HISTORY OF CONSTRUCTION CULTURES

VOLUME 2

edited by
João Mascarenhas-Mateus
and **Ana Paula Pires**

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History of Construction Cultures – Mascarenhas-Mateus & Paula Pires (eds)
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The metamorphoses of the EUR Water Tower, Rome, between autarchy and economic miracle (1940–59)

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ABSTRACT: In a 1961 article, the engineer Roberto Colosimo Sr described his iconic water tower at EUR, Rome (1957–59, also known as 'the mushroom'), recalling a previous 1940 project, unexecuted due to the entry of Italy into World War II. This paper analyses the transition between the two towers as a sort of animal metamorphosis, largely conditioned by the different scientific and cultural contexts. The first design maximized the strength through form-resistant structures. Its image would have evoked late antique architecture, in which firmness was entrusted to mass and geometry. The continuous and bold structures of the first solution, conceived during the autarchy imposed by the Fascist government, became more discrete in the 1957 project. The second solution, built in reinforced concrete, transformed the massive buttress of the autarchic design in punctual supports, intertwined in a stellar arrangement of shelves, which showed the high technological level and creative genius of post-war Italian engineering. The paper refers to archival documents to jointly study the two projects, revealing the metamorphoses that took place between two projects conceived for the same place and by the same author, but within different political and economic conditions.

1 INTRODUCTION

On December 1st, 1942, Vittorio Cini, the general commissioner of the Ente Autonomo Esposizione Universale di Roma, resigned from his position. His decision marked the end of construction of the sumptuous international fair E42, established in 1936. In reality, the opportunity to fulfil the "Olympiad of Civilizations" had already vanished on June 10th, 1940, when Italy had entered the war.

Since 1937, E42 planning had required the development of many projects, which were coordinated by Marcello Piacentini in collaboration with the architecture department directed by Gaetano Minnucci. Such "urban visions" were mainly based on the cross scheme of the Roman *castrum* (Figure 1). The Via Imperiale – currently a trunk of Via Cristoforo Colombo – was the SW-NE oriented *cardo maximus*. The *decumanus maximus* crossed it connecting the two poles of the Palazzo dei Congressi and the Palazzo della Civiltà e del Lavoro. A pseudo-obelisk in reinforced concrete and Apuan marble dominated the Piazza Imperiale (today entitled to Guglielmo Marconi) at the perpendicular intersection of two axes. Of the approved 1939 scheme, only a dozen buildings were completed, remaining for a long time as monumental epiphanies in the 400-hectare-wide pentagonal area once destined to the Exposition.

Figure 1. E42, Servizio Architettura Parchi e Giardini, Ufficio Piano Regolatore, general plan of E42, mapping of waters (lake, fountains, pools, etc.) and green areas, 1940.

A later solution comprised significant changes both for the entrance square towards Rome, with the definition of the two exedras of the INA and INPS, and for

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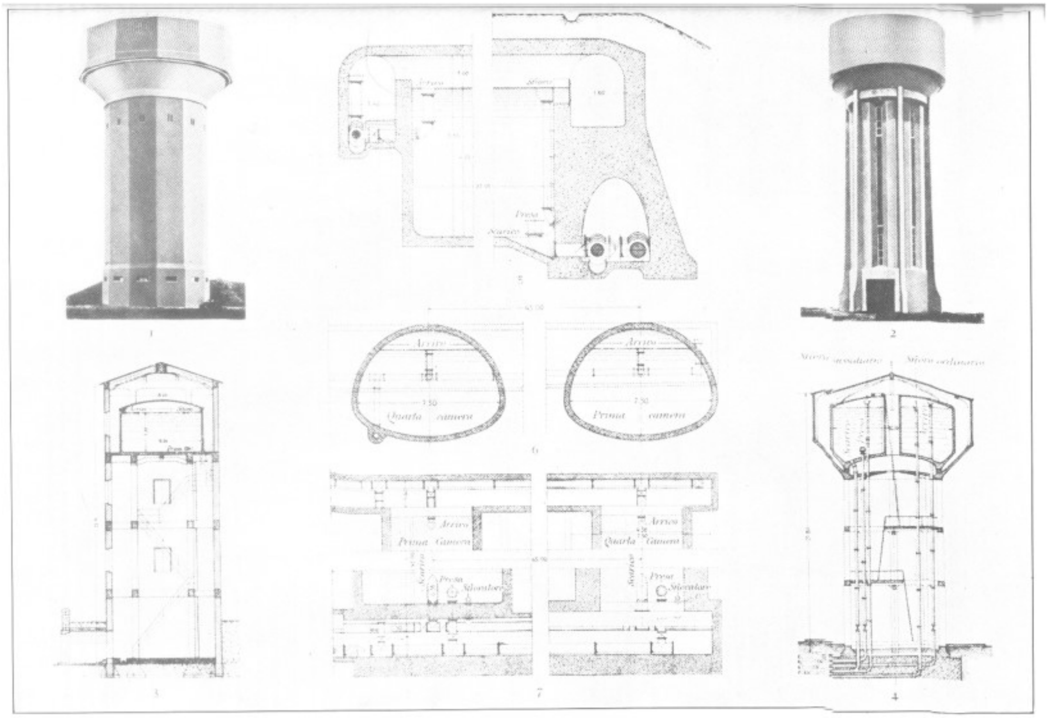

Figure 2. Roberto Colosimo Sr, table for the entry 'Serbatio' (Tank), in *Enciclopedia Italiana di Scienze, Lettere ed Arti*, vol. XXXI, Roma: Istituto della Enciclopedia Treccani, 1937, pp. 412–4.

the western area. Destined to a large artificial basin (the 'Laghetto') and to a waterfall garden, the latter area had to be marked by Adalberto Libera's majestic parabolic arch and a Palace for Water and Light, both unexecuted.

The project of the lake and waterfall garden, as well as the other gardens and parks for the E42, was entrusted to Raffaele de Vico (1881-1969) and Roberto Colosimo Sr (1893-1986): the former a landscape designer, the latter a hydraulic engineer. Colosimo was even asked to design a water tower on the top of the hill towards the sea to feed the fountains and the several water outlets for irrigation or fire prevention.

Although crucial in the scenography and functionality of the entire exhibition area, they were not completed, and the works were limited to excavations and incomplete arrangements. Incidentally, Roberto Colosimo was one of the most successful hydraulic engineers of his age: university professor, he also authored many books, including those on the aqueducts of Lugo and Bertinoro, of Ravenna, of Ferentino and Alatri (Colosimo 1930, 1935, 1937). In the 1930s, he also wrote entries on "Condotta", "Fognatura" and "Serbatoio" (conduct, sewage and tank) for the Treccani Encyclopedia (Colosimo 1931, 1932a, 1936, Figure 2).

In the 1950s, the EUR was planned to house facilities for the 1960 Olympic games. This required a new landscape design for the area, including a hydraulic system to be fed by a water reservoir. The definition of these elements was entrusted to the designer and the engineer who had already prepared the project for the E42: de Vico, for the gardens, and Colosimo senior, for the hydraulic system.

Colosimo designed a complex hydroelectric system, fed by a tunnel aqueduct which draws water from the sources of the Cecchignola and from the well of San Leone, with a flow rate of 400 l/s. The system comprises a network which passes under the EUR area with a flow rate between 120 to 300 l/sec. It was provided with lifting stations in the waterfall garden (completed in 1961) and in the artificial lake. The lake, one km long and 60 to 130 m wide, had a surface of 85,120 m^2, and a depth varying from 2 to 4 m, for a total of 220,000 m^3 of water. To grant continuous availability of water, the system was equipped with a series of tanks, with the function of hydraulic compensation or reserve. Among them, the project included a hanging tank. Its structure, already drawn up in 1940, was reformulated according to a new design and a different technology to be finally erected in 1957 (Figure 3).

2 THE WATER TOWERS OF EUR: A METAMORPHOSES

A text published in a 1961 issue of *L'Industria Italiana del Cemento* describes the iconic water tower of EUR, built between 1957 and 1959 and soon renamed by Romans as 'il Fungo' (the mushroom). In the arti-

Figure 3. Roberto Colosimo Sr with Aldo Capozza and Sergio Varisco, the Water Tower of Eur, Rome, 1957–59.

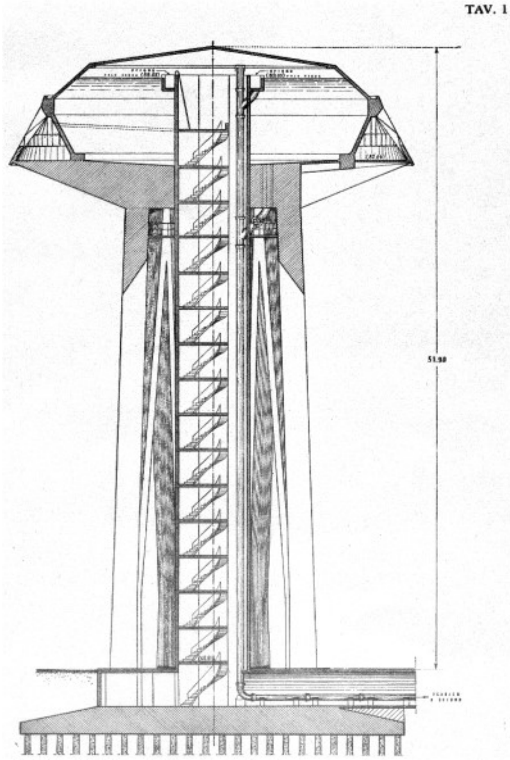

Figure 4. Roberto Colosimo Sr with Aldo Capozza and Sergio Varisco, section of the Water Tower of Eur, Rome, 1957–59.

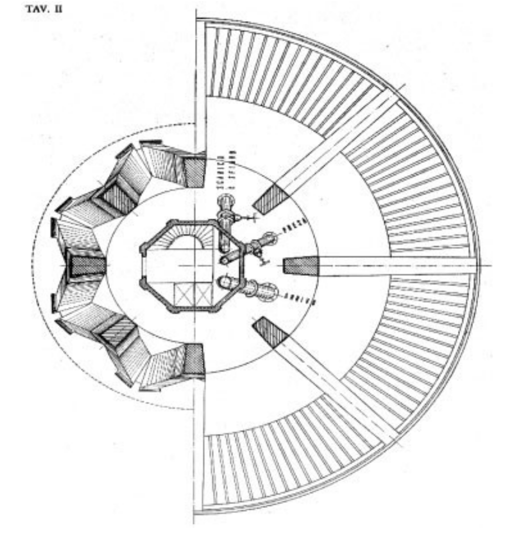

Figure 5. Roberto Colosimo Sr with Aldo Capozza and Sergio Varisco, plan of the Water Tower of Eur, Rome, 1957–59.

cle, Colosimo recalls the project he had presented in May 1940, which remained unbuilt for Italy's entry into World War II (Colosimo 1961). It is only a brief mention, since the essay is dedicated to the new 52-m-high water tower, designed after the war in collaboration with Aldo Capozza (EUR technical office) and Sergio Varisco (in charge of the architecture).

The tank, working as a piezoelectric tower, soon became one of the landmarks of the area, then crowded by the construction of office blocks and sport facilities. The tower presents an inventive structure, whose structural and formal instances are eloquently solved by a trestle-like frame in reinforced concrete (Figure 4). This concrete exoskeleton is made of eight pillars. At a height of six metres from the ground level, they split in a fork-like configuration, bending diagonally to the height of 34 m, where they join the contiguous trunks. They meet in a ring with eight large shelves supporting the upper tank (Figure 5).

The tank, covered by a segmented conical roof, was surrounded below by a hollow annulus with a triangular section. The exterior side of the triangle was perforated by un uninterrupted fenêtre-en-longueur to bring light into a space conceived as a belvedere-restaurant-bar (to be managed by the tenor, Mario Del Monaco).

The construction work conducted by the Vianini Company was as advanced as the tower design. The construction site was served by two antennas and a *blondin*, a machine created for construction sites with horizontal development which was modified to work along a vertical axis (Figure 6). The boldness of the structure, in which the geometry complicated the exact

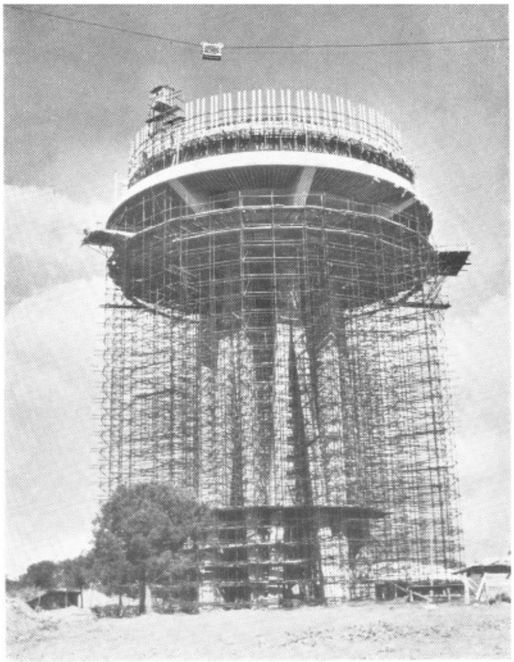

Figure 6. Roberto Colosimo Sr with Aldo Capozza and Sergio Varisco, view of the EUR Water Tower, Rome, 1957-59 the construction site was served by two antennas and a *blondin*.

Figure 7. Raffaele de Vico and Rodolfo Stoelcker, structure of the water tank in via Eleniana, Rome, 1932, from G. di Castelnuovo, *Roma di Mussolini: primo decennale della rivoluzione fascista*, Roma: Azienda Editoriale Italiana, 1932, p. 131.

Figure 8. Raffaele de Vico and Rodolfo Stoelcker, facade of the water tank in via Eleniana, Rome.

determination of stress and bending, led Antonio Martinelli, consultant engineer for the Vianini Company, to adopt special measures, especially in the choice of materials. As testified by some photographs of the construction site, the tower was supported by a reinforcement in structural steel (Twisteel), while the castings used a high-strength R680 type cement.

The first solution presented by Colosimo in 1940 comprised an equally daring structure. While the built tower would make extensive use of steel, the first project envisaged a concrete construction completely devoid of steel reinforcement. In the report, the designer proudly described the project as fully in line with the metallurgical autarchy promoted in Italy in those years. The rejection of steel was made possible by resorting to structures that were only subjected to compressions, like the domes and vaults forming a system of radial buttresses around the tank. In the late 1930s, the regime propaganda had programmatically affected the resources strategical to military goals, both in terms of construction employment and material supply.

The material shortage for construction was mainly related to a propagandistic reason which did not reflect its effective economical convenience. Indeed, the shortfall due to the importation of steel was no more burdensome than that of wood, cement, or aluminium, which were instead promoted as "very Italian" materials. However, the restriction led to research and experiments on new construction methods. Many of them aimed at improving the resistance of structures with non-steel reinforcement, as well as structures built in weakly-reinforced and unreinforced concrete.

The refrain "better calculations and better construction" limited the use of steel in concrete to the point that the government assessed a 'degree of self-sufficiency' measuring the cost of structures, even weakly-reinforced ones, in foreign currency (cost in gold) (Capomolla 1994-95, 98). The limitation in using steel was a first step towards stricter autarchy in construction, which was confirmed by the blocking of private construction in 1939, enshrined by a decree law in 1940.

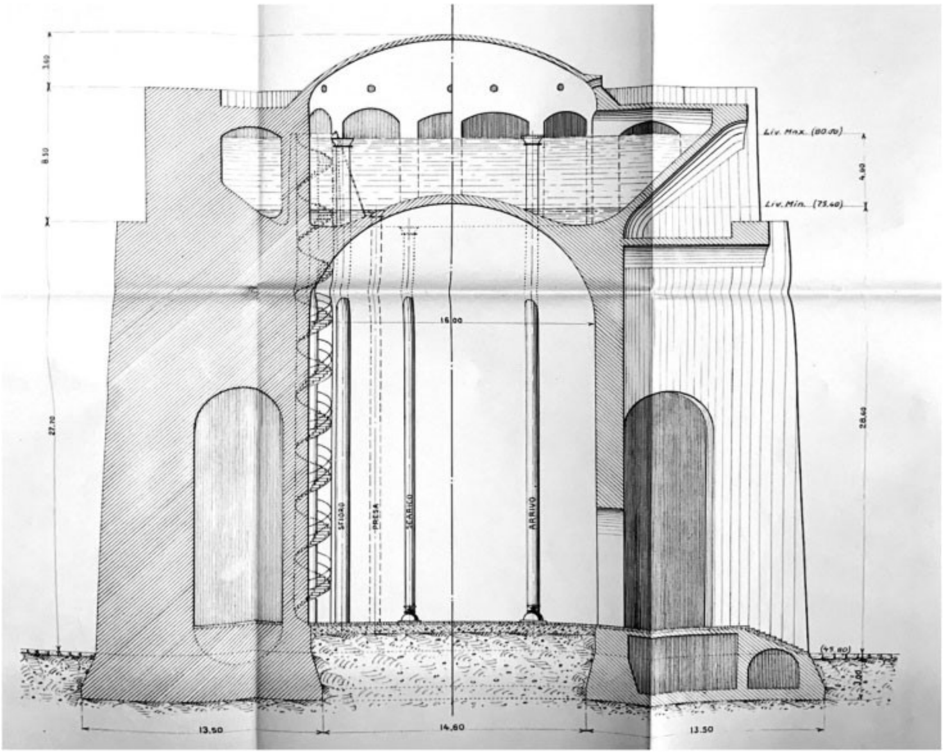

Figure 9. Roberto Colosimo, section of the autarchic water tank of E42, Rome, 1939–40, Archivio Studio Idrotecnico Colosimo, Roma.

Indeed, most of projects presented in the 1938 and 1939 issues of *L'Industria Italiana delle Costruzioni* deal with structural elements in fibre cement, cement without reinforcement, and cement with a reinforcement in steel wires, wood, or bamboo poles, indirectly confirming the creative effects of autharchy. Conversely, other structures designed for the E42 proclaimed the boldness of autarchy but covertly resorted to steel reinforcement.

It was the case of Libera's monumental arch, sponsored as a structure in concrete "without a kilogram of steel", to use the words of its designer (Capomolla 1994/1995, 105). Actually, Libera expected to erect the arch with a weakly-reinforced concrete structure. Nevertheless, calculations went beyond his predictions, prescribing a massive steel core, which would have eventually been coated in Avional D metal alloy. Similarly, Marconi's stele (1939–59) in the Piazza Imperiale, which was described as an unreinforced concrete structure, actually had a reinforced core to resist wind loads due to its 55 m height.

Unlike Libera's and Marconi's monuments, Colosimo's first project for the water reservoir of E42 envisaged a tank which, although subjected to variable loads, thermal oscillations and wind actions, was to be realised in unreinforced concrete.

Structural calculations confirmed the possibility of this solution, which was architecturally defined through exposed, hammered surfaces. The surface finishing rendered concrete as if it were stone, however artificial, suggesting an idea of technological and cultural self-sufficiency.

To understand Colosimo's innovative vision, one must consider that water towers and suspended tanks were usually realized in metallic or mixed technologies (metal and masonry). Reinforced concrete technology was adopted in their construction only in the 1920s,. For instance, in 1933, Raffaele de Vico was commissioned a 2000 m^3 tank to serve the Appio Latino, Tuscolano, Prenestino and Tiburtino districts in Rome (Figures 7, 8). The water system, fed by the Pia Antica Marcia aqueduct, was built between 1933 and 1934 by the company of Rodolfo Stoelcker. The reservoir comprised four, large cylindrical tanks in reinforced concrete, suspended at a height of 23 metres, each supported by five reinforced concrete pillars. Despite their fascinating structure, the four tanks were hidden behind a conventional urban facade in bricks and stone (Ciranna 2018).

Reinforced concrete tanks, like the mushroom-shaped tank described by Goldstein Bolocan in *L'industria Italiana del Cemento* of April 1936 were widespread in the 1930s (Bolocan 1936). On the contrary, the first tank designed by Colosimo for the E42, with a capacity of 2000 m^3, was a structure completely in concrete, as the metric estimate confirms. The project maximised the resistance by shape of the tower, increasing its load-bearing capacity with

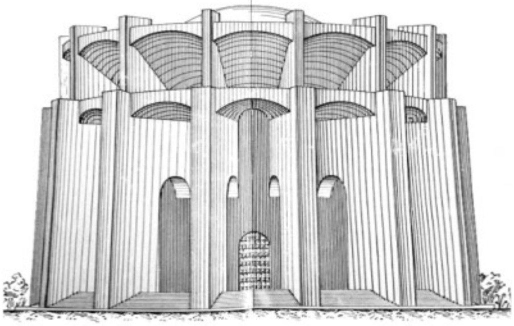

Figure 10. Roberto Colosimo, elevation of the autarchic water tank of E42, Rome, 1939–40. Archivio Studio Idrotecnico Colosimo, Rome.

the attribution of three-dimensional curvatures. The design tended to homogeneously exploit the material, distributing the stress along the entire resistant section. Resorting to curved surfaces minimised the bending stress. The geometry therefore reduced the dangers of tension stress in favour of plain compression, more suitable to the property of concrete, which is not resistant to tension when unreinforced. The proof was in the calculation attached to the project that defined the loads resulting from own weight, overload, hydrostatic thrust, and verified the stability of a buttress. The calculus was accompanied by the graphical procedure used to verify the maximum and minimum values of stress at the base of each pier (Figure 11).

Like a *peripteros*, the structure was elevated on a circular *crepidoma* with a 49-m diameter. The steps were interrupted by two rings of 14 solid piers, radially disposed around the *cella* housing the manoeuvring room, the pipes (for loading, unloading, and overflow) and the spiral staircase for maintenance.

The 20-m-wide *cella* was surmounted by a hemispherical dome, whose extrados, stiffened by a crown of radial vaults, constituted the bottom of the reservoir (Figure 9). The dome had a variable thickness, which increased from 0.50 m at its top towards the impost. It supported the weight of the reservoir above, transferring the load to the radial buttresses.

To simplify the geometry, the reservoir tank could be compared to a tumbler, whose perimeter was stiffened by 14 vaults, arranged radially, which transferred the loads to the piers below. The basin was encircled by vaults which had a trapezoidal plan and their longitudinal axis angled at 45° on the horizontal, according to a truncated conical surface. In the plan, the geometry could be schematised as a hypocycloid, a curve generated by the trace of a fixed point which follows the rotation of a smaller circumference inside a bigger one.

It was made of a concatenation of inverse curves which were internal to the footprint of the building (Figure 10). The inclination of the vaults and the radial geometry made the section change with height. This star-like geometry was intersected with ten vertical buttresses. Disposed radially to the tank, they marked

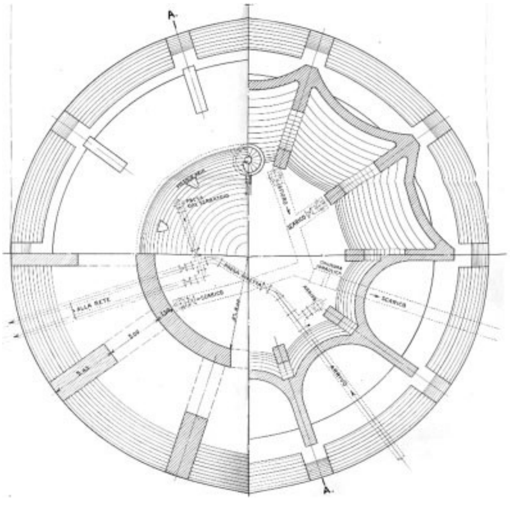

Figure 11. Roberto Colosimo, plan of the autarchic water tank of E42, Rome, 1939–40. From below, left, clockwise: ground floor (+2.10); roof, maximum level of water (+33.00), minimum level of water (+28.00). Archivio Studio Idrotecnico Colosimo, Rome.

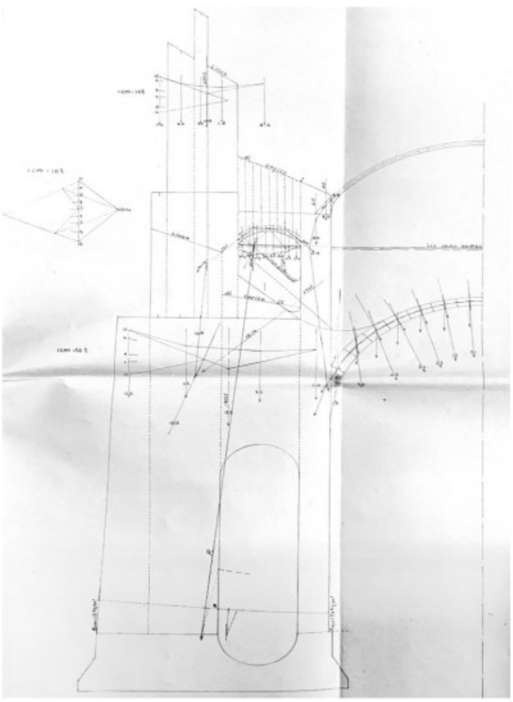

Figure 12. Roberto Colosimo, Cremona diagram for a buttress of the autarchic water tank of E42, Rome, 1939–40. Archivio Studio Idrotecnico Colosimo, Rome.

the points of the star, in correspondence of which they were pierced by rounded arches. The front part of the buttresses was conceived as the piers of a thin (0.30 m) segmental dome, perforated by a series of oculi for ventilation and lighting.

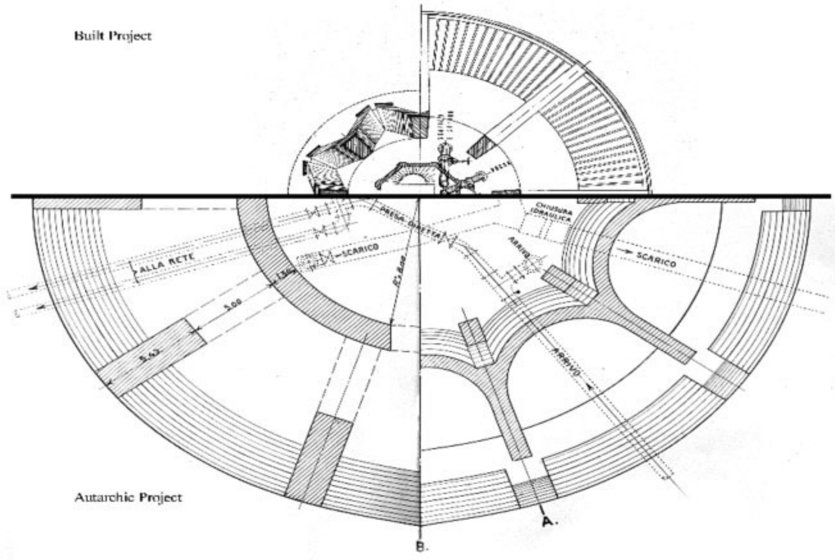

Figure 13. Comparison between the first project and the built tower. Archivio Studio Idrotecnico Colosimo, Rome.

The bases of the buttresses were instead connected and braced by a second ring system of vaults. These vaults had a trapezoid plan but horizontal generatrixes. Hence, we could say that the lower vaults (with the horizontal generatrixes) were conoidic barrel vaults, while those bordering the tank (with angled generatrices) were conic ones.

The buttresses differed between the lower and the upper parts, too. The upper ones, less stressed, were 1 m thick. Pushed towards the centre of about 2 m, they were perforated by round arches evoking the image of ancient cisterns. The lower buttresses were slightly splayed to the exterior with a thickness of 2 m. Reaching a height of 25 m, they were similarly perforated by round arches creating a circular *peribolos* around the cell.

Other details on the tank construction can be derived from the price analysis, the metric calculation and the work estimate attached to the project. According to them, the buttresses and the vaults had to be erected with unreinforced concrete. Indeed, the only metal recorded in the calculation was intended for the spiral staircase, the anchoring brackets, the pipes, and the ventilation grilles.

The concrete mix was designed according to a ratio of 300 kg of cement, 450 type, to 0.800 m3 of gravel and 0.400 m3 of sand. The documents do not specify the use of anti-shrinkage additives, which would have reduced the danger of cracks while hardening.

3 CONCLUSION

Comparing the sections of Colosimo's autarchic water tower with those of a typical reinforced concrete tower, the shapes of the tanks can highlight deep similarities. However, the autarchic solution in unreinforced concrete completely entrusted stability to a massive belt of buttresses, which can be easily opposed to the slim trestle-like supports of reinforced concrete towers. The bold structure, required to stiffen the tower, would communicate a certain image of *romanitas*. Indeed, its image would have evoked Late Antiquity architecture, those whose stability was entrusted to mass and geometry (Figure 12). However, the need to ensure a good safety margin made the concrete structure excessively oversized, bordering on historicistic rhetoric.

The reference to history would also be evident in the finishing of the surfaces, both internal and external. They would be hammered until reaching a visual uniformity erasing the signs of the formworks. The idea of hammering concrete, as if it were a stone, also reinforced the monolithic image of the structure. Differently, the *crepidoma* would be paved with travertine, to create a chromatic contrast with the concrete.

Unlike the E42 tower, the tower designed in reinforced concrete in 1960 has a detailed structure and an entirely different stylistic and iconographic direction. The two solutions, albeit developed in less than 20 years (1940 and 1957), reflect the rapid change in shapes, construction, and economic politics. Indeed, throughout the years, the project lost the linguistic and material constraints imposed by the regime's rhetoric.

Yet the study of the two projects proposed in this paper reveals a sort of metamorphosis, like that occurring to butterflies. The squat and powerful structures of the first solution, conceived when the use of steel in construction was expressly forbidden, are turned into slender and detailed supports in the 1957 project. Elegantly intertwined in a stellar arrangement of shelves, the structure of the water tower built at EUR display the technological level reached after the war by the Italian School of Engineering.

DEDICATION AND AKNOWLEDGEMENTS

This paper is dedicated to Giulio Regeni (1988-2016), PhD student at the University of Cambridge, killed in Cairo while he was researching independent labour unions in Egypt.

The authors owe a special thanks to Roberto Colosimo Jr and Raffaello Colosimo of the Colosimo Hydrotechnical Office for their kind provision of archival documents, and Fabio Colonnese for his suggestions.

The water tower analysed in the paper concerns a solution for 3,500 l of water. The project was accompanied by a further solution: a slightly smaller one with a capacity of 2,000 l, provided with only ten buttresses.

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