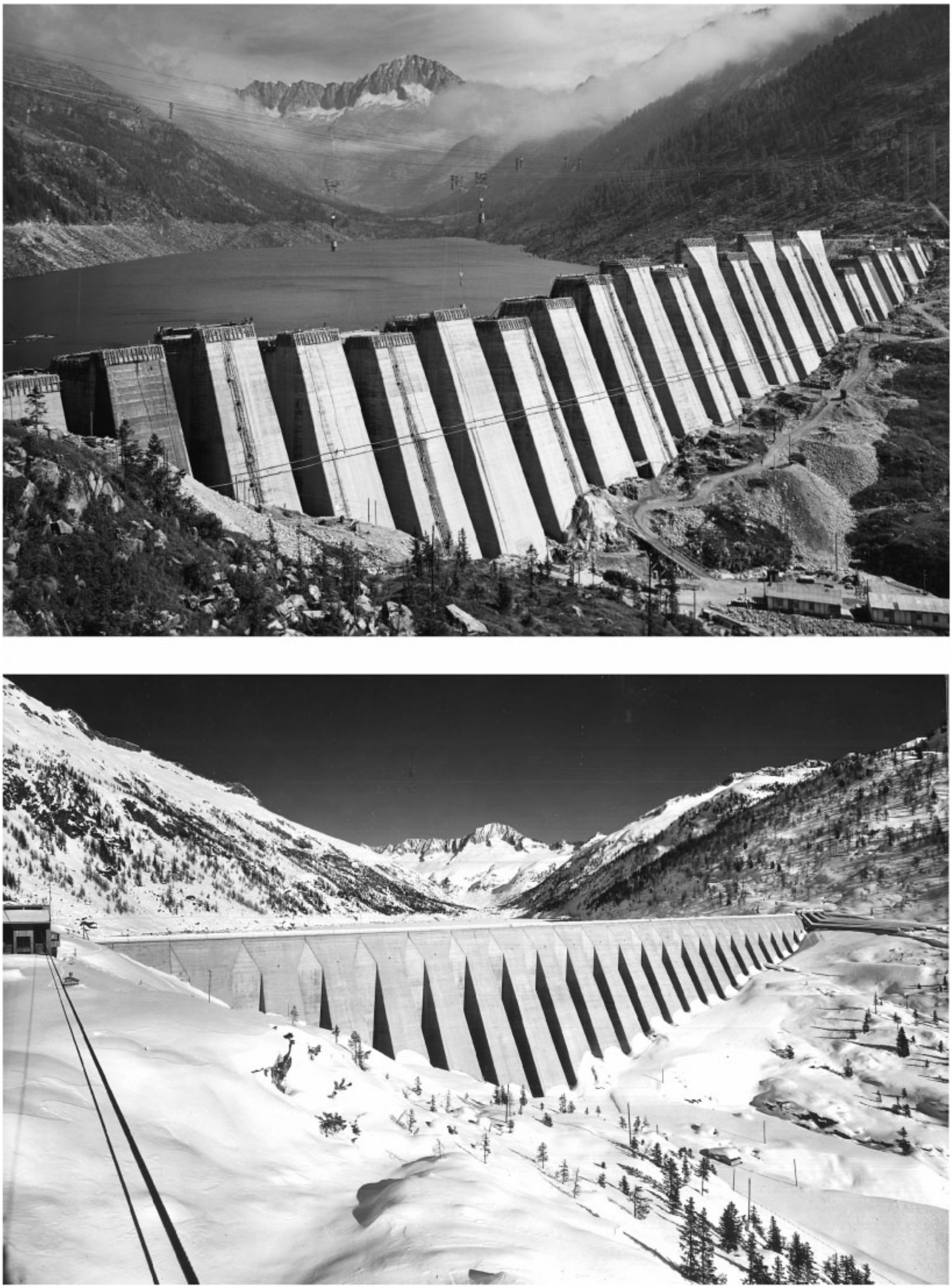

Figure 4. The hollow gravity "Marcello type" dam at Malga Bissina on the Upper Chiese River, 1955–57. View from the valley, in construction and completed (SIXXIdata: Claudio Marcello Private Archive).

the end of the works, to a laboratory for the observation of cosmic rays thanks to which Carlo Rubbia, later a Nobel Prize laureate in Physics, carried out a part of his graduation thesis.

The construction of this "dam on the glacier" was recounted by the very young Ermanno Olmi, later a famous film director, in a 16 mm documentary shot for Edison. His mother worked at Edison Company

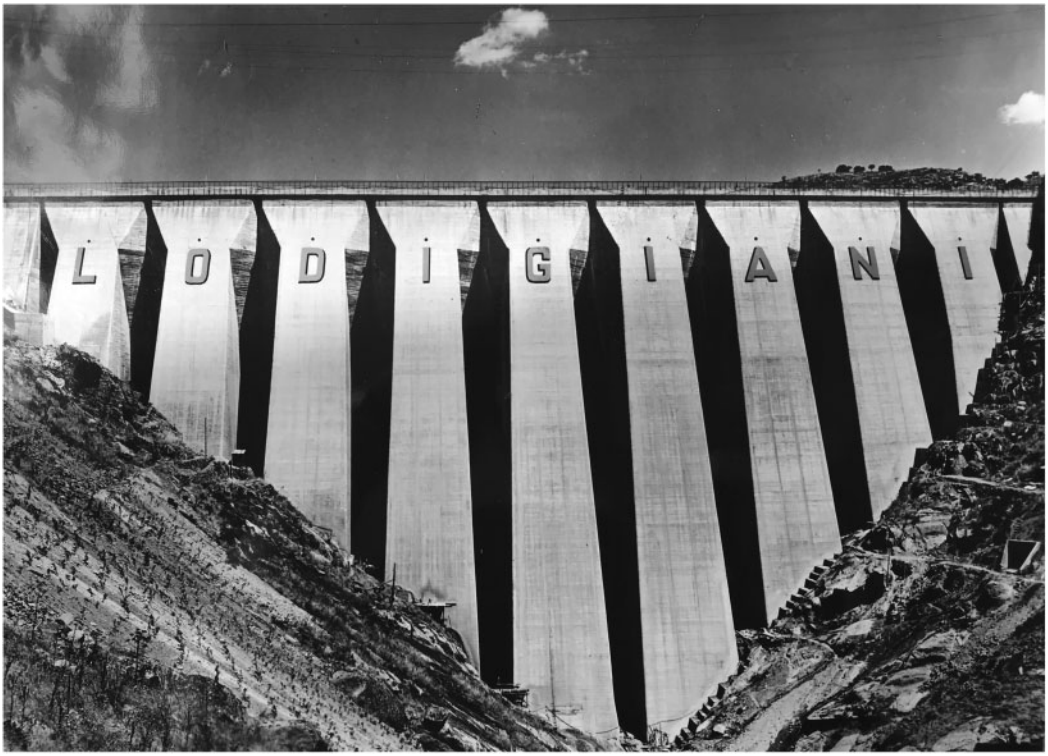

Figure 5. The hollow gravity "Marcello type" dam at Ancipa on the Troina River, 1949–52. View from the valley (SIXXIdata:Claudio Marcello Private Archive).

and, on her intercession, he was hired, still a student, as an errand boy; then Edison entrusted him with the film projections for the workers and, from there, he found a way to shoot company films at the construction sites. There are even two documentaries about the Sabbione Dam, each ten-minutes long, produced at different times: one more amateur, the other with original music written by Pier Emilio Bassi and narrated by a professional reader. Olmi focused on the human side of the site, populated by workers from every region of Italy, who lived for months in the high mountains, far from their families. And while he was fine-tuning his original cinematographic poetics, he gave us a very precious document on the ways of construction.

By 1962, Marcello had built seven more hollow gravity dams. Three dams on the Lombard peaks of Val Camonica, including that of Pantano d'Avio, built by the Salci Company, one of the highest Italian reservoirs above sea level, and the Venerocolo Dam, during whose construction site, in a winter break, Olmi sho (Figure 6) his first 35 mm film, *Il tempo si è fermato* (Time stood still), whose protagonist is the dam guardian. Then, for the Società Idroelettrica dell'Alto Chiese (Hydroelectric Company for the Upper Basin of the Chiese River), the small Malga Boazzo Dam and the Malga Bissina Dam. The latter, with a length of 561 metres and a height of 87 metres, is one of the most evocative wide valley dams in the world, naturally thanks to the magnificent landscape.

Then three "Marcello type" dams were also built abroad: one in Brazil, one in Greece and one in Spain, the Alcantara Dam, which created the largest artificial lake in Europe.

4 THE CONCRETE BLOCK DAM

Marcello, meanwhile, learned that there were geological situations in which his dam was not suitable: especially when there were weak, compressible soils that could be deformed in a differential way. For this reason, on 4 February 1954 he filed a patent to protect the rights to a new concrete block dam.

The cubic blocks, 4 metres on each side, were thrown one on top of the other to form a vertical pile and then a triangular shaped element is generated by joining several piles of different heights. At a distance of 12 centimetres, another triangular element is thrown into blocks. A layer of gravel was placed in the gap, which acted as a lubricant and allowed the dam to adapt to ground differential movements without breaking. The site photos of these dams, with the huge blocks on top of each other, look like scenes from a film about the

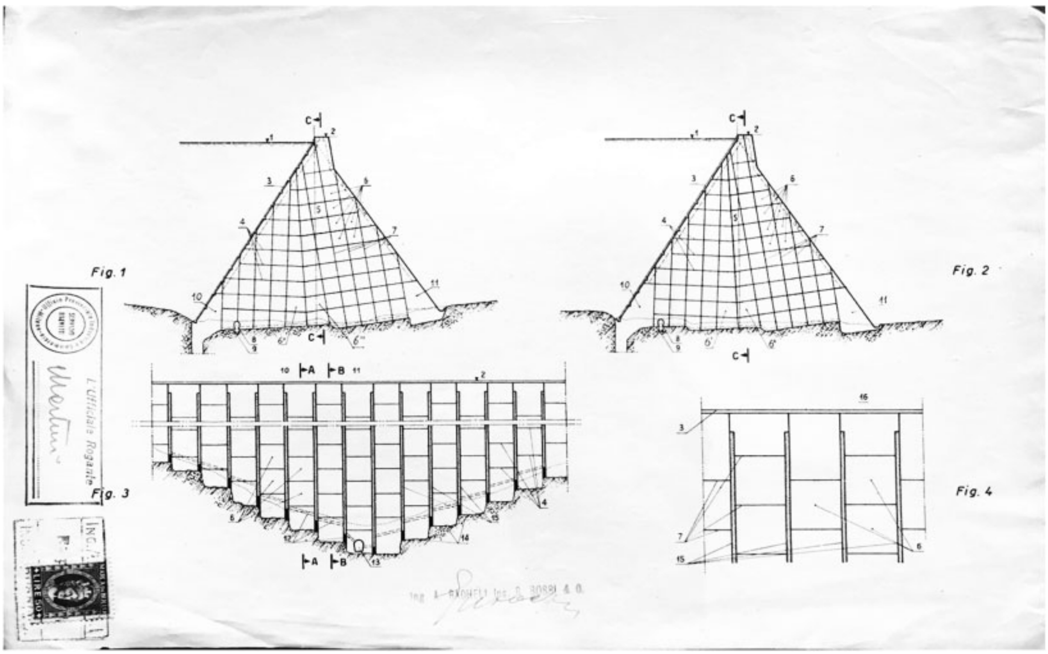

Figure 6. Patent no. 512970, Claudio Marcello, Milan, "The concrete block dams", 4 February 1954 (SIXXIdata: National Central Archive, Patent Fund).

Figure 7. Concrete blocks during the construction site of the Pian Palù Dam in the Noce Valley, 1954–59 (SIXXIdata: Chiolini Photographic Archive).

pyramids or a documentary about the construction of the cyclopean walls of some ancient city (Figures 7, 8).

Once the heart of the dam was finished, Marcello carefully hid the blocks behind the two faces: the upstream one, against the water, is covered with very pure iron sheets to guarantee the seal and avoid corrosion; the downstream one, the "facade" of the dam, is designed with a very modern texture, engraved with deep chamfers. Looking at it from afar, it looks like a punched card, one of those appearing with the first computers, which, in a sort of machine language, speaks to us of pressure, capacity, and energy. In short, a passion for history, vision and the ability to create design objects at the scale of the landscape: Claudio Marcello is a perfect spokesman for the Italian School of Engineering.

Between 1954 and 1958, Marcello built four concrete block dams, three in Italy and one abroad, in Latin America. The first is the one on the Plàtani River, which creates the Fanaco Lake in Sicily, completed in 1955. Not far away, the Pozzillo Dam on the Salso River, also used as a reservoir for the irrigation of the whole plain of Catania.

Here too, a documentary produced by Incom (Industria Corti Metraggi Milano – Short Film Industry in Milan), directed by Vittorio Gallo, followed its construction step by step: a film with Neorealist poetics, attentive to the faces and glances of the workers, which described the hard work site without filters and also the dangerous acrobatics which men were forced to perform on the upstream and downstream faces (Figures 9, 10).

In the meantime, the construction of the Pian Palù Dam, in the province of Trento, which barred the Noce River, completed in November 1958, was also underway. And finally, the dam on the Bianco River in Peru.

But soon everything stopped. With nationalisation, the history of hydroelectric power in Italy changed, and investments were interrupted: it was no longer the time, not even for Marcello, to build a dam a year.

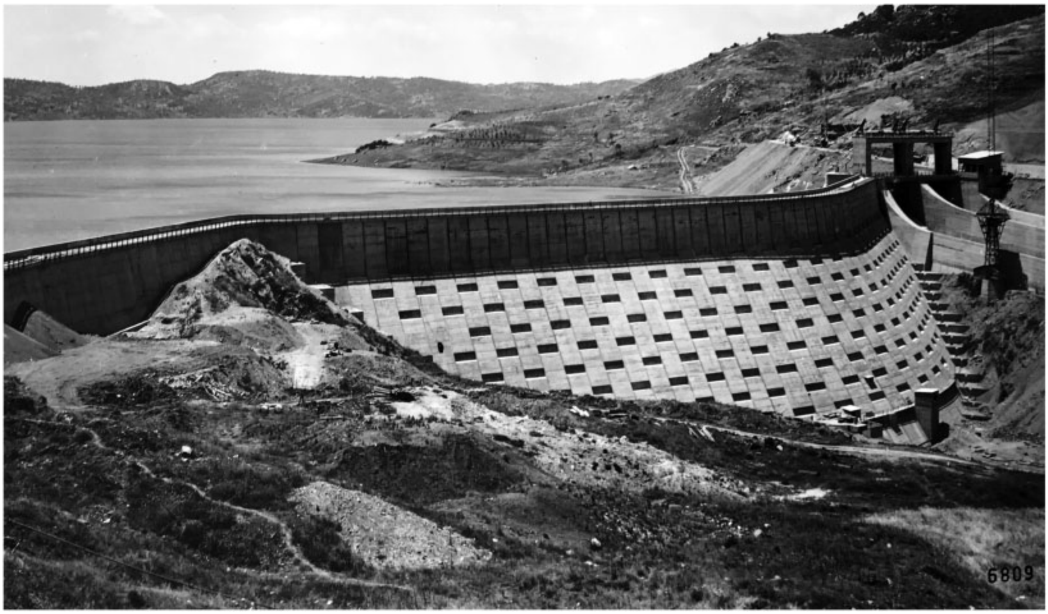

Figure 8. Pozzillo Dam on the Salso River in concrete blocks, 1956–58. View from the valley of the completed dam (SIXXIdata: Claudio Marcello Private Archive).

Figure 9. Platani Dam in concrete blocks, 1953–55. Construction site view of the upstream face (SIXXIdata: Claudio Marcello Private Archive).

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presas sobre terrenos de asiento diferencial

CLAUDIO MARCELLO, Dr. Ingeniero

El problema de la construcción de presas sobre terrenos de asiento variable debido al distinto grado de compresibilidad ha sido resuelto, hasta hoy, por el empleo de diques de tierra, en escollera o con muros de mampostería en seco.

En este último tipo, la estructura resistente es completamente distinta de la que impermeabiliza la obra, lograda con un diafragma o pantalla de hormigón, chapa metálica, de madera o arcilla.

El tipo de mampostería en seco o concertada ha tenido sus primeras aplicaciones en los Alpes italianos y en el África Occidental francesa, donde se han realizado algunas obras de consideración. Estas presas presentan ciertas ventajas económicas respecto al tipo escollera, que son las siguientes:

a) Menor porcentaje de huecos y, por tanto, menor compresibilidad en el cuerpo de la obra.

Figure 10. Extract from the journal, *Informes de la Construcción*, April 1960 (free on Internet).

5 CONCLUSION

The years of the dam boom in Italy were the same years in which the Italian School of Engineering became the most famous in the world. These were the years in which Pier Luigi Nervi, Riccardo Morandi and Silvano Zorzi designed the Autostrada del Sole, and in which the Rome Olympics were held.

Eduardo Torroja was among Marcello's leading supporters: in April 1960, the issue of *Informes de la Construcción*, the journal he directed at that time, was entirely dedicated to Italy and included concrete block dams by Marcello along with the works of Pier Luigi Nervi, Riccardo Morandi and Gino Covre.

The great successes of Italian structural engineering were promoted, among others, by a famous exhibition held in New York, at MoMA – Museum of Modern Art – in the summer of 1964, celebrating the world engineering of the 20th century. In that exhibition, in which many Italian works were exhibited, there were also 25 great dams from all over the world, from China to the United States, from Switzerland to France, which represented world excellence. As many as four were "Made in Italy" and signed by Claudio Marcello: the Ancipa, Malga Bissina, Pozzillo and Valle di Lei dams. Certainly a wise selection, perfect to tell the story of the "Italian Style" dam!

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Un metro lungo cinque, 1961. 23'. B/W. Director: Ermanno Olmi, text: Tullio Kezich, voice: Romolo Valli and Alfredo Danti, original score: Pier Emilio Bassi.