BRÂNCUȘI MONUMENTAL ENSEMBLE OF TÂRGU JIU

Annexes

Nomination for inscription on the World Heritage List

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Brâncuşi Endless Column: A Masterpiece of Art and Engineering

Giovanni Solari

Department of Civil, Chemical and Environmental Engineering, University of Genova, Via Montallegro, 1, 16145 Genova, Italy

Abstract

The Endless Column by Constantin Brâncuşi is "the most radical sculpture in the history of classic modernism", "the only one of modern times that can be compared with the great Egyptian, Greek and Renaissance monuments". It "is not only an artistic masterpiece, but also an extraordinary feat of engineering", the greatest example of collaboration between a sculptor and an engineer. This article illustrates the path that led the artist to conception of the column, its planning and construction, the investigations on preservation of the monument and its restoration, the aerodynamic tests in the wind tunnel, the modeling of the wind and the structure in virtue of which the aeroelastic instability, dynamic response and fatigue life were investigated. The conclusions discuss the column's role in the panorama of the great works of modern engineering.

Keywords: Aerodynamics, Art, Constantin Brâncuşi, Endless Column, Restoration, Wind Engineering

1. Introduction

Constantin Brâncuşi was born on February 19th 1876 in Romania, in the village of Hobita Gorj, near Târgu Jiu, and died in Paris, France on 16th March 1957. He spent his childhood between the village he was born in, Târgu Jiu, Slatina and Craiova, where he attended the School of Art and Crafts. In 1903 he was awarded his diploma from the National School of Fine Arts in Bucharest. The following year he left Romania and went to Paris, where he created a series of works that left an indelible mark on the history of art in the 20th century.

Brâncuşi's leading work, however, is judged by many to be the only one created in Romania and his only public work, the Târgu Jiu Memorial built between 1937 and 1938 to commemorate the resistance of the local population during the First World War. Among the buildings of the memorial the Endless Column, UNESCO World Heritage, stands out as "the most radical sculpture in the history of classic modernism", "the only one of modern times that can be compared with the great Egyptian, Greek and Renaissance monuments".

In order to build the column, a stele of 29.26 m in height with a slenderness ratio of 66, beyond the limits of its time and in large part current, Brâncuşi was assisted by an engineer, Stefan Georgescu Gorjan, with whom he gave life not only to one of the most celebrated works of art of all time, but to the greatest masterpiece arising from the collaboration between a sculptor and an engineer. According to UNESCO, "it is not only an artistic masterpiece, but also an extraordinary feat of engineering. Its dual function and its unique message make it imperative to make every effort to preserve it".

During the course of its existence the column has gone through various vicissitudes. With the Second World War over, in the era of communism, it was seen as a subversive symbol. Abandoned and even damaged, it survived thanks to the personal initiatives of the design engineer. When Ceausescu was deposed in 1989, Romania once more turned to look at preservation of the monument. It was the start of a long period of controversies, on the type of intervention to carry out, and through which one reached the restoration of 2001. Among other interventions it envisaged the restoring of the corroded zones of the spine, a reinforcement at the base of the spine to guarantee a level of safety to the wind actions coherent with the code prescriptions and re-plating of the coating modules, bringing them back to their original color.

In the period in which the restoration took place, a series of studies were begun on the actions and the effects of the wind, still in progress, aimed at verifying the real safety of the work. They showed that, at its origin, the structure possessed a more than adequate safety and that its reinforcement was not necessary. Above all they showed that the column not only represented a milestone of art and engineering, but it most likely translated the principle of perfect aerodynamic conception and the maximum synthesis between form and structure. Despite being endowed with such a marked slenderness as to potentially make it prey to the wind, thanks to its undulated edges the column has absolutely modest drag, it creates a greatly chaotic vortex wake and therefore being unable to induce violent transversal actions, it eludes every form of instability.

This paper illustrates the artistic path that led Brâncuşi

†Corresponding author: Giovanni Solari
Tel: +39-10-353-2524; Fax: +39-10-353-2292
E-mail: giovanni.solari@unige.it

to conception of the column (Point 2), its design and construction (Point 3), the investigations into preservation of the monument (Point 4) and its restoration (Point 5), the wind tunnel tests (Point 6), the modeling of the wind and of the structure (Point 7) by virtue of which the aeroelastic instability, the dynamic response (Point 8) and the wind-induced fatigue (Point 9) are investigated. The conclusions (Point 10) summarize the main results of the study and discuss the role of the column in the panorama of the great works of modern engineering.

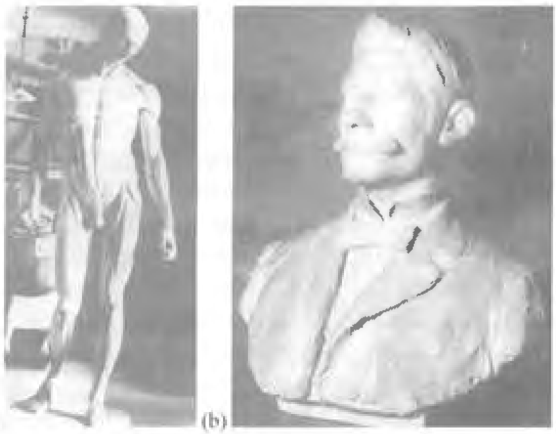
2. Brâncuşi's Artistic Path

Constantin Brâncuşi (Tabart, 1995; Brezianu 1999), "the father of the modern sculpture", was born on February 19th 1876 in Romania, in the village of Hobita, Gorj, near Târgu Jiu, in an area known for its rich popular traditions of craftsmanship, above all for decorations carved in wood. His parents were very poor and he spent his infancy in a rural house.

In 1889 Constantin reached Craiova, where he worked in a bistro "The coloured star" (1892). In his free time he carved splendid wooden objects, above all a violin in pine wood. They were noticed by Ion Georgescu Gorjan, the owner of the bistro, who helped him to enrol in the School of Art and Crafts in 1894, where he passed his examinations and was admitted to the courses of specialisation in "wooden sculptures".

In 1898 Brâncuşi was admitted to the National School of Fine Arts in Bucharest, where he transferred once again thanks to the help of Ion Georgescu Gorjan and to a new evening job in a restaurant. Here he carved first *Vitellius* (1898) and *Head of Laocoon* (1900), then *Ecorché* (1901), "a man's statue with the skin removed that shows the muscular system and the ligaments" and the bust of his benefactor (1902) (Fig. 1).

Awarded his diploma in 1903, the following year Brâncuşi transferred to Paris. There, thanks to a small scholarship received from Bucharest, and to the by now usual



(a) (b)

Figure 1. (a) Ecorché (1901); (b) bust of Ion Georgescu Gorjan (1902).

(a) (b)

Figure 2. (a) Pride (1905); (b) L'Enfant (1906).

evening job in a restaurant, he enrolled in the School of Fine Arts and frequented Mercié's workshop. In this period he carved *Pride* and *L'Enfant* (Fig. 2). He exhibited them in the Show of the National Society of Fine Arts, where he was judged "one of the most gifted artists of the new generation", and at the Autumn Show, where he met Rodin. A brief period of apprenticeship began with the latter but from which he left after a few months stating that "nothing can grow under large trees".

He decided therefore to open his own first workshop in rue de Montparnasse, where he began to create sculptures and do inlay work. Here he created in the same year (1907), four fantastic works: *Torment*, *The Prayer*, *The Wisdom of the Earth* and above all *The Kiss* (Fig. 3), the first sign of an anti-naturalistic and anti-romantic turn, aimed at the stylization of clearly and essentially concluded volumes; on this line, Brâncuşi reached the definition of pure, impersonal, primordial forms obtained through a progressive

(a) (b) (c) (d)

Figure 3. (a) Torment; (b) The Prayer; (c) The Wisdom of the Earth; (d) The Kiss (1907).

Figure 4. (a) The Kiss, Cemetery of Montparnasse (1908); (b) wooden column (1909).

Figure 5. (a) Maiastra (1910); (b) Miss Pogany (1912).

elimination of the accessory attributes. That is he tended "not to reproduce the external form but the idea, the essence of the things".

Brâncuşi once again took up the theme of *The Kiss* in 1909. Its first creation had a cubic form. That one in the cemetery of Montparnasse on the tomb of a young woman who committed suicide over love is more slender (Fig. 4(a)). The busts of the two bodies united by long arms recall the Romanian tradition according to which two trees planted at the sides of a grave evoke the strength of the love for eternity. This new version of *The Kiss* is the idealization and the prologue of the first wooden column, exhibited in 1909 at the Autumn Show (Fig. 4(b)).

Between 1910 and 1912 Brâncuşi created *Maïastra* and *Miss Pogany* (Fig. 5). The first is a golden bird that, in Romanian folklore, is able to change itself, to foretell the future, to bring separated lovers back together and to give sight back to the blind. With this representation Brâncuşi connected the notion of unity with that of metamorphosis, creating the first attempt to place his own sculptures in space. It also highlighted the first joining of the sculpture and the pedestal, one of the dominant themes of Brâncuşi's art: starting from the lower part, he tried to free himself from a material condition into a spirit that recalled oriental thought. The second represents a Hungarian girl who "inspired him by lowering her eyelids and by keeping her eyes half open". His success was by then overwhelming. He exhibited at the *Salon des Indépendants* together with Mondrian and Duchamp. He participated at the Armory Show in New York, contemporaneously exhibiting in Paris, London and Munich. He had his first personal show in the United States (1914).

Between 1913 and 1914, Brâncuşi carved *Le Premier Pas*, *Madame L.R.* and *Caryatid* (Fig. 6), his first wooden sculptures of African inspiration. They offered testimony of his new interest for primitivism and above all for Neolithic art. Rousseau said: "you want to turn antiquity into modernity".

In the same period Brâncuşi's exotic art blended well with the Romanian rustic tradition. Totemic columns were born, inspired by the funeral pillars of Transylvania (Fig. 7) and the superimposition of shapes that respect the spirit of the material. They are representations of the human body and new idealizations of the column that reappeared between 1917 and 1918. In 1920 Brâncuşi erected a column made up of 9 wooden modules in the garden of Edward Steichen (Fig. 8).

Brâncuşi's artistic line was defined by now. He accentuated his taste for abstraction, the search for the perfect and genetrix form that released stress and energy. He stuck with simple kinds of sculpture: the head, the stele

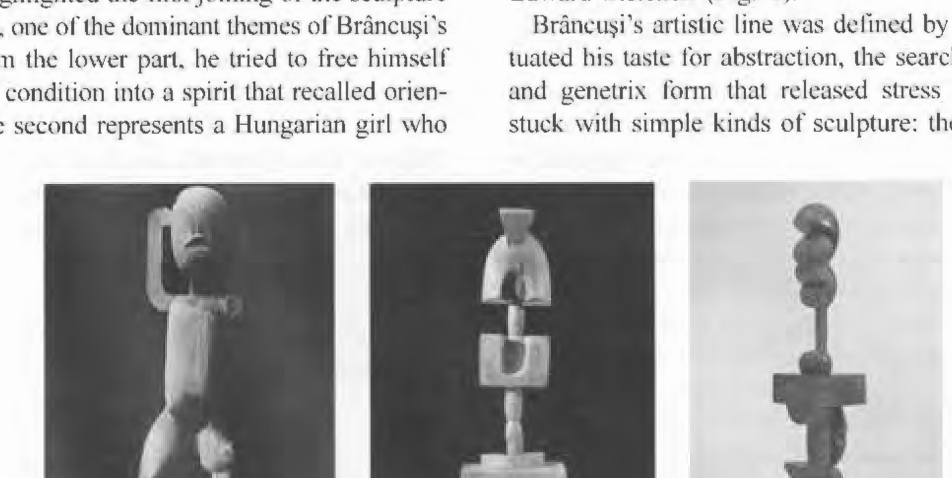


Figure 6. (a) Le Premier Pas (1913); (b) Madame L.R. (1914); (c) Caryatid (1914).

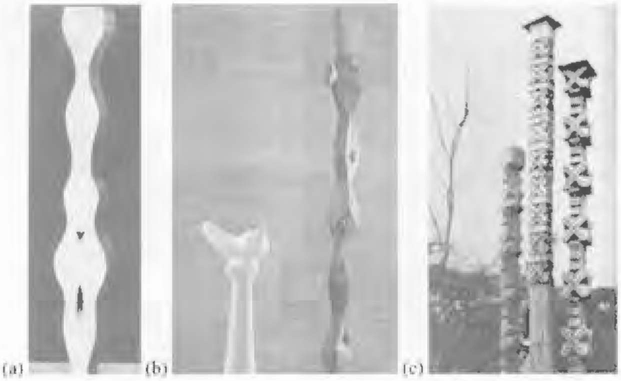


Figure 7. Totemic columns (a,b) inspired by the funeral pillars of Transylvania (c).

Figure 8. Column in the garden of Edward Steichen (1920).

and the caryatid. He worked with elementary shapes: the egg, the sphere, the cube and trapezoidal solids. He experimented with the interaction of such shapes with various types of raw and polished materials: stone, wood, bronze, brass and marble. Then he reached more complex aspects such as the combination of different elements or the multiplication of modular shapes. From here the superimposition of a principal shape on a plinth or the development of columns was born, in which Brâncuşi spasmodically sought the ideal relationship between the sizes of modules.

Between 1923 and 1925 Brâncuşi carved the *Bird in Space* (Fig. 9(a)), with which he continued his search for the pure shape. Starting again from *Maïastra* the ovoid shape became slender, the bird released its breath, the head and the legs joined in the verticality of the ascent and the body lost its own end. The quality of the bronze material and its shine made the shape of the bird immaterial and impalpable.

In 1931, by invitation of the Maharajah of Indore, he designed the Temple of Meditation in India, the conception of which evoked the pure and ovoid shape of the beginning of the world. There was a lake around which the three versions of the *Bird in Space* were placed - in white and black marble and polished bronze. In the centre of the temple there was the *King of the Kings* (Fig. 9(b)) originally called

Figure 9. (a) The Bird in Space (1923-1925); (b) The King of the Kings (1931).

the *Spirit of Buddha*. The work, never completed, incorporated the principle of essentiality, the integration of architecture, sculpture and furnishings, the poetic evocation of spiritual thought.

3. Design and Construction of the Endless Column

The idea of building the Endless Column in Romania dates back to 1921, when Brâncuşi proposed dedicating a monument to the memory of the heroes of the First World War. He returned to this idea in 1930, expressing the desire to erect a column at least 50 m high in a Bucharest square. Therefore, when in 1934 he was invited to design a monumental complex devoted to the resistance of the population of Târgu Jiu during the First World War, he made his dream come true near the place where he had been born.

Brâncuşi designed a complex set out along a line on the 45^{th} parallel, the Avenue of Heroes (Fig. 10). The avenue began in a park on the banks of the River Jiu, near the Table of the Silence (Fig. 11(a)), a work formed by a low and circular table surrounded by 12 seats in the shape of an hourglass. It represents the circle that holds people together inviting them to silence and meditation. It recalls the flow of blood of the soldiers killed in war. From the Table of Silence the Avenue of Heroes leads to the Gate of the Kiss (Fig. 11(b)) at the opposite end of the park. Elegantly sculpted, it is the place where a man meets a

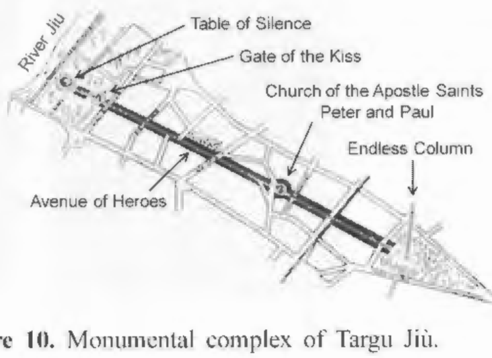


Figure 10. Monumental complex of Targu Jiù.

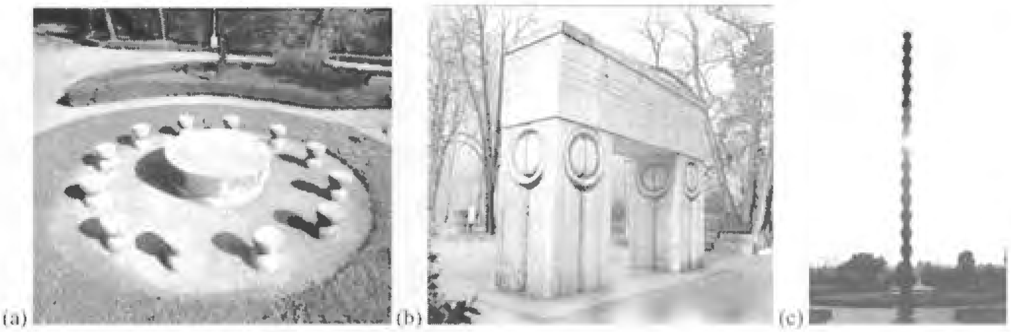


Figure 11. (a) The Table of Silence; (b) The Gate of the Kiss; (c) Endless Column.

woman and together they form a sacred union that represents the universe. This is the triumph of life over death. Beyond the Gate of the Kiss, the Avenue of Heroes leads to the orthodox church of the Apostle Saints Peter and Paul, then to a meadow, where the Endless Column (Fig. 11(c)) rises, initially called by Brâncuşi the "Column of Endless Gratitude" (Georgescu Gorjan, 2001; Andronescu and Melczer 2004).

To build the column Brâncuşi needed to have an engineer at his side. He was recommended the engineer head of the Central Laboratory of Petrosani, in Târgu Jiu. By a strange twist of fate, the latter was Stefan Georgescu Gorjan, the son of the owner of the "The coloured star" who had helped him in his early years. Brâncuşi was moved and appreciated both the professional skills of Stefan and his great general knowledge. In December 1934 Gorjan joined Brâncuşi in Paris and suggested: "fixing the base of the iron pillar in a thick foundation of concrete and inserting along the pillar identical modules of covering, whose overlapping would give the impression of continuity." Brâncuşi approved enthusiastically.

In the summer of 1937 Brâncuşi went to Târgu Jiu to choose the site for the column, then stayed in Gorjan's house in Petrosani, and together they worked for two weeks to reconcile the artistic vision, the technical aspects and the economic availability. Brâncuşi decided that the modules of the column would respect the law of plastic harmony, fruit of a long pathway of experimentation: their length was 4 times the smaller side and twice the longer one. He was instead very open on the technical questions that led to the choice that the column should be 29.26 m high. Having set this parameter, Brâncuşi and Gorjan agreed that the modules should have dimensions of 450 mm × 900 mm × 1800 mm (Fig. 12). The column therefore had a slenderness ratio of 66 with reference to the smallest size of the section, an exceptional value, beyond every custom, the limits of its time and to a large extent those of today.

In October 1937 the excavation of the foundations was carried out in the shape of the trunk of a pyramid. They were made up of two superimposed blocks of unreinforced concrete (Fig. 13(a)). The lower block, 2 m high, measured 4.50 m by 4.50 m in plan. The upper block, 3 m high, was of the "terraced" type and had three ledges that measured 4.00 m by 4.00 m, 3.50 m by 3.50 m and 3.00 m by 3.00 m in plan. The plate at the base of the spine was connected

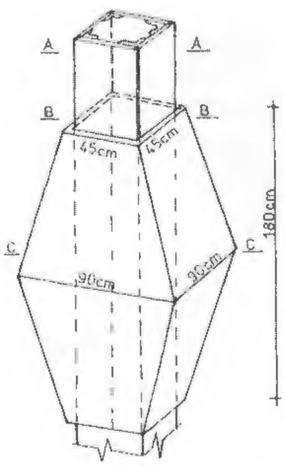


Figure 12. Modules of the column: law of plastic harmony.

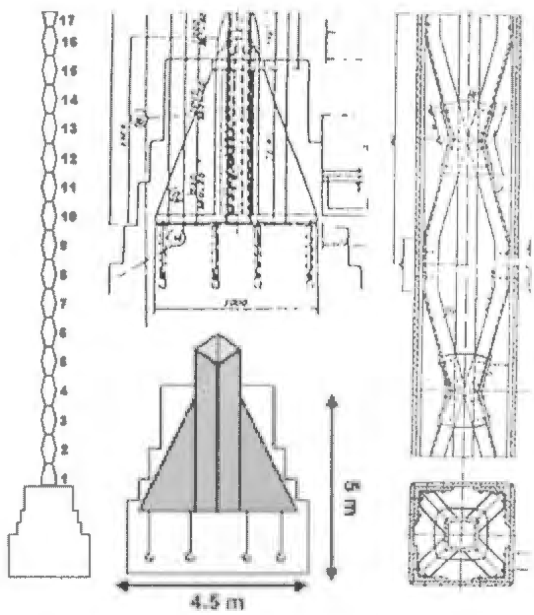


Figure 13. Foundation of the column: (a) concrete block; (b) connection between the base of the spine and the foundation by anchor bolts; (c) trellis made up of sections laid in a cross.

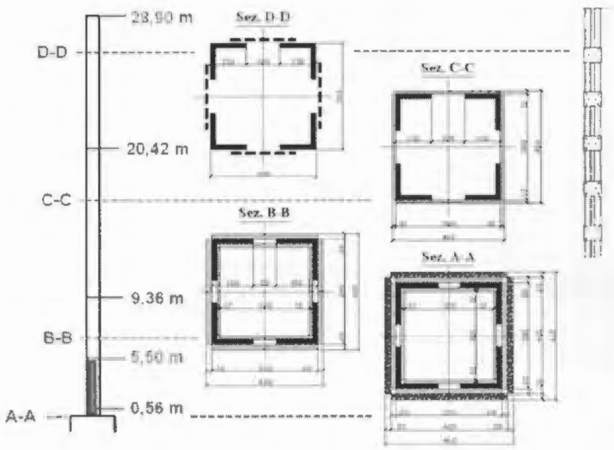


Figure 14. Steel spine of the column.

Figure 15. Phases of construction of the column.

with the foundation through 8 anchor bolts (Fig. 13(b)), anchored to the upper concrete block; they were also connected to a trellis made up of sections laid to form of cross, incorporated in the lower concrete block (Fig. 13(c)).

The spine, completed in mid-November, was created in three pieces welded on site to allow their transport. It consisted of a steel stem, 28.90 m in height, with a square cross-section of varying dimensions from 380×380 mm at the top to 460×460 mm at the base (Fig. 14). The summit tract with section D-D consisted of 4 angle brackets 130×130×16, connected by tie battens made up of plates 380×300×12. Below the height of 20.42 m, in the tract with section C-C, externally to the 4 angle brackets there were 4 rectangular plates 380×12. Below the height of 9.36 m, in the tract with section B-B, the 4 angle brackets became 150×150×18, the 4 rectangular plates become 380×20, internally to the angle brackets there were 4 rectangular plates 320×12. Below the height of 0.56 m, externally to the previous elements, there were 4 rectangular plates 420×20. The spine was filled with concrete up to the height of 5.50 m. The connections of the sections that made up the spine were carried out with rivets and bolts without nuts.

The modules placed on the spine were of cast iron. Each module consisted of two trunks of a square base pyramid, joined in correspondence of the largest bases. The edges of the pyramid trunks were not rectilinear, therefore the faceting of the modules was curved and different for every facet. The cast iron was painted internally and externally plated with thin layers of zinc, brass and a protective lacquer that gave it a yellow-gold aspect.

All in all 15 complete modules were created plus two half end modules (Fig. 15). Thanks to them, unlike ancient columns with a base and a capital, the column had neither a beginning nor an end. The semi-module at the base was made up of a trunk of a pyramid 90 cm high, the larger base of which continued in a prism with a square base to an overall height of 136 cm; thanks to this, the column seems firmly anchored to the ground. At the top the semi-module is made up of a trunk of a pyramid topped by a cover; seen from below it seems smaller and transmits a sense of perpetual incompleteness and potential endless continuation in space. The modules were connected to the spine by means of metallic connectors that allowed transfer of the horizontal forces but not the vertical ones. The modules were not bonded to one another.

The assemblage of the modules was completed in June 1938. The column was inaugurated in October 1938. Having completed the column, Brâncuşi left Romania never to return. His life stayed rich in successes but at the same time it became more and more solitary and isolated. On March 16th 1957 he died in Paris at the age of 81.

The Endless Column once more took up the idea of the "*axis mundi*" that sustains the vault of the heavens and connects the earth to the sky. Through the column, symbol of "ascension" and "transcendence", man raises his own spirit, he reaches absolute freedom and beatitude, rejecting every form of conditioning. According to Brâncuşi it was a "stairway to Heaven" destined to the souls of dead soldiers. It reproduced a movement upward and "a cosmic infinity" that transcended the force of gravity and the mortality of man. According to critics it is the only sculpture of modern times that can be compared to the great Egyptian, Greek and Renaissance monuments, although it looks to the future from the pedestal of a new era of sculpture that is deeper, freer and more abstract. It is "the most radical sculpture in the history of classical modernism". It cuts the history of sculpture in two, setting the beauty of this Romanian genius on the border between the classical era and the modern one.

4. Preservation of the Column

With the Second World War over, the era of the communism prevented Brâncuşi, defined an "undesirable person" from returning to his country. The column was seen as a subversive symbol. Stefan Georgescu Gorjan was imprisoned and sent to do forced labor. Many documents collected on the column were destroyed. In 1953 the mayor of Târgu Jiu had a cable attached to a tractor and had the column pulled to try to topple it. The attempt was not successful, but the spine and the foundations were damaged.

When Gorjan returned to liberty he devoted the rest of his life, at his own expense, to maintenance of the work. He had the column re-plated between 1965 and 1966. He repeated this operation in 1976 at the time of the centennial of the birth of Brâncuşi. UNESCO proclaimed 1976 "international year of Brâncuşi".

In 1984 the Romanian institute for Research on Constructions (INCERC) compiled a report in which it supplied accurate measurements of the construction. Another INCERC report supplied the results of measurements that estimated a fundamental period of vibration equal to 1.8 s. The damping was not measured. In the same report the consequences of the pull of 88 kN caused by the cable towed the tractor in 1953 were examined. It estimated a tilt of 7°, with a shift of 21 cm at the summit.

In 1985 a technical committee studied the conditions of preservation of the Column. It defined the behaviour of the monument over the years excellent and stated that its maintenance required at most protective measures against corrosion (Fig. 16) (Georgescu et al., 1986). Gorjan died 2 months later, on March 5th 1985, happy about the interest of his country regarding the masterpiece.

In 1989 Ceausescu was deposed and Romania went back to looking at the preservation of its monuments. "We want to restore everything", said Radu Varia, a famous Romanian art critic and expert on Brâncuşi, who set up the Constantin Brâncuşi International Foundation in New York in 1991 and proposed a plan of restoration for the column. The following year Varia managed to have the memorial of Târgu Jiu declared by the Romanian government a "monument of public utility and national interest". Just as Varia wished, in May 1996 the column was listed in the World Monuments Watch of the first 100 world monuments to which to destine World Monument Fund (WMF). At the same time Romania asked UNESCO for the column to be placed in the World Heritage List.

Everyone agreed on the decision to restore the monumental complex and above all the column. They all appreciated Varia's initiatives. However, his ideas on the type of restoration created enormous controversies. Varia sustained that when the column had been built it was a fable of engineering; over time, nevertheless, condensation had formed on the inside that had damaged it. For this reason he wanted to clean up and restore both the interior and the exterior using a different coating than brass. He wanted to install sensors inside the column to monitor the temperature and the humidity. He wanted to replace the corroded spine with a column in stainless steel. He wanted to rebuild the foundations.

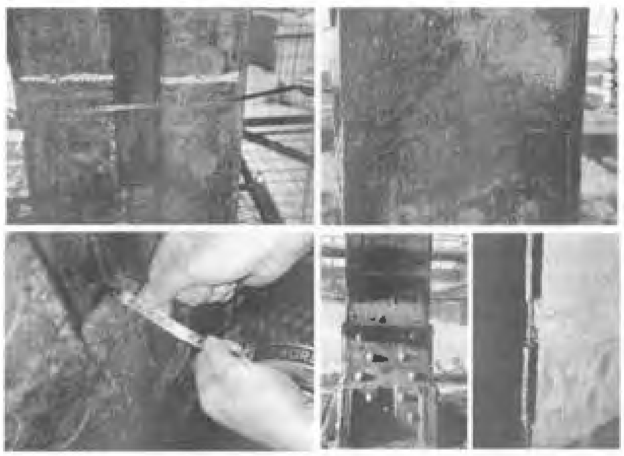


Figure 16. State of preservation of the column (1985).

That was the beginning of a battle of opinions. Many followed Varia in the idea of replacing the spine. Others sustained that such an intervention would de-naturalize and deface the monument. Above all Sorana Georgescu Gorjan, the design engineer's daughter, defended the identity of the monument, saying that to destroy even just one element of the column would be the same as destroying it.

Despite this, in September 1996 the modules of the column were dismantled for a deeper and closer examination. Initially the spine was abandoned for many months in the rain and snow, as evidence that its substitution was by then taken for granted. Later it was wrapped in an ineffective and even more harmful plastic sheet: the covering held in the damp and encouraged corrosion. This worsened the consequences of a previous intervention: the plugging of a hole in the semi-module of the summit that favored the internal circulation of air.

Towards the end of 1996 the competence of Varia to administer the project and his methods were brought into discussion by the Romanian Government. The modules were heavy and the crane used for dismantling them, of insufficient height, damaged several of them. To overcome the difficulties, some of these were dismantled with a sledge hammer. Only at a later time did he resort to scaffolding. The situation worsened when Varia removed some steel samples from the spine to perform metallurgical studies (Fig. 17). The results were not published; the pieces removed disappeared and had to be recast and welded to close the holes.

At the beginning of 1997 new metallurgical analyses were carried out that showed that the steel was not of high strength and possessed minimal quantities of carbon, sulfur and phosphorus. The yield strength was included between

Figure 17. Bored mudulus.

229 and 262 N/mm^2, the ultimate strength between 318 and 411 N/mm^2; so the material, classified as type OL 37-2 according to the Romanian code, could be likened to Fe360 steel according to Eurocode 3 (2005a). Similar examinations showed that the preservation of the modules was satisfactory and that the plating performed by Gorjan had protected the base material well. Instead, the initial color had completely disappeared.

On the other hand worries were raised by a report on the resistance of the spine compiled by INCERC in September 1997. An analysis of the free vibrations confirmed that the fundamental period was equal to 1.8~1.9 sec. The actions of the wind were calculated with the Romanian, American, Canadian codes and with Eurocode 1 (2004). Operating with the admissible stress method, for wind perpendicular to a face the safety coefficient was equal to 1.43; for diagonal wind it was included between 0.98 and 1.08. Repeating the analyses bearing in mind the corrosion, the safety coefficient respectively reduced itself to the values of 1.35 and 0.93~0.98. Apprehension over these results was partially mitigated by the fact that the structure had existed without problems for 60 years.

In the spring of 1997 the WMF renewed its support to Romania for the restoration of the monument, but asked to examine Varia's much discussed project. Following such request the Romanian Ministry of Culture asked for the intervention of UNESCO, which sent a delegation of experts to Romania, from November 30th to December 5th 1997, which compiled a preliminary report in January 1998. Sometime later UNESCO sent a second delegation of experts to Romania; in May 1998 it compiled a document (Croci et al., 1998) that represents a milestone in the history of the monument.

The document began by examining the 3 solutions proposed by the Romanian experts: A) the modules are not removed; B) the modules are removed but the spine stays intact; C) the modules are removed and the spine is replaced with a new one in stainless steel. Going back to the calculations of INCERC, the committee observed that the spine had a resistance inferior to that required by the regulations. Therefore it acknowledged that solution C) was technically the best. On the other hand it pointed out that science and technology must place themselves at the service of culture, and that separate pathways cannot be undertaken to reach the dual purpose of guaranteeing safety and the authenticity of the work. Therefore the committee proposed a fourth solution D) which consisted of restoring the spine without replacing it; it foresaw 9 points: a) dismantling the spine; b) examination of its internal surfaces; c) installation of the elements of the spine in a laboratory; d) sandblasting and painting to eliminate the corrosion; e) reinforcement of the spine; f) treatment for protection against corrosion; g) remounting of the spine; h) maintenance; i) plating of the modules.

As regards the spine, the committee suggested increasing the resistant section of the corroded zones adding new original steel plates to the elements inside the spine so as not to modify its external dimensions. As regards the modules, they recommended balancing the repair and the preservation of the original surfaces, suggesting caution about excessive restoration; for the plating, they also recommended using methods respectful of the technical limits in place in 1936 and that the choice of alloy maintained the original color.

In conclusion the report declared that the column was a work of art of engineering and recommended making every effort to preserve its "artistic value, potential unity and integrity". Thus the committee agreed that substitution of the spine would destroy the artistic value of the column, since the criterion of authenticity would no longer be valid.

On the provisions of this document the Romanian Government paid for new tests on the spine. They showed that the plates did not have any fractures. Of 8 welded joints examined none showed cracks. The steel had low carbon content, a limited tendency to form cracks and fractures and was easy to weld. The welds were not with complete penetration. Of 100 bolts examined, only one was broken. From the point of view of corrosion, the spine was in much better condition than expected. The spine was in a more suitable condition to be preserved than to be replaced.

5. Restoration of the Column

Once it had been established that Varia's scheme of restoration was based on wrong assumptions, the WMF recommended adoption of a project of intervention inspired by the guidelines contained in the report from UNESCO. To allow everybody to express their own ideas, it also organized an international conference in Târgu Jiu and Bucharest, from June 2nd to 4th 1999, to identify a scheme of restoration that was not invasive (Treatment, 1999).

In 1999 Romania gave up the idea of replacing the spine. The World Bank financed Romania with \$2 million to restore the monument without replacing it. UNESCO declared the Column "World Heritage" stating that "it is not only a masterpiece of modern art, but also an extraordinary enterprise of engineering. Its double function and its unique message make it mandatory to make whatsoever effort to preserve it". Unfortunately the fund allocated by the World Bank was almost entirely used, once more, to solving the problem of corrosion, relegating the structural aspects to a marginal role.

On December 30th 1999 the Romanian Ministry of Culture and the Union of Plastic Artists (UAP) signed the contract of restoration-consolidation of the column. In January 2000 their guidelines were issued for the restoration (Crisan, 2000). On January 24th 2000 Dan Lungu, a professor at the Technical University of Civil Engineering, Bucharest and recently made director of INCERC, compiled a new report on the actions and the effects of wind on the column (Lungu, 2000), which mitigated the previous results on the safety of the work, besides confirming some criti-

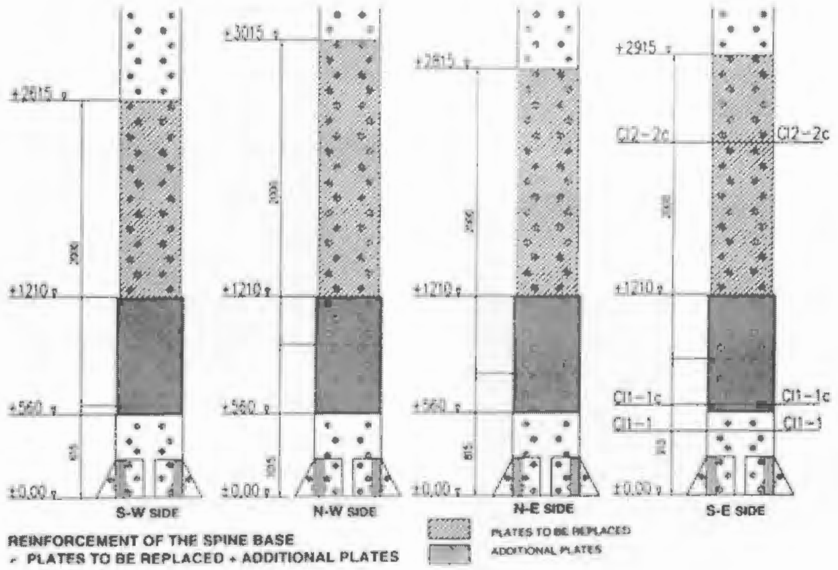


Figure 18. Project of the intervention at the base of the spine.

calities. Applying the new American standard, not yet issued, the spine was verified; applying Eurocode 1, the stress exceeded the yield strength by 25% in the sections at the height of 55 cm and 125 cm.

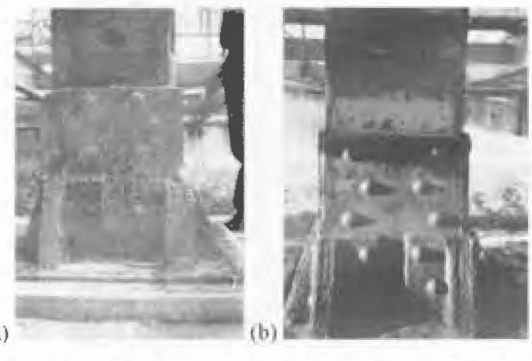
On the basis of Lungu's document, in February 2000 the strategy for structural recovery was outlined (Crisan and Dogariu, 2000). The objectives of the intervention were: 1) to bring the spine to its initial structural parameters verified on site for 63 years; 2) to increase the resistance and the stability of the original spine with regard to the actions of wind and earthquake. The operations to achieve such objectives consisted of: 1) strengthening the lower part of the spine and replacing the welds; 2) creating a system of damping inside the spine. The reinforcement at the base of the spine envisaged (Fig. 18): 1) replacing the 4 slightly corroded external plates between the heights of 1.21 and 2.62 m, with 4 identical plates (22×378×2000 mm) made of type OL 52 steel corresponding to Fe 510 steel; 2) externally applying an additional collar to the spine made up of 4 plates 20 mm thick, between the heights of 0.56 and 1.21 m. The intervention also envisaged a check and if necessary the replacing of the horizontal welds between the plates. It was proposed to study the damping system at a later time, only if necessary.

On July 3rd 2000 Lungu sent me a fax in which he told me the vicissitudes of the column and he explained that he had succeeded in blocking the idea of replacing the spine accepting small interventions of reinforcement even though not proven by in-depth analysis as the work would require. He thus asked me to carry out advanced analysis that might possibly show that the aerodynamics of the column was much better than estimated with conventional methods. He was convinced that the genius of Brâncuşi has been able to create not only an artistically perfect shape, but also so efficient as to render the actions of the wind minimum. We met in Genova at the beginning of August.

In Genova I expressed my doubts to Lungu on the reliability of the structural analysis on the action of the wind, carried out using standards clearly inapplicable to such a particular structure. I also expressed my worries about the lack of analysis on the crosswind response, particularly on vortex shedding and galloping. The fact that the column had survived more than 60 years was only a motive for partial comfort: with respect to phenomena with potentially catastrophic consequences such as vortex shedding and galloping, it was necessary to investigate the effects of events with at least 500~1000 years of return period.

At the end of our meeting we compiled a program for the studies to be carried out; they included full-scale measurements, wind tunnel tests, analysis of the dynamic response and the aeroelastic behavior, evaluation of the wind-induced fatigue and of the structural reliability. Lungu was convinced that the Romanian ministries and banks would be willing to finance such an important study. At the beginning of September, we signed a declaration of intent between the University of Genoa, INCERC and the Rumanian Ministry of Culture.

The restoration work began on October 1st 2000 and was



(a) (b)

Figure 19. Base of the spine before (a) and after (b) the intervention.

completed on December 15th (Milligan and Tully, 1995; Parigoris, 2002). The structural solution, coherent with the UAP report (Crisan and Dogariu, 2000) (Figs. 19 and 20), was approved by the World Bank and by the Romanian Ministerial Committee for Historical Monuments. The ornamental modules were endowed with a protective covering and with a shiny bronze finish of golden color that replicated the original (Fig. 21). They were not bonded to one another but connected with silicone to better absorb the movements induced by the wind and possibly by an earthquake. A system of ventilation at the base of the stem and a device for protection from lightning were also created (Fig. 22).

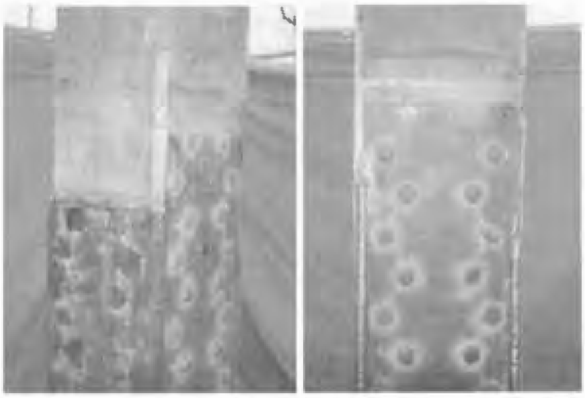


Figure 20. New steel plates.

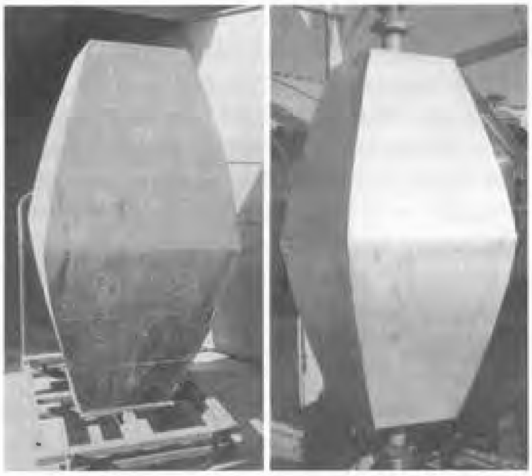


Figure 21. Restoration of the modules.

Figure 22. Endless Column at the end of the restoration works.

The monitoring and dynamic identification of the Column were often carried out at night so as not to hinder the restoration work. The investigations made use of environmental vibrations taken with a measuring system of microtremors (Lungu et al., 2005). The measurements were taken after the sealing of the joints with silicone.

The vibrations of the spine without the ornamental modules were measured on November 3rd. The first and second natural periods were respectively 1.205 s and 0.268 s; the damping coefficients of the first two modes were respectively 0.0082 and 0.018. The vibrations of the column complete with the modules were measured on November 14th. The fundamental period was 1.949 s; the damping coefficient was included between 0.0159 and 0.0193 as a function of the direction of vibration. The presence of the modules increased both the period and the damping; so the modules did not have merely an ornamental role, on the contrary they developed an important structural function. It is worth noting that the sealing of the modules with silicone probably reduced the dissipation in comparison to the original state of the column, when the modules were not connected.

Unfortunately, despite the signature of the declaration of intent, reality showed itself once more different from what had been expected. Many months passed in which the government and the Romanian banks took their time over the decision to destine resources to the study of wind actions. When it was clear that this would not happen, curiosity to understand the behavior of the column was so great that I decided to start the study out of pure scientific interest. In this way, in April 2001 an experimental, theoretical and numerical research began that is still in progress. At first it focused on the behavior of the monument in its real configuration; later it was extended to the spine deprived of the covering modules, a condition in which the column has been left for long time.

6. Wind Tunnel Tests and Aerodynamic Properties

The experiments on the column with the covering modules were carried out in April 2001 in the open circuit wind tunnel of CRIACIV, with a test section of 2.4×1.6 m (Solari et al., 2002). Tests were performed in smooth flow, on a 1:6 rigid sectional model including three modules (Fig. 23), with a span length 900 mm. The model, put horizontally with respect to the flow, was sustained between two rectangular end-plates, so to get an approaching flow

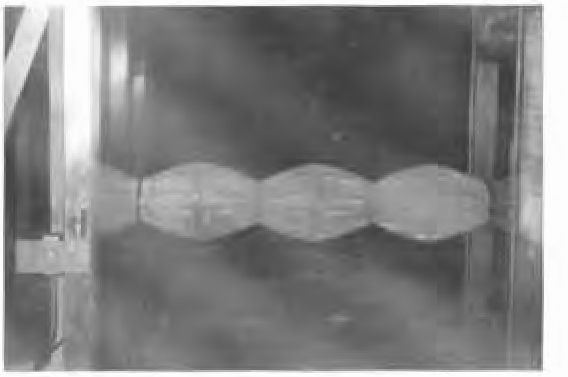


Figure 23. Sectional model of the column in the wind tunnel.

with no appreciable 3-D effects. The model structure consisted of a rigid circular steel arm; the appropriate shape of the cover elements was obtained through Plexiglas curved surfaces, fixed to rigid Plexiglas ribs. The supporting arm was restrained by 6 steel trusses connected to as many load cells. The signals from the 6 cells were acquired with sampling frequency 1000 Hz.

Let X, Y be a couple of Cartesian axes parallel/perpendicular to the sides of the column. Let x, y be a couple of Cartesian axes rotated the angle of attack β with respect to the axes X, Y; x is aligned with the mean wind velocity $\bar{u}$ (Fig. 24). Let D and L be the drag and lift force per unit length, along x and y respectively, measured by the load cells. From such measures the following drag and lift coefficients, Strouhal number and rms value of the lift coefficient were obtained:

$$c_D=\frac{\bar{D}}{\frac{1}{2}\rho\bar{u}^2 b};\ c_L=\frac{\bar{L}}{\frac{1}{2}\rho\bar{u}^2 b};\ S=\frac{n_s b}{\bar{u}};\ c_{Lrms}=\frac{\sigma_L}{\frac{1}{2}\rho\bar{u}^2 b} \quad (1)$$

where $\bar{D}$ and $\bar{L}$ are the mean values of D and L, σ_L is the root mean square (rms) value of L, $\bar{q}=\rho\bar{u}^2/2$ is the mean velocity pressure, ρ is the density of air, n_s is the vortex shedding frequency obtained from the power spectral density of L, b is the reference size of the section, in this case the maximum width B of the covering modules ($b=B=900$ mm in full-scale).

The approaching wind speed was varied in the range 10 to 20 m/s, in order to check for possible Reynolds number effects. In this case, they are almost negligible. The relative angle of attack β of the wind was varied by rotating the model from –55° to +55°, with steps of 5°. Smaller steps

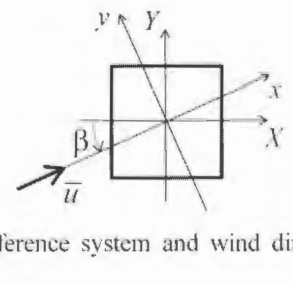


Figure 24. Reference system and wind direction.

for β were adopted close to 0° and 45°. Figure 25 shows the diagrams of c_D, c_L, $c_D+c'_L$, c'_D-c_L, S and c_{Lrms}, as functions of β; $c'_D=\partial c_D/\partial\beta$ and $c'_L=\partial c_L/\partial\beta$.

The experiments on the column without the covering modules were carried out in the closed circuit wind tunnel of the Faculty of Engineering of the University of Genova, with test section 1.7×1.35 m. Two configurations were studied (Fig. 14): 1) a prismatic element with square section, representative of sections A-A, B-B and C-C of the spine and of the section D-D wrapped in a plastic sheet; 2) the part of the spine with section D-D, constituted by 4 angle brackets connected by batten plates.

The aerodynamic properties of the prismatic element with square section, also documented in several scientific papers, were determined between the end of 2011 and the beginning of 2012 during a test campaign aimed at studying, more in general, the role of rounded corners (Carassale et al., 2012). Tests were performed in both smooth and turbulent flow on rigid sectional models composed by the assemblage of aluminum plates; the models had a span length 500 mm and were mounted in cross-flow configuration on a force balance realized by 6 load cells. End plates were installed at the extremities of the models to maintain two-dimensional flow conditions (Fig. 26). In order to explore possible Reynolds number effects, herein almost negligible, tests were carried out varying the wind-tunnel velocity in the range between 5 to 25 m/s and the side l of the element in the range between 60 to 150 mm. The relative angle of attack β of the wind was varied by rotating the model from –5° to +50°, with steps between 2° and 5°. Signals from the 6 cells were acquired with sampling frequency 2 KHz. Similarly to Fig. 25, Fig. 27 shows the diagrams of c_D, c_L, $c_D+c'_L$, c'_D-c_L, S and c_{Lrms} as functions of β in smooth flow conditions. These quantities are made non-dimensional with reference to the side l of the square section ($b=l$ in Eq. (1)).

The aerodynamic properties of the top part of the spine were determined by wind tunnel tests carried out at the end of 2012. Tests were performed in smooth flow, on a 1:6.5 rigid sectional model composed by the assemblage of aluminum plates (Fig. 28); the model had a span length 500 mm and was mounted in cross-flow configuration using the same balance, end plates and acquisition system described above. In order to explore possible Reynolds number effects, also in this case almost negligible, tests were carried out varying the wind-tunnel velocity in the range between 7.8 to 24.7 m/s. The relative angle of attack β of the wind was varied by rotating the model from –5° to +50°, with steps between 2 and 5°. Similarly to Figs. 25 and 27, Fig. 29 shows the diagrams of c_D, c_L, $c_D+c'_L$, c'_D-c_L, S and c_{Lrms} as functions of β. These quantities are made non-dimensional with reference to the side l of the section ($b=l$ in Eq. (1), with $l=380$ mm in full scale, excluding the batten plates).

It is worth noting to compare the drag force of the column with the covering modules and that of an equivalent

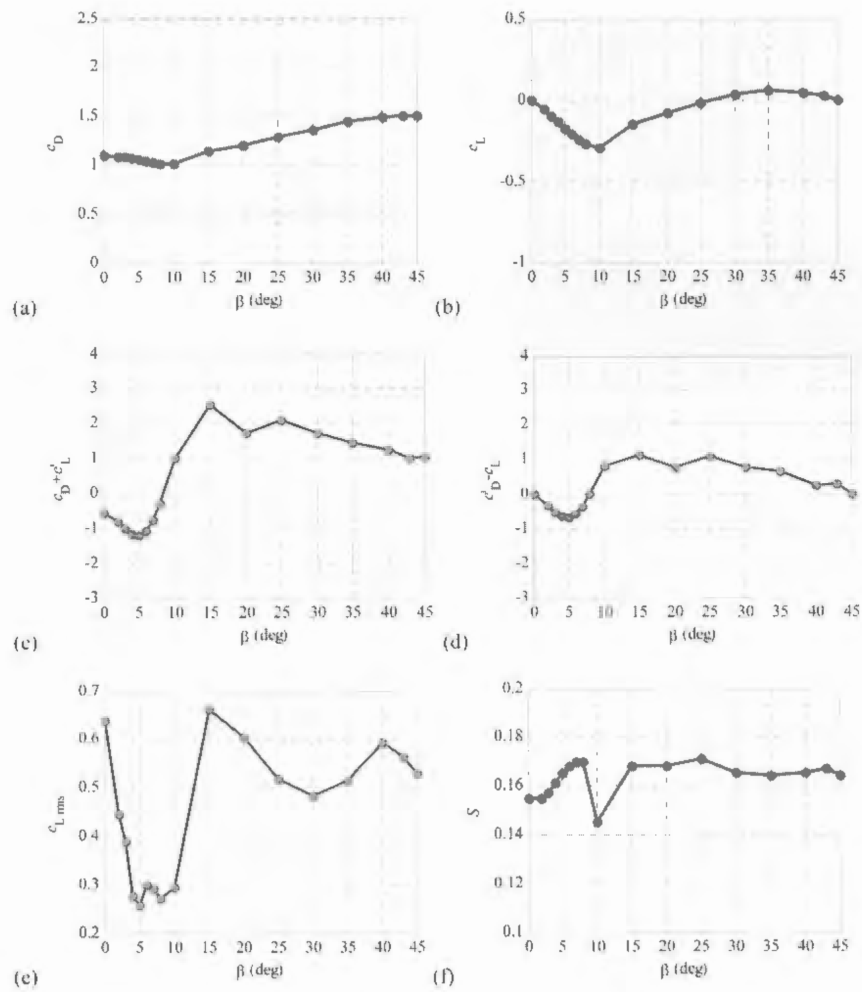


Figure 25. Aerodynamic parameters of the column: (a) drag coefficient; (b) lift coefficient; (c) coefficient $c_D + c'_L$; (d) coefficient $c'_D - c_L$; (e) Strouhal number; (d) rms value of the lift coefficient.

Figure 26. Sectional model of a square section prismatic element in the wind tunnel.

prismatic element, with square section of constant length side l and exposed surface equal to that of the column ($l = 0.82 \cdot B$). In virtue of its shape variable with the height, when the wind is perpendicular to a side ($\beta = 0°$) or diagonal ($\beta = 45°$), the column has a drag force equal, respectively, to 62% and 83% of that of the equivalent element. So it has, in terms of the drag force, a very high aerodynamic efficiency, above all when the wind is perpendicular to its sides.

It is also worth noting to compare the parameters of the vortex wake created by the column and by a square section prismatic element. Using the definition of S in Eq. (1), the vortex shedding frequency n_s of the column is intermediate between the couples of the n_{s1} and n_{s2} values corresponding, respectively, to two prismatic elements with sides equal to the largest ($l_1 = B = 900$ mm) and to the smallest ($l_2 = B/2 = 450$ mm) size of the section of the column. Furthermore the tests demonstrate that, for any wind direction, the vortex shedding frequency of the column falls in a dispersed harmonic band, caused by a very irregular vortex wake. So the column has, also with reference to the vortex shedding, a very high aerodynamic efficiency.

Finally note the behavior of the top part of the spine. Being the angle brackets separated, the air passes through the section. Thus the drag force is reduced and the excitation due to the vortex shedding decreases to almost vanish; for $\beta = 0°$ and $\beta = 45°$, in particular, there is no regular shedding of vortices. On the other hand, for $\beta = 0°$, the negative value of $c_D + c'_L$ is high. Thus the spine, free or

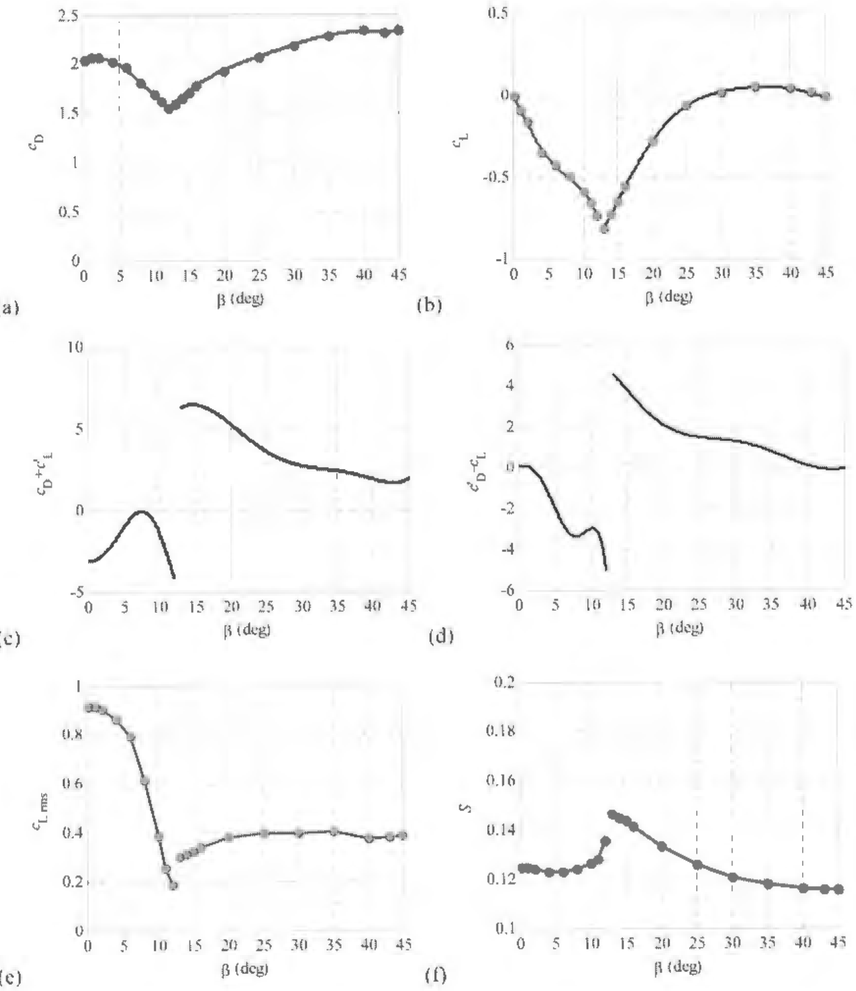


Figura 27. Aerodynamic parameters of the square section prismatic element: (a) drag coefficient; (b) lift coefficient; (c) coefficient $c_D + c'_L$; (d) coefficient $c'_D - c_L$; (e) Strouhal number; (d) rms value of the lift coefficient.

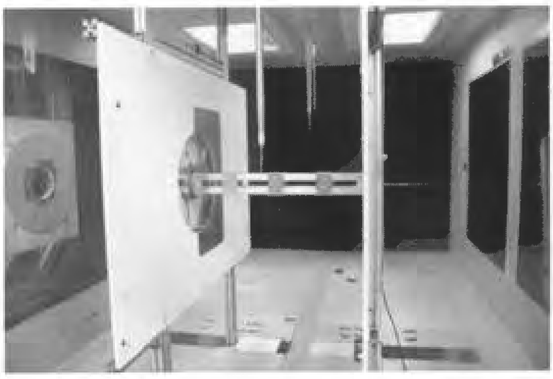


Figure 28. Sectional model of the top part of the spine in the wind tunnel.

wrapped, has high susceptibility to galloping.

7. Wind and Structural Modeling

Coherently with the Eurocode 1, the Rumanian code assigns the zone of Targu Jiù a base reference wind velocity $u_b = 25.3$ m/s (averaged over 10 minutes, at the height $z =$ 10 m, in a flat homogeneous terrain with roughness length $z_0 = 0.05$ m and return period $R = 50$ years).

The column is set in a park with mown grass, surrounded by trees and hedges (Fig. 30(a)). To the west is the center of Targu Jiù; to the north, east and south is a suburban area that degrades towards open country (Fig. 30(b)). Using the Eurocode 1 and the Rumanian code, the column is in a terrain of category II, with roughness length $z_0 = 0.05$ m. The mean wind velocity with $R = 50$ years at the top of the column, $h = 29.26$ m, is $\bar{u}(h) = 30.63$ m/s.

The actual properties of the wind at the column are estimated by means of a detailed model of the roughness length of the terrain, using the method formulated by ESDU (1993). Figure 31(a) shows the mean wind velocity profiles $\bar{u}(z)$, for 12 wind directions α (α = 0°, 30°, ... 330°; α = 0° corresponds to the wind from the north, Fig. 31(b)). The same figure shows the mean wind velocity profile for $z_0 = 0.05$ m; it is greater than all the directional profiles. The maximum value of the mean wind velocity at the top of the column with $R = 50$ years is $\bar{u}(h) = 28.82$ m/s (less than the value $\bar{u}(h) = 30.63$ m/s provided by the code) and occurs for α = 120°.

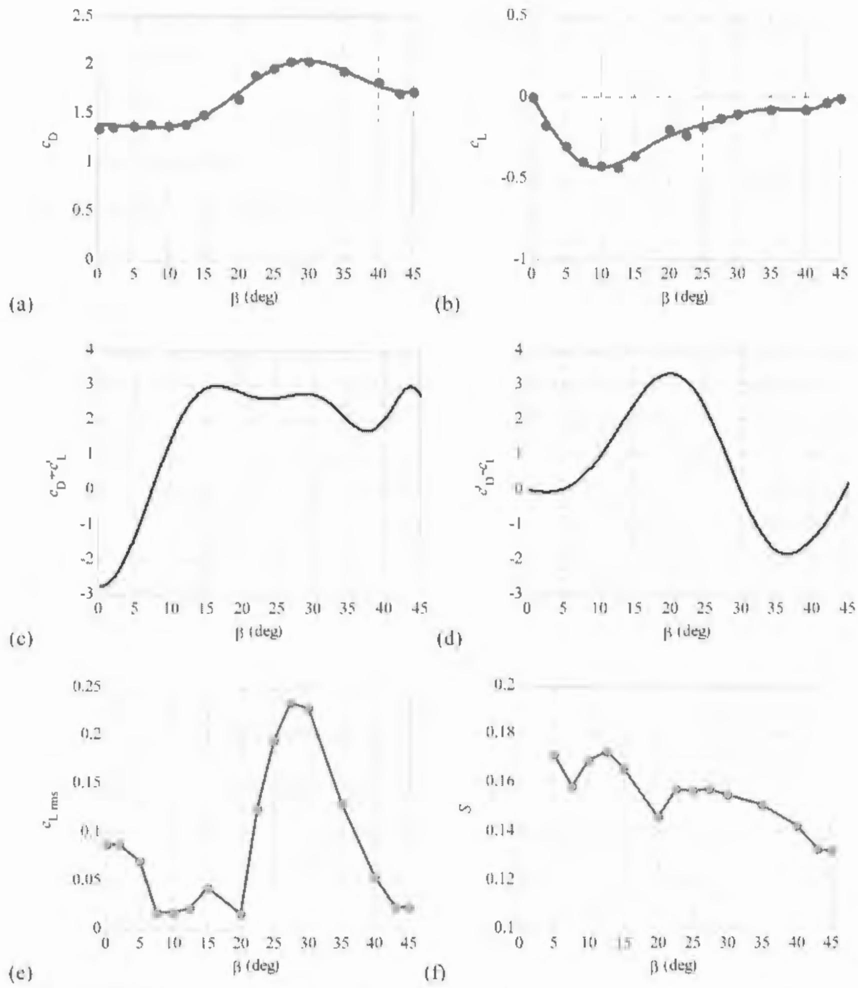


Figura 29. Aerodynamic parameters of the top part of the spine: (a) drag coefficient; (b) lift coefficient; (c) coefficient $c_D + c'_L$; (d) coefficient $c'_D - c_L$; (e) Strouhal number; (d) rms value of the lift coefficient.

Figure 30. Plan view of the site of the column: (a) park; (b) neighbourhood area.

The atmospheric turbulence is represented by the model proposed by Solari and Piccardo (2001).

The structure is schematized by two finite element models corresponding, respectively, to the column without and with the covering modules. Both these models are constituted by beam elements, vertical and superposed, with 6 degrees-of-freedom (DOF) per node. The node at the base is clamped.

The stiffness and the mass of the column without the covering modules are evaluated as a function of the geometry of the cross-section of the spine (Fig. 14). Since the inertia central ellipse is a circle with the center in the barycentre, all the couples of barycentric orthogonal axes x, y (Fig. 24) are also principal axes of inertia. So, the flexural modes occur in couples with equal natural frequencies and modal shapes, respectively, in the planes x, z and y, z. The calculated natural frequencies are in perfect agreement with the measured ones (Table 1).

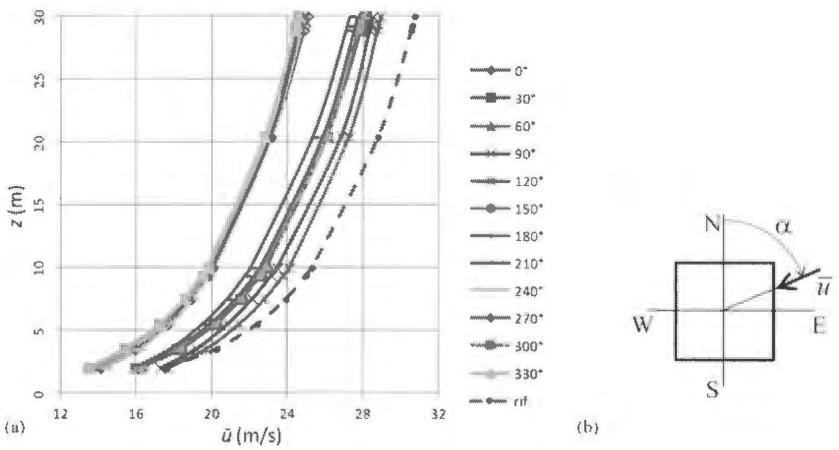


Figure 31. (a) Mean wind velocity profiles at the column as a function of the wind direction; the dashed line corresponds to the roughness length $z_0 = 0.05$ m (code); (b) reference system.

The mass of the complete column is determined by taking into account the contribution of the covering modules. The increment of the stiffness due to such modules is considered by attributing the steel of the spine an equivalent elasticity modulus obtained equating the numerical and measured fundamental frequency (Table 2).

The numerical results show that the first flexural modes of the column with and without the covering modules are almost coincident. The modal shapes in the planes x, z and y, z of the first couple of modes is well approximated by the law $\psi(z) = (z/h)^{1.75}$.

All the analyses herein carried out attribute the damping coefficients the measured values. Thus, for the spine without the covering modules $\xi_{s1} = \xi_{s2} = 0.0082$; for the column with the covering modules $\xi_{s1} = \xi_{s2} = 0.016$.

8. Aeroelastic Instability and Dynamic Response

The column is so slender, light and slightly damped as to be a natural candidate to the onset of aeroelastic instabilities and in particular of galloping, a form of instability corresponding to cancel the damping. It is called 1-DOF galloping when this phenomenon involves only one mode of crosswind vibrations; it is called 2 DOF galloping when it involves two modes of alongwind and crosswind vibrations, respectively; it is called multi-DOF galloping when it involves more modes of vibration. In the present case the natural frequency of the first couple of modes is so smaller than the other ones as to allow only 1-DOF and 2-DOF galloping. The first occurs when the wind blows along a symmetry axis of the cross-section ($\beta = 0°$ and $\beta = 45°$), decoupling the alongwind and crosswind vibrations; the second occurs in all the other cases, when the alongwind and crosswind motions are coupled. The critical galloping velocity $\bar{u}_{cr}$ is the minimum value of $\bar{u}(h)$ for which galloping occurs.

Figure 32 shows the critical galloping velocity of the column with the covering modules, as a function of the wind direction. For $\beta = 0°$, so in the case of 1-DOF galloping, $\bar{u}_{cr} = 217$ m/s ($c_D + c'_L = -0.56$). The critical velocity reduces for small values of the angle of attack β, reaching the minimum $\bar{u}_{cr} = 95$ m/s for $\beta = 5°$, where $c_D +$

Table 1. Natural frequencies of the spine (without the covering modules)

Natural frequency	calculated	measured
mode k	n_k (Hz)	n_k (Hz)
1, 2	0.833	0.830
3, 4	3.716	3.735
5, 6	6.849	-

Table 2. Natural frequencies of the column (with the covering modules)

Natural frequency	calculated	measured
mode k	n_k (Hz)	n_k (Hz)
1, 2	0.513	0.513
3, 4	2.519	-
5, 6	6.410	-

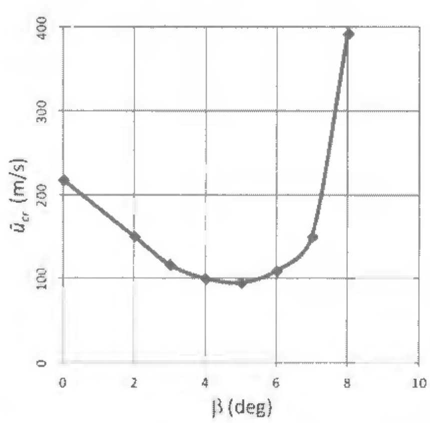


Figure 32. Galloping critical velocity of the spine as a function of the wind direction.

$c'_L = -1.21$ assumes its minimum value (Fig. 25(c)). For $\beta > 8^o$, where $c_D + c'_L > 0$ (Fig. 25(c)), the column is not susceptible to galloping. Anyway, again in virtue of the efficiency of its shape, the column has a so high critical velocity as to make the galloping so improbable as to be actually impossible.

The situation worsens dramatically when the spine is not covered by the modules. When its top is transparent to the wind flow, the minimum value of the critical velocity is $\bar{u}_{cr} = 20$ m/s and it occurs for $\beta = 0^o$ ($c_D + c'_L = -2.80$, Fig. 29(c)). Such value further reduces when the spine, wrapped in a plastic sheet, has a square section also in the top part. In this case, for $\beta = 0^o$, $\bar{u}_{cr} = 19$ m/s ($c_D + c'_L = -3.03$, Fig. 27(c)); for $\beta = 12^o$, $\bar{u}_{cr} = 15$ m/s ($c_D + c'_L = -4.14$, Fig. 27(c)). These values of the mean wind velocity correspond to return periods lower than 50 years; thus, without the covering modules, and even more if wrapped in a plastic sheet, the spine is exposed to a very high risk of collapse due to the galloping.

Once it is determined that the column with the covering modules has a high safety margin with respect to the galloping, while the spine without the modules is exposed to a relevant risk of collapse, one has to evaluate the dynamic response of the complete column to the forces induced by the mean wind velocity, by the atmospheric turbulence and by the vortex wake. In general, they cause both alongwind and crosswind actions. The problem simplifies when the wind is directed along a symmetry axis of the cross-section, namely for $\beta = 0^o$ or $\beta = 45^o$. In this situation the mean wind velocity determines an alongwind mean static force. The longitudinal, u', and the lateral, v', turbulence components cause alongwind and crosswind actions, respectively. The vortex shedding produces crosswind actions much larger than the alongwind ones. Using the method proposed by Piccardo and Solari (2002), a wind loading effect is given by the relationship:

$$e(t) = \bar{e} + e'_Q(t) + e'_R(t) \tag{2}$$

where $\bar{e}$, e'_Q and e'_R are, respectively, the mean value, the quasi-static part and the resonant part of e. Based on Eq. (2) the mean value of the distribution of the maximum of e, referred to as the maximum value, is given by:

$$\bar{e}_{max} = \bar{e} + g_e\sqrt{\sigma^2_{Qe} + \sigma^2_{Re}} \tag{3}$$

where g_e is the peak coefficient of e; σ^2_{Qe} and σ^2_{Re} are the variances of e'_Q and e'_R. The evaluation of g_e, σ^2_{Qe} and σ^2_{Re} generally requires a numerical approach. Closed form expressions of these quantities are given by Piccardo and Solari (2002) under the conditions that the dynamic response is dominated by the first couple of modes of vibration, and the effect e depends only on the alongwind or crosswind motions. In the present case the first condition is widely satisfied; the second is satisfied for $\beta = 0^o$ and $\beta = 45^o$ (Fig. 24).

Figure 33 shows the diagrams of the maximum values of the two components of the displacement at the top, $x(h)$ and $y(h)$ (Fig. 33(a), (b)), and of the bending moment at the base, $M_x(0)$ and $M_y(0)$ (Fig. 33(c), (d)) as a function of $\bar{u}(h)$, for $\alpha = 90^o$ ($\beta = 0^o$, Fig. 33(a), (c)) and $\alpha = 135^o$ ($\beta = 45^o$, Fig. 33(b), (d)). Excluding the low mean wind velocity values, where the vortex-excited response occurs, the wind-induced effects along x, due to the mean wind velocity and the longitudinal turbulence component, are always much greater than those along y, due to the lateral turbulence component and the vortex shedding.

The diagrams of the crosswind response point out the critical condition that occurs for $\bar{u}(h) = 2.96$ m/s, when the vortex shedding is resonant with the first mode of crosswind vibration; the very high value of the Scruton number ($Sc = 119$) prevents the lock-in phenomenon in the nonlinear range and strongly limits the response. As far as concerns the resonance of the vortex shedding with the second mode of crosswind vibration, which occurs for $\bar{u}(h) = 14.55$ m/s, it does not produce any relevant effect.

The resistance verification at the Ultimate Limit States, carried out in accordance with the Eurocode 3, show that the column has, already in its original configuration, large safety margins for any section and any wind direction. This fact points out the groundlessness of all restoration carried out in order to increase the resistance of some sections on the basis of reasons inspired by local alleged weaknesses of the spine with respect to the wind.

9. Wind-induced Fatigue

It is well known that the wind-induced fatigue is a severe snare for steel structures, especially for those which are slender, flexible, light and low-damped. The Endless Column therefore requires a detailed assessment of its fatigue life. This is given by the relationship:

$$T_f = \frac{1}{\bar{D}(1)} \tag{4}$$

where T_f is expressed in years and $\bar{D}(1)$ is the mean annual value of the fatigue-induced damage. This quantity is determined on the basis of two hypotheses:

1) the distribution function of the reference mean wind velocity is given by the hybrid Weibull model:

$$F(\bar{u}) = 1-(1-F_0)\exp\left[-\left(\frac{\bar{u}}{c}\right)^k\right] \quad (\bar{u} \geq 0) \tag{5}$$

where F_0 is the probability of occurrence of the wind calms, k and c are the shape and scale parameters, respectively;

2) coherently with the Eurocode 3 (2005b), the S-N fatigue curve of a structural detail is given by:

$$N \to \infty \quad \text{for } \Delta \leq \Delta_L$$

$$N = \frac{a_2}{\Delta^{m_2}} \quad \text{for } \Delta_L \leq \Delta \leq \Delta_D \tag{6}$$

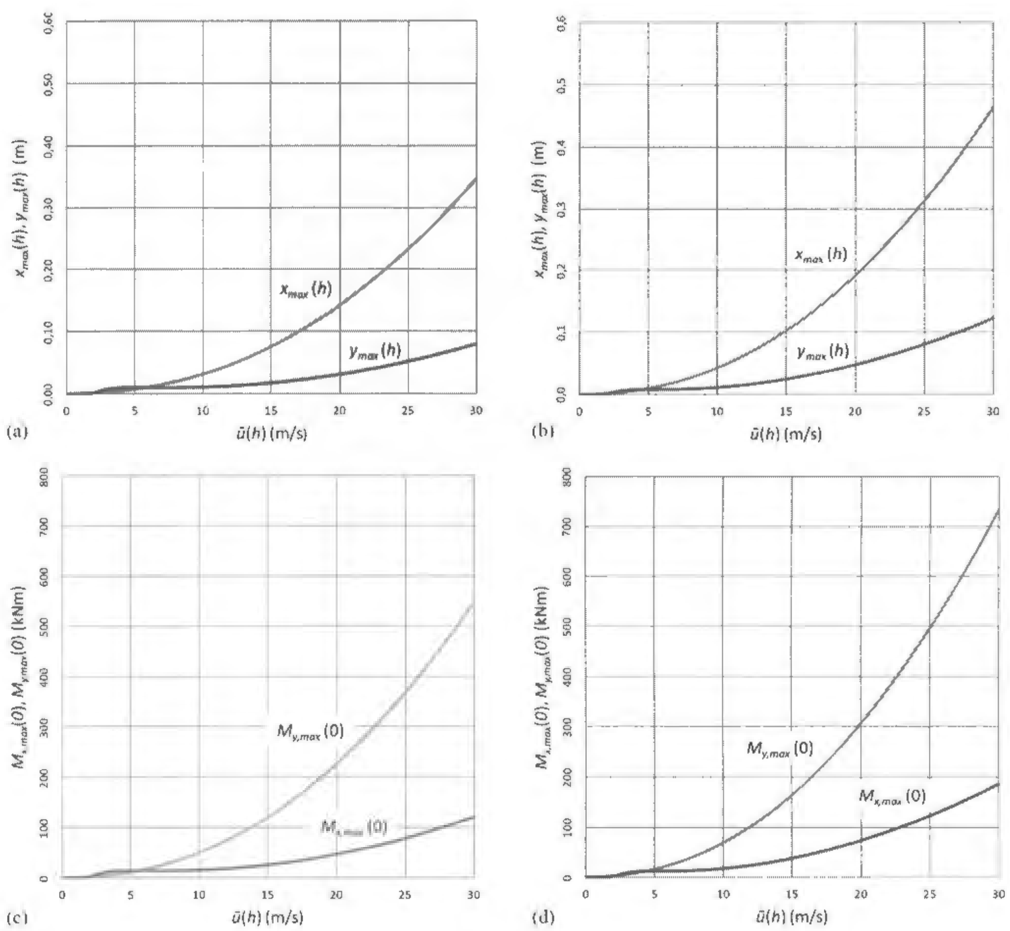


Figure 33. Maximum values of the top displacements (a,b) and of the base bending moments (c,d) of the column when the wind is perpendicular to a side ($\beta = 0°$) (a,c) and diagonal ($\beta = 45°$) (b,d).

$$N = \frac{a_1}{\Delta^{m_1}} \quad \text{for } \Delta \geq \Delta_D$$

where Δ is the stress range, N is the number of cycles with range Δ that causes the fatigue collapse, Δ_D and Δ_L are the values of Δ that correspond, respectively, to $N = N_D = 5\times10^6$ and $N = N_L = 10^8$. The fatigue curve is identified by the detail category Δ_C, namely the value of Δ corresponding to $N = N_C = 2\times10^6$.

The mean value of the annual fatigue-induced damage is evaluated in directional form as the sum of the mean annual values of the damage associated with the different wind directions. It follows that:

$$\overline{D}(1) = \sum_{j=1}^{S} \overline{D}_j(1) \tag{7}$$

where S is the number of the considered directional sectors, $\overline{D}_j(1)$ is the value of the mean annual value of the damage caused by the wind blowing from the j-th sector. It is evaluated by means of the method proposed by Repetto and Solari (2009, 2012) considering only the stress state caused by the wind in the alongwind direction, thus neglecting the contributions of the vortex shedding and of the lateral turbulence component. In this case such hypothesis is justified by at least two reasons: 1) the internal forces in the alongwind direction are much larger than those in the crosswind direction (Fig. 33); 2) since the internal forces in the alongwind direction are not correlated with the crosswind ones, the maximum values of the respective stresses are not contemporary.

The analyses, still preliminary, are carried out on the basis of several conventional choices: 1) since no reliable data of the wind climate of Targu Jiu is available, as a first approximation it is assumed that the base reference velocity and its frequency of occurrence are the same for any wind direction; 2) three possible values are attributed to the shape parameter of the Weibull model (Eq. 5), k = 1,4 1.8, 2.2; 3) three reasonable values are attributed to the detail category of the spine at different heights, Δ_C = 40, 45, 50 N/mm^2. Therefore, the following results have to be dealt with as indicative.

Figure 34 shows the diagrams of the maximum value of the normal stress σ induced by the wind in a spine corner, for $S = 8$ directional sectors associated with the 4 symmetry axes of the cross-section. The analyses are referred to the column after the restoration. The maximum stresses occur at heights 0.56 and 9.36 m, when the wind is diagonal. It is worth noting that the section at 9.36 m height has been

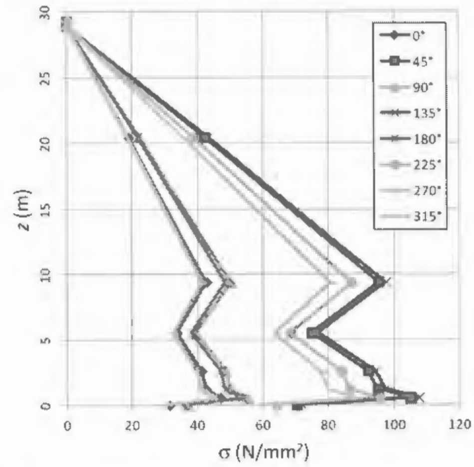


Figure 34. Maximum value of the normal stress induced by the wind in a corner of the spine, as a function of the wind direction α.

never considered as critical.

Figure 35 shows the diagrams of the fatigue life T_f of the section of the spine at different heights, on varying the parameters k and Δ_C. It is apparent that the fatigue life is extremely sensitive to the values of both these parameters: it increases when the detail category Δ_C increases; it decreases when the k value increases. In the intermediate case, for $k = 1.8$ and $\Delta_C = 45$ N/mm^2, T_f takes values quite reassuring but not definitely high: $T_f = 111$ and 159 years at heights 0.56 and 9.36 m, respectively. It is very high for $k = 1.4$ and $\Delta_C = 50$ N/mm^2: $T_f = 422$ and 588 years at heights 0.56 and 9.36 m, respectively. It is insufficient for $k = 2.2$ and $\Delta_C = 40$ N/mm^2: $T_f = 25$ and 36 years at heights 0.56 and 9.36 m, respectively; this result is in contrast with the fact that before the restoration the column has lived for about 60 years without exhibiting relevant fatigue damage.

It is worth noting that the connection with the silicone of the covering modules has deprived the column of a source of dissipation by friction likely relevant. Figure 36, analogous to Fig. 35, shows the values of T_f for a structural damping coefficient $\xi_s = 0.032$, double of that measured after the restoration. In this hypothetical case the fatigue life substantially increases.

There is no evidence to draw firm conclusions nor to advance any theory. However, there is a minimum doubt that the column has spent its first 60 years of life without exhibiting apparent fatigue damage also in virtue of the damping provided by the lack of connection among the modules. Limitedly to the available data, it is not entirely clear that the new configuration of the column ensures an equal future survival in the absence of damage. This topic deserves to be deepened with more specific evaluations based on reliable data.

10. Conclusions and Prospects

The study of the actions and effects of the wind on the

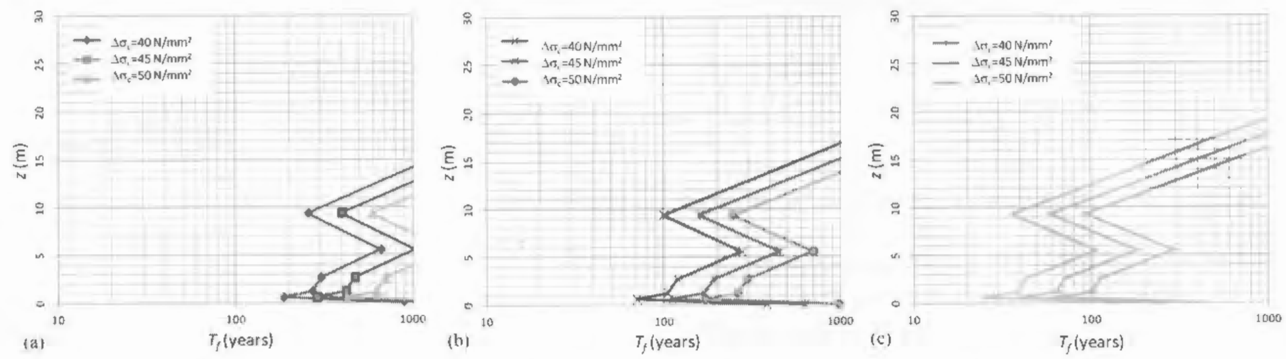


Figure 35. Fatigue life of the cross-sections of the spine ($\xi_s = 0.016$): (a) $k = 1.4$; (b) $k = 1.8$; (c) $k = 2.2$.

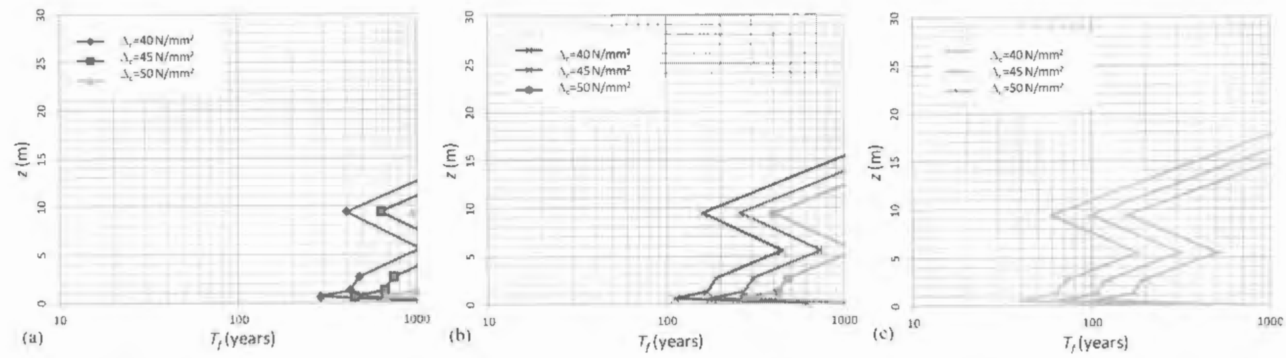


Figure 36. Fatigue life of the cross-sections of the spine ($\xi_s = 0.032$): (a) $k = 1.4$; (b) $k = 1.8$; (c) $k = 2.2$.

Figure 37. (a) Taipei 101, Taiwan; (b) World Financial Center, Shanghai; (c) Infinity Tower, Dubai; (d) Burj Khalifa, Dubai; (e) Glasgow Science Centre Tower, Ireland.

Endless Column, begun in Genova in 2001 and still in progress, shows that the column is not only a milestone of art and engineering, but it truly translates the principle of perfect aerodynamic conception and the maximum synthesis between form and structure. Despite being endowed with such an elevated slenderness as to potentially make it prey to the wind, thanks to its undulated edges the column has a modest drag, it creates a chaotic vortex wake and therefore being incapable of inducing violent crosswind actions, it eludes every form of aeroelastic instability. The distribution of the structural material admirably takes on the risks to which it is exposed. The construction details create elevated dissipative resources and guarantee maximum durability and robustness to the column. All is balanced in an extraordinarily equilibrated way. Many studies developed downstream of these evaluations have regularly confirmed these assessments (Gabbai, 2007; Dragomirescu et al., 2009).

Not by chance the numerous interventions performed over the years to modify the column have regularly worsened the set up and exalted its peculiarities. The towing applied in 1953 with the tractor damaged the spine and the foundation highlighting the robustness of the structure. The closing of the ventilation hole in 1990 accelerated the decay. The removal of the covering modules and the abandoning of the spine to bad weather, in 1996, exposed the work to an elevated risk of collapse and deteriorated the material. The wrapping of the spine with a plastic sheet increased the risk of collapse and encouraged corrosion. The reinforcement of the spine in 2002 was pointless. The adding of silicone to the joints between the covering modules deprived the column of a source of dissipation such as to highlight the opportunity of new in-depth examinations with regard to fatigue.

Today the Endless Column is a point of reference and an icon for all the works, more and more numerous, in which the architect and the engineer find a meeting point and symbiosis in integrated aerodynamic design, a new vision of constructions where the shape is the interface between stylistic demands and the process of optimization of the structural performance (Irwin, 2009). Some skyscrapers, particularly Taipei 101 (Fig. 37(a)), are expressly inspired by the column adopting a configuration for modules overlapping by varying sections that reduces the drag force and breaks up the vortex wake. Others make use of sections of variable (World Financial Centre, Shanghai, Fig. 37(b)), rotated (Infinity Tower, Dubai, Fig. 37(c)) or tapered (Burj Khalifa, Dubai, Fig. 37(d)) shape that mitigate the wind actions by virtue of the principles used firstly by the column and widely debated in the recent technical literature of wind engineering (Tamura et al., 2010).

The column is also the emblem of the works that use aerodynamic fairings to adapt their own form to the action of the wind; among these Glasgow Science Centre Tower (Fig. 37(e)) stands out, a stele with winged form that rotates in the wind to reduce the drag force, and in general bridges (Great Belt East Bridge, Denmark; Bronx Whitestone Bridge, U.S.) and cables (Tatara Bridge, Japan; Sutong Bridge, China) endowed ever more often with outlines and covering profiles to contrast aerodynamic phenomena most prejudicial to stability.

Brâncuşi and Gorjan were aware of having created a masterpiece of art and engineering. Nevertheless, it is difficult to understand to what extent they realized the aerodynamic implications of their project, the meaning of the form that they had conceived, the inspiring principle of the aerodynamic fairing entrusted to the covering modules and the concept of the shape control. A sentence from Constantin Brâncuşi allows us to imply that his genius had at least partly realized what would be recognized of him in the future: "Nature creates the plants that grow from the earth, strong and straight like my column. Its shape is the same, from the earth toward the sky. It does not need a pedestal to support it. It is firmly anchored to the ground because everything must be born from the ground. The wind does not move it, it supports itself with its own strength. It is immovable".

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3 An Exceptional Experience of Structural Restoration: The «Endless Column» of Constantin Brâncuși, by Mircea and Rodica Crișan

Transsylvania Nostra, no.1, Year I (2007): 7–11

Mircea Crisan, Rodica Crisan

O experienţă inedită de restaurare structurală: coloana fără sfârşit a lui Constatin Brâncuşi

An Exceptional Experience Of Structural Restoration: The 'Endless Column' Of Constatin Brancusi

Rezumat

Construită în deceniul al 3-lea al secolului 20 (1934-1937), Coloana Fără Sfârşit de la Târgu Jiu este o sculptură monumentală, cu înălţime de 30 m, recunoscută pe plan internaţional ca fiind o capodoperă a artei moderne datorată lui Constantin Brâncuşi.

In anii '90, Coloana Fără Sfârşit a făcut obiectul a numeroase studii, investigaţii, rapoarte, propuneri de restaurare şi dezbateri aprinse, la nivel naţional şi internaţional, multe dintre ele cocentrându-se asupra problemei stâlpului central, ca principal element de rezistenţă.

Ultima intervenţie de restaurare, realizată după proiectul unui colectiv al UAP[1] România, a început în septembrie 2000 şi a fost finalizată în luna decembrie a aceluiaşi an.

'Inainte de a fi tehnică, restaurarea trebuie să fie o filozofie'.
Roberto Pane[2]

Summary

Built in the 3rd decade of the 20th century (1934-1937), the Endless Column in Targu Jiu, Romania is a monumental sculpture with a height of 30 meters, internationally recognized as a masterpiece of modern art due to Constantin Brancusi.

In the last decade of the 20th century, the 'Endless Column' has been the subject of many studies, investigations, reports, restoration proposals and hot debates, at national and international level, mainly focusing on the Column's central spine problem.

The last restoration, designed by the Romanian UAP[1] team, was initiated in September 2000 and finalized in December 2000.

'Before being a technique, the restoration must be a philosophy'.
Roberto Pane[2]

'Brâncuşi nu mai aparţine ţării noastre şi nici vreunei alta. Aparţine lumii.(...) Brâncuşi este cea mai pură glorie românească pe care individualitatea naţiunii noastre o impune civilizaţei. Prin Brâncuşi civilizaţia devine datornică pentru prima oară scumpei noastre ţări.... A lua în primire şi a pătrunde opera lu i Brâncuşi înseamnă un act de înaltă spiritualitate.'[3]

Realizată în deceniul al 3-lea al secolului 20, Coloana Fără Sfârşit reprezintă o chitesenţă a spiritului creator al sculptorului, un *'portret al lui Brâncuşi făcut de el însuşi.*[4]

Având o înălţime de cca. 30 m, Coloana Fără Sfârşit reprezintă o raritate între sculpturile monumentale din lume prin problemele de rezistenţă pe care le implică. In perioada 1934-1935, Constantin Brâncuşi şi mai tânărul său colaborator (mai puţin celebru), inginerul Ştefan Georgescu-Gorjanu, au pus la punct împreună concepţia tehnică a Coloanei, sculptura fiind în final rezultatul efortului comun artist-inginer. Folosirea oţelului întro structură verticală de tip consolă, fără reazeme suplimentare, a reprezentat în epocă o performanţă tehnică deosebită; Coloana este o expresie de vârf a posibilităţilor tehnice locale ale vremii în ceea ce priveşte concepţia inginerească, ca şi în ceea ce priveşte calitatea materialelor şi a execuţiei.

Coloana Fără Sfârşit are trei părţi componente:

- sistemul de fundare, cu o înălţime totală de 5 m, realizat dintr-un bloc de beton simplu în patru trepte;
- stâlpul central, cu o secţiune pătrată, realizat din corniere şi platbande de oţel OL37 îmbinate cu nituri şi buloane Ø 24 mm; stâlpul având o înălţime de 28.90 m; umplut cu beton pe o lungime de cca.5.50 m de la bază;
- 17 module din fontă, în formă de dublu trunchi de piramidă cu muchii rotunjite, măsurând 1.80 m în

Many studies referring to the artistic work of Brancusi are unanimous in considering that the sculpture of Brancusi stays in the center of the world modern art.

'Brancusi doesn't belong to our country anymore or to any other country in the world. He belongs to the world. (...) Brancusi is the purest Romanian glory, which the individuality of our nation imposes on the world. Due to Brancusi the civilization becomes indebted to our beloved country for the first time. (...) Assuming and understanding the work of Brancusi means an act of high spirituality.'[3]

Built in the 3rd decade of the 20th century and fulfilling an older dream of Brancusi (it seems that the idea had pursued him for almost 30 years) *'the sculpture is transforming into architecture.(...) Severe and rigorous column, metallic axis connecting the earth with the sky, this sculpture is a victory of geometry. But a geometry which includes the fundamentals motifs of his art, its faces and its living structures'.*[4]

Having a height of 30 m, the Endless Column could also be considered a rare kind of sculpture due to the peculiar engineering problems involved. During 1934-1935, Constantin Brancusi and the younger (and less renowned) engineer Stefan Georgescu-Gorjanu have jointly elaborated the technical design of the Column; the sculpture was finally the result of the mutual artist-engineer effort. The use of steel in a vertical console-type structure, with constant cross-section and without props, was a rare structural achievement for its time; the engineering concept, as well as the quality of the materials and workmanship involved express the high national technical level of the time.

The Endless Column is made-up out of three components:

- *the foundation system* (5.00 m in height) made up of a plain concrete block with four steps;
- the central spine made out of carbon steel, with a square cross-section, made of angle irons and steel strips connected with rivets and screws Ø 24 mm; the spine measures 28.90

înălţime şi 45 ¸ 90 cm în lăţime.

Ca recunoaştere a valorii sale universale deosebite, Coloana Fără Sfârşit a intrat în atenţia World Heritage Committee, constituit în baza Convenţiei UNESCO din 1972, care a asigurat asistenţă internaţională pentru conservarea sa. In 1996 Coloana a fost înscrisă în lista World Monuments Fund cuprinzând 100 de monumente din lume ce trebuie restaurate cu prioritate.

In anii '90, Coloana Fără Sfârşit a făcut obiectul unui mare număr de studii, investigaţii, rapoarte, propuneri de restaurare, elaborate de diverse echipe româneşti.

In 1996 modulele au fost demontate pentru investigarea stării de conservare a stâlpului central. In 1997 s-a propus refacerea fundaţiilor şi înlocuirea stâlpului central cu unul nou, din oţel inoxidabil. Intrucât o astfel de intervenţie ar fi alterat grav valoarea culturală a monumentului prin pierderea autenticităţii materiale, propunerea a fost contestată de mai mulţi critici de artă şi de Uniunea Artistilor Plastici din România.

In 1999, la întrunirea internaţională organizată de WMF, Ministerul Culturii din România, Banca Mondială şi Fundaţiile Internaţionale Brâncuşi, reprezentanţii UAP au susţinut necesitatea şi posibilitatea păstrării stâlpului central original. Participanţii la întrunire – istorici de artă, restauratori, ingineri structurişti – au căzut de acord că o astfel de soluţie este nu doar cea mai bună pentru conservarea autenticităţii materiale a Coloanei, ci şi posibilă din punct de vedere tehnic. Ca urmare, Ministerul Culturii a organizat o selecţie de oferte de proiectare privind restaurarea Coloanei, punând drept condiţie conservarea stâlpului central original. Astfel, colectivul UAP[5] a primit misiunea de a întocmi proiectul de restaurare în aceşti termeni.

In acea perioadă autorităţile române de resort luaseră deja decizia de a propune Coloana Fără Sfârşit spre a fi inclusă în Lista Patrimoniului Mondial a UNESCO.[6] In aceste condiţii, colectivul UAP a considerat oportun să-şi definească strategia de intervenţie în conformitate cu principiile stipulate în documentul intitulat *'Management Guidelines for World Cultural Heritage Sites',* editat de ICCROM in 1993[7] şi conceput ca un cadru de implementare a obiectivelor Convenţiei Patrimoniului Mondial.[8]

In spiritul documentului menţionat, studiul preliminar privind principiile de restaurare a Coloanei Fără Sfârşit[9] a fost structurat în două părţi:

1) Definirea resursei de patrimoniu – sau *ce* trebuie protejat;

2) Definirea principiilor de intervenţie – sau *cum* să fie protejate calităţile şi valoarea resursei de patrimoniu[10].

Un set de criterii relevante în raport cu conţinutul conceptului de 'valoare culturală' a fost propus ca un cadru de referinţă pentru evidenţierea calităţilor semnificative (de conservat) ale Coloanei şi deci a priorităţilor în cadrul intervenţiei; aceste criterii au fost utilizate ca listă de control pentru validarea tratamentului propus.

Luând în considerare ierarhia valorilor resursei de patrimoniu, era evident că tratamentul va trebui să protejeze înainte de toate *valoarea intrinsecă* a Coloanei, conservându-i autenticitatea, sub toate cele patru aspecte ale sale: materialele, manopera, concepţia, amplasamentul.

Proiectul[11] trebuia să concilieze cerinţa conservării valorilor culturale ale resursei de patrimoniu, cu imperativul asigurării integrităţii structurale şi a durabilităţii Coloanei.

In relaţie directă cu Principiile de Restaurare, trata-

m in height; the spine is filled up with plain concrete along approximately 5.50 m;
- 17 modules in cast iron, shaped like double pyramid frustums with curved edges, measuring 180 cm in height and 45 - 90 cm in length.

As recognition of its outstanding universal significance, the Endless Column entered in the attention of the World Heritage Committee, which granted international assistance for its conservation. In 1996 the Column has been nominated to be included on the list of the World Monuments Fund, along with 100 other monuments from around the world, which are to be restored with priority.

In the final decade of the 20th century, the 'Endless Column' has been the subject of many studies, investigations, reports, restoration concepts, elaborated by various Romanian teams.

In 1996 the modules were dismantled as to investigate the state of conservation of the central spine. In 1997 it was proposed that the foundations be remade and that the old spine be replaced with a new one made out of stainless steel. As altering the cultural value of the monument significantly, this solution was contested by several Romanian art critics and by the Romanian Union of Plastic Artists.

In 1999, at the international workshop organized by the World Monuments Fund, the Romanian Ministry of Culture, the World Bank and the International Brancusi Foundations, the UAP representatives have defended the necessity and the possibility of preserving the original central spine. The workshop participants - art historians, conservators, structural engineers - have consented that this solution was not only the best one for preserving the material authenticity of the art object, but also possible from technical point of view. Consequently, the Romanian Ministry of Culture has organized a bidding selection for the restoration of the Column, claiming the preservation of its original spine. So, the UAP team[5] has received the task to draw up the restoration project in these therms.

At the time, the Romanian authorities had already expressed the intention of proposing the Endless Column to be nominated to the World Heritage List of UNESCO.[6] Under this circumstances, the UAP team considered it opportune to define the guiding principles for the restoration of the Endless Column according to the 'Management Guidelines for World Cultural Heritage Sites', edited by ICCROM in 1993[7] and conceived as a framework for implementing the purposes of the World Heritage Convention.[8]

Led by the spirit of the above document, the preliminary study aiming to define the restoration guidelines[9] was divided into two parts:

1) Definition of the heritage resource - or *what* is to be protected;

2) Definition of the treatment principles - or *how* to protect the quality and the values of the heritage resource.[10]

A set of criteria defining the concept of 'cultural value' was proposed as a framework for pointing out the relevant qualities of the Column and assigning priorities; these criteria were used as a 'checklist' for validating the treatment strategy.

Considering the hierarchy of the heritage resource values, it was obvious that the treatment had to protect, first of all, *the intrinsic values of the Column*, preserving its *authenticity* in all of its four aspects: materials, workmanship, design, setting.

The project[11] had to resolve the critical relationship between the exigency of preserving the cultural values of the heritage resource and the imperative of ensuring structural integrity and continued durability for the Column. Directly related mentul aplicat stâlpului central a avut la origine observația că *'în general, intervenția minimă eficientă s-a dovedit a fi cea mai bună politică'*.[12] Cu alte cuvinte, se poate spune că, în restaurare, celebrul *'less is more'* al lui Mies van der Rohe se îmbogățește cu noi semnificații.

Din expertiza tehnică s-au reținut următoarele elemente, ca decisive pentru tratamentul ce urma a fi propus:

- secțiunea critică a stâlpului central este situată la cota + 0.55 m; la acest nivel se face trecerea de la o secțiune ce conține [4 TG20 x 420; 4 TG20 x 380; 4 TG12 x 320 și 4 L150 x 150 x 18] la o alta constituită din [4 TG20 x 380; 4 TG12 x 320 și 4 L150 x 150 x 18];
- din evaluările analitice rezulta că singura zona în care este posibilă depășirea capacității de rezistență (în raport cu prevederile codului ASCE 7 și EUROCODE 1) este cea aflată între cotele + 0.55 m și + 2.60 m;
- sudurile orizontale dintre tole, punctele cele mai sensibile ale stâlpului central; deși nu erau penetrate complet (deci nu corespundeau standardelor actuale), nu prezentau microfisuri;
- stâlpul central nu prezenta nici un fel de simptome de degradare datorită depășirii capacității de rezistență la încovoiere, simptome ce ar fi trebuit să fie vizibile îndeosebi la nivelul sudurilor orizontale.

Evaluările analitice, ca și buna comportare in situ a stâlpului central timp de 63 de ani, au confirmat concepția structurală originară a Coloanei și au dovedit *posibilitatea conservării stâlpului central în poziția sa originară*.

Astfel, intervenția a fost orientată către următoarele obiective:

- atribuirea unui plus de rezistență și stabilitate la vânt și cutremur, pentru stâlpul central original, prin intervenții locale care să nu afecteze autenticitatea obiectului de patrimoniu, dar să crească nivelul de

to the Restoration Guidelines, the treatment of the central spine was mainly based on the observation that *'generally the minimum effective intervention has proved to be the best policy'*.[12] So, we may say that the famous *'less is more'* of Mies van der Rohe gains new significance in restoration.

From the preliminary technical analysis, we have retained the following elements, as decisive for the treatment to be proposed:

- the 'critical' section of the central spine is situated at elev.+0.55 m; at this level there is a sudden passing from a section which contains [4 TG20 x 420; 4 TG20 x 380; 4 TG12 x 320 and 4 L150 x 150 x 18] to another one made up from [4 TG20 x 380; 4 TG12 x 320 and 4 L150 x 150 x 18];
- from the analytical evaluations results that the only area of a possible exceeding of the resistance capacity (both as compared to ASCE 7 and as compared to EUROCODE 1) is the area between +0.55 and +2.60;
- the horizontal joining welds between the sheet plates are the most sensitive points of the spine; although the welds are not completely penetrated (thus not complying with the present norms) they do not have any micro-cracks;
- the central spine of the Column does not show any symptoms of damage caused by exceeding the bending capacity, symptoms that should have been located especially in the horizontal welds;

The analytic evaluations, as well as the good behavior of central spine on-site for 63 years, have validated the original structural design of the Column and have proved the possibility to conserve the original central spine at its original location.

So, the treatment was directed to the following purposes:

- assign to the original spine a plus of resistance and stability to wind and earthquake actions, through local interventions

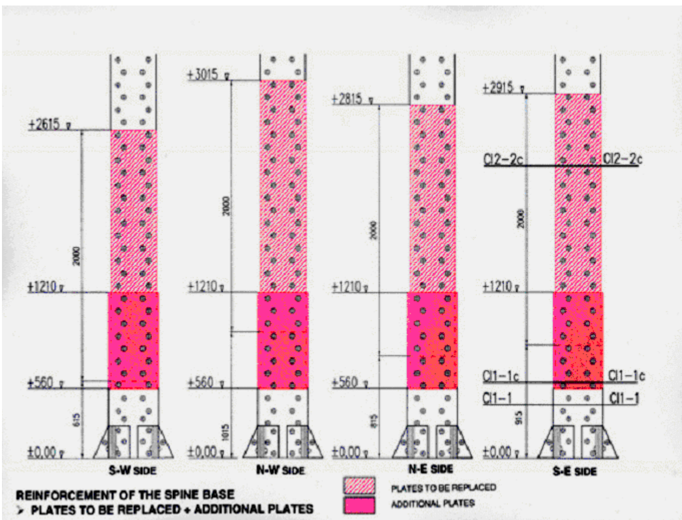

Fig. 1 – Ranforsarea bazei stâlpului central.

Figure 1 - Reinforcement of the spine base

siguranță cu privire la conservarea integrității sale în timp;

- stoparea fenomenului de coroziune și prevenirea unor degradări viitoare, prin aplicarea unor tratamente protective de înaltă performanță, controlul umidității interne a Coloanei, inspecții periodice și lucrări periodice de întreținere curentă.

Intervenția structurală constă în *ranforsarea zonei sensibile* de la partea inferioară a stâlpului central și *refacerea sudurilor din rosturile orizontale* între tole pe cca 25% din înălțimea coloanei (până la cota + 7.88 m), asigurând

that do not affect the authenticity of the art object, but increase the safety level with regard to the conservation of its integrity in time;

- arrest corrosive phenomena and prevent future decay, by high performance protective treatment of the spine, control of internal humidity, regular inspections and cyclical routine maintenance.

The structural intervention consists in the *reinforcement of the 'critical' area* at the lower part of the central spine and the *remaking of the welded horizontal joints* between the plate sheets along approximately 25% of the spine's height (up to

astfel o penetrare adecvată a sudurilor în zona de risc. Ranforsarea bazei stâlpului central (fig.1) realizată prin:
- înlocuirea a patru tole de la baza stâlpului cu patru tole noi realizate din oţel de înaltă rezistenţă (OL52);
- introducerea a patru tole suplimentare, de asemenea din oţel de înaltă rezistenţă, pe înălţimea primului modul, între cotele + 0.56 m and + 1.21 m.

Soluţia de consolidare se bazează pe două condiţii favorabile: sistemul de îmbinări originare (cu buloane, nituri, suduri) care permite desfacerea părţilor componente; alcătuirea stâlpului în secţiune transversală pe înălţimea primului modul care permite introducerea unor tole suplimentare.

Intervenţia este reversibilă, noile tole fiind asociate părţilor originale prin intermediul buloanelor. Materialul nou – oţel de înaltă rezistenţă – este perfect compatibil cu oţelul originar iar eficienţa şi durabilitatea sa nu ridică nici un fel de îndoieli.

Folosirea unui oţel de înaltă rezistenţă în noile tole are două efecte semnificative privind durabilitatea stâlpului: creşterea rezistenţei la încovoiere în secţiunea critică, dar şi conferirea posibilităţii de adaptare dinamică în cazul unor acţiuni extraordinare, prin activarea unor deformaţii plastice reversibile în materialul interior.

elev.+7.88 m), thusly providing the proper penetration of the weld along the risk area (maximum strain area).
The reinforcement of the spine base (fig.1) is made by:
- Replacing four thick plate sheets at the base of the column with four new ones made of highly resistant steel.
- Introducing four additional sheet plates, also in highly resistant steel, along the first module, between elevations +0.56 m and +1.21 m.

The reinforcement solution relies on two favorable conditions: the original assembling system (screws, rivets, welds), that allows the unbinding of the component parts, and the cross-section structure of the Column along the first module, that allows the introduction of additional plate sheets.

The intervention is reversible, the new plate sheets being connected to the original parts with screws. The new material - highly resistant steel - is perfectly compatible with the original steel; its effectiveness and the durability are well known.

The use of superior steel in the new plates has two important effects concerning the durability of the spine: it increases the bending resistance of the 'weak' section and also provides for the possibility of dynamic accommodation in case of extraordinary actions by activating reversible plastic deformations in the inner material.

The replacement of original elements is limited to approximately 3% of the total weight of the central spine (four

Fig. 2 – Inlocuirea celor patru tole vechi de la baza stâlpului central cu altele noi din oţel de înaltă rezistenţă.

Figure 2 - Replacing the old plate sheets at the base of the column with four new ones made of highly resistant steel

Fig. 3 – Baza stâlpului ranforsată, cu tratamentul protectiv aplicat

Figure 3 - The spine base reinforced, with protective coating applied

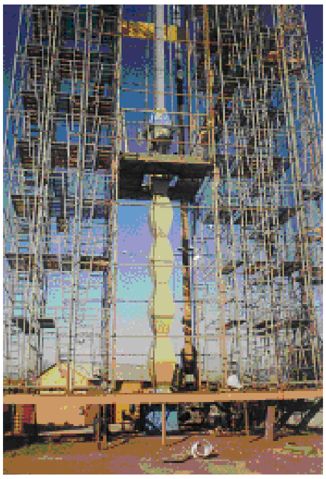

Fig.4 – Reasamblarea Fig.5 - Modulele reasamblate Fig.6 – Coloana Fără Sfârşit modulelor restaurată (decembrie 2000)

Fig.4 – Reassembling Fig.5 - Modules reassembled Fig.6 - The Endless Column the modules r*estored (December 2000)*

Inlocuirea materialului original este limitată la cca 3% din greutatea stâlpului central (patru tole exterioare, pe 3 m înălţime, la partea inferioară a stâlpului). Tolele nou introduse sunt marcate în aşa fel încât să poată fi lesne diferenţiate de cele originale.

Intervenţia respectă integritatea sistemului structural istoric şi conservă concepţia sa originară; chiar dacă local sunt folosite produse şi tehnici contemporane, originalul nu este falsificat.

Restaurarea structurală realizată în 2000 conservă materialele şi alcătuirile originare, menţinute în poziţia lor iniţială, asigurând totodată prelungirea vieţii lor. Astfel, intervenţia asigură rezistenţa şi stabilitatea stâlpului central, consevând totodată autenticitatea resursei de patrimoniu.

Lucrările de execuţie, incluzând consolidarea in situ a stâlpului central, restaurarea celor 17 module şi reasamblarea acestora pe stâlpul central, s-au desfăşurat în perioada septembrie – decembrie 2000.

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5 Echipă pluridisciplinară coordonată de Dorin DANILA, sculptor restaurator (şef proiect complex)
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9 *'Principii de restaurare'* - studiu preliminar în cadrul proiectului complex de restaurare, elaborat de prof. dr. arh. Rodica CRISAN, Universitatea de Architectură şi Urbanism, 'Ion Mincu', Bucureşti, Romania.
10 Pentru definirea conceptului de 'valoare culturală' şi a criteriilor relevante din acest punct de vedere, ca şi pentru stabilirea principiilor de intervenţie, au fost consultate următoarele surse: *Management Guidelines for World Cultural Heritage Sites*, ICCROM 1993; BRANDI, Cesare, *Teoria restaurării*, Ed. Meridiane, Bucureşti 1996; FEILDEN B.M., *Conservation of Historic Buildings*, Architectural Press, Oxford, 1996; *Carta di Venezia sulla conservazione e il restauro dei monumenti*, 1964, în Documenti, norme ed istruzioni per il restauro dei monumenti, a cura di E. Romeo, Electa Napoli, 1990; *Convention concerning the Protection of the World Cultural and Natural Heritage* - Paris, 16 November 1972, in BCMI n. 1-2/1990; UNESCO Mission at Bucharest and Targu Jiu, Romania, *Technical Report on the Endless Column by C. Brancusi,* 1998.
11 Proiect de restaurare structurală.
Şef de proiect şi soluţie de restaurare structurală: prof. dr. ing. Mircea CRISAN.
Alte contribuţii de seamă: prof. dr. ing. Dan LUNGU (evaluări privind acţiunea vântului); dr. ing. Lucian DOGARIU (evaluări analitice asistate); dr. ing. Helmut KOBER (detalii de execuţie); ing. Cornel RADULESCU (consultant în probleme de suduri); prof. dr. arh. Rodica CRISAN (consultant în probleme de principii de restaurare)
12 Management Guidelines for World Cultural Heritage Sites, ICCROM 1993, p.11.

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exterior plate sheets, along 3 m high at the lower part of the spine). The newly introduced plates are integrated into the original technical design; the new parts are properly marked as to be easily told apart from the original ones.

The intervention respects the integrity of the historical structural system and preserves its original design; even if contemporary products and techniques are used locally, the original is not faked.

The structural restoration made in 2000 allows the preservation of the original materials and structures, maintained in their original position, as well as the prolongation of their life span. So the intervention ensures the resistance and the stability of the central spine, preserving at the same time the authenticity of the heritage resource.

The restoration works – including the on-site reinforcement of the central spine, the restoration of the 17 dismantled modules and their reassembling on the spine – began in September 2000 and were finalized in December 2000.

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11 Structural restoration project.
Project manager and structural restoration concept prof. Mircea CRISAN, structural engineer, PhD
Other main contributors: prof. Dan LUNGU, structural engineer PhD (wind action evaluations); Lucian DOGARIU, structural engineer PhD (computer assisted evaluations); Helmut KOBER, structural engineer PhD (working details project manager); Cornel RADULESCU, structural engineer (welding consultant); prof. Rodica CRISAN, architect PhD (restoration principles consultant)
12 *Management Guidelines for World Cultural Heritage Sites*, ICCROM 1993, p.11.

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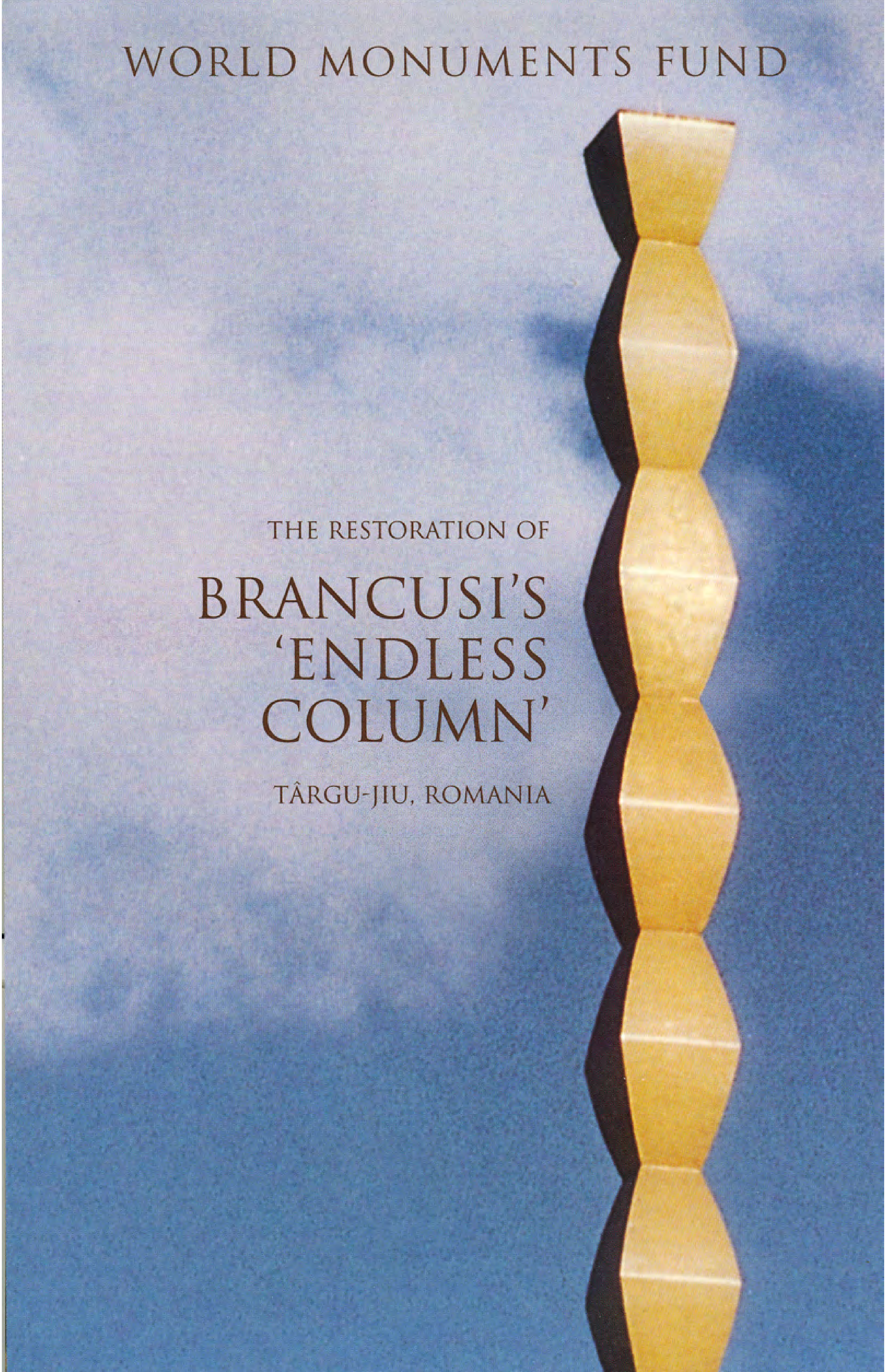
4 The Restoration of Brancusi's «Endless Column», Târgu-Jiu, Romania

World Monuments Fund, 2006

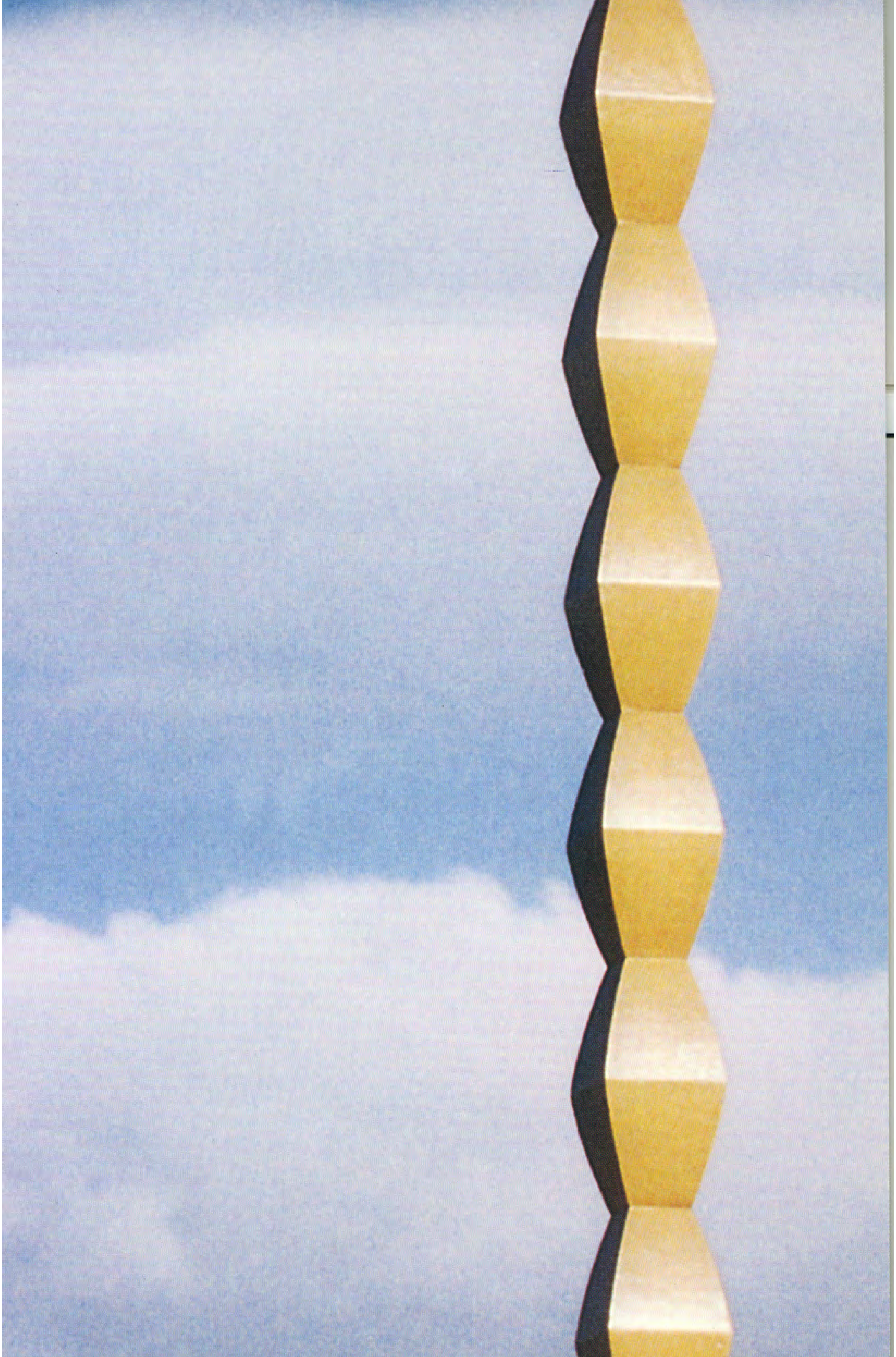
WORLD MONUMENTS FUND

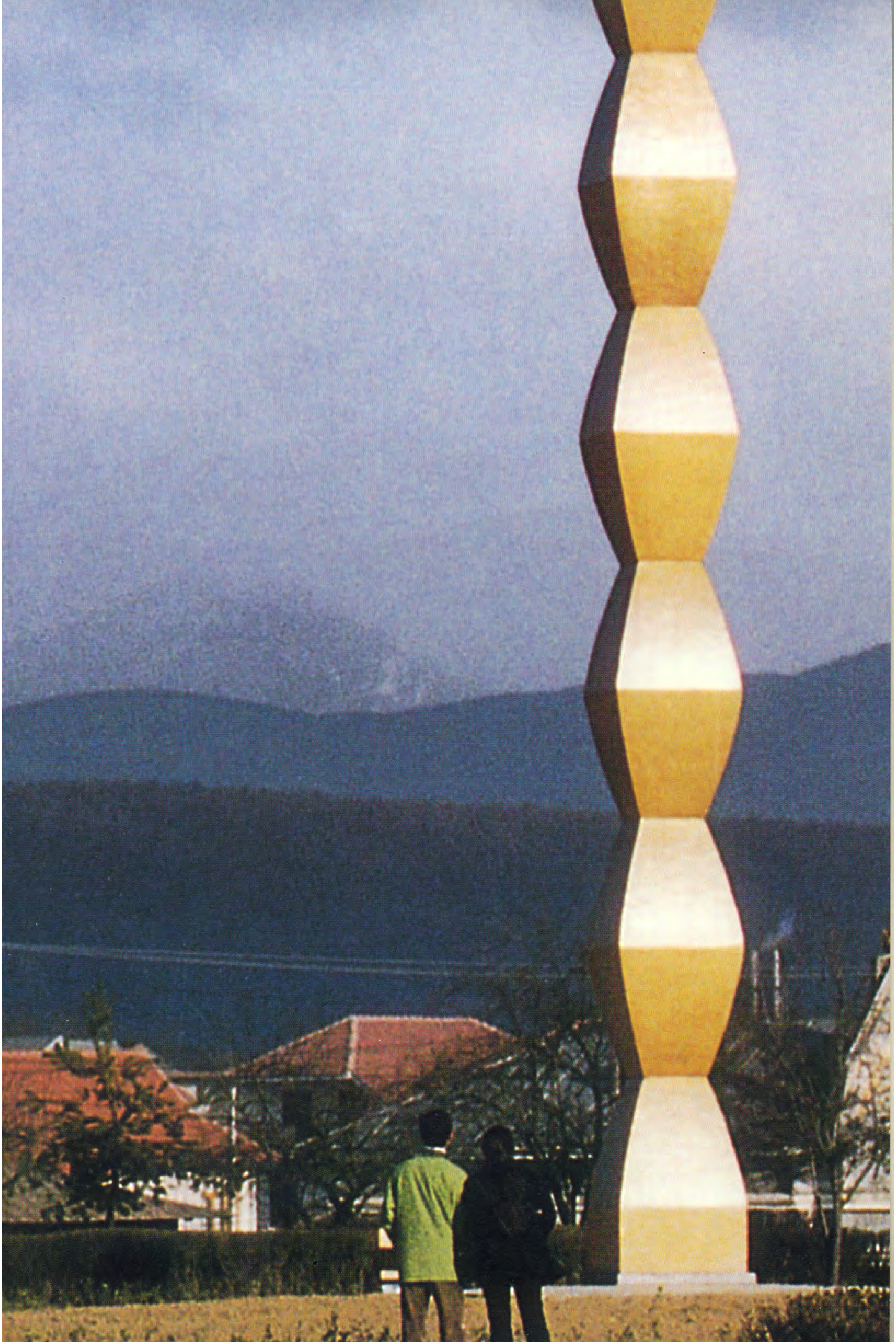


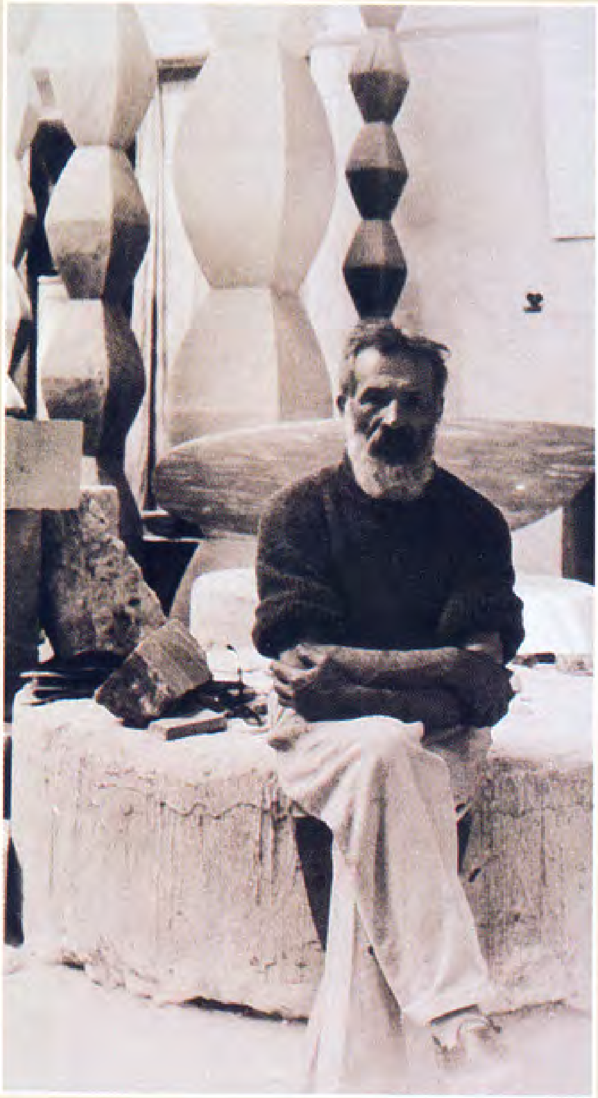
THE RESTORATION OF

BRANCUSI'S 'ENDLESS COLUMN'

TÂRGU-JIU, ROMANIA







BRANCUSI POSES IN HIS PARIS STUDIO WITH MODELS FOR THE ENDLESS COLUMN

INTRODUCTION

Constantin Brancusi's monumental *Endless Column*, located near his birthplace of Hobita, Romania, is a 98-foot column of cast-iron modules (clad with zinc, brass and a clear protective organic coating) threaded onto a steel spine. It is part of an ensemble (along with the travertine Gate of the Kiss and the Table of Silence) built as a memorial to those who died defending the town of Târgu-Jiu during World War I.

Although beloved by the Romanian people as a great cultural symbol, the column had suffered from years of exposure to the elements and the modules were deteriorating. In 1996, World Monuments Fund placed the *Endless Column* on its World Monuments Watch List of 100 Most Endangered Sites.

In 1998, the Romanian Government and World Monuments Fund established an international partnership, financed by both WMF and The World Bank for the restoration of the entire ensemble. The *Endless Column* restoration was a collaborative effort of the Romanian Government, World Monuments Fund, The World Bank, and other institutions, architects, art historians, engineers, conservators, and craftsmen. The restored sculpture was rededicated in December 2000.

HISTORY

In late 1934, Constantin Brancusi (1876–1957), the internationally acclaimed Romanian sculptor (then living in Paris), accepted an offer from the Women's League of Gorj to create a memorial dedicated to the soldiers, "fallen at the River Jiu in defense of the town against a German force in 1916. . . . his first idea for the memorial was a tall column, but it was enlarged during discussions with a committee" to include a stone portal for the public gardens of the town of Târgu-Jiu (Sidney Geist). Finally, in 1937, Brancusi reconceived the project as a tripartite ensemble spread along an east-west axis with the Table of Silence and Gate of the Kiss at one end, the *Endless Column* at the other.

The Gorj region of Romania is an area with a strong tradition of wood carving. Brancusi began working on the theme for of the *Endless Column* in 1917, the earliest dated example from 1918. Scholars have noted that the sculpture's forms echo decorative motifs found in vernacular Romanian architecture and folk art. The column has been seen as both a symbolic means of ascension to heaven for the dead soldiers' souls and, as Brancusi said, a way to "sustain the vault of heaven." The cast-iron modules of the *Endless Column* (fifteen full, two half) were based on a model made in wood (finished by Brancusi himself) and plated in 1938 with a "very pure golden-yellow" finish based on the artist's instructions. The technical solution for the design and erection of the column was engineered by Stefan Georgescu-Gorjan, son of a childhood friend of Brancusi's

DISMANTLING, REPLATING, AND REASSEMBLING

Since its completion in 1938, the *Endless Column* has been re-plated twice, once in 1965–66 and again in 1976.

A third restoration began in 1996 when the Brancusi International Foundation prepared the site for conservation and restoration. The modules were removed and stored individually in sealed and protected containers. The Romanian government assumed leadership of the project in 1997 and completed it as an international partnership.

LEFT: A SEGMENT OF THE ENDLESS COLUMN DURING THE RESTORATION PROCESS. ABOVE: A RESTORED SEGMENT AFTER FINAL REPLATING.

In 1999, WMF convened 32 leading architects, engineers, scholars, conservators, and project partners from around the world in Romania including Thomas Blinkhorn, Liviu Popescu and Daniela Chisiu, The World Bank; Giorgio Croci, University of Rome; Sergiu Nistor, Department of Cultural Heritage; Cedric Proffit, DGT Fabrications; John Stubbs, World Monuments Fund; Mihai Radu, Lauster Radu Architects; Elena Prodan, Ministry of Culture; Marielle Tabart, the Brancusi Atelier, Paris; Dorin Danila, U.A.P.; Mircea Crisan, structural engineer; Mircea Constantinescu, Francisc Dosza and Florin Fagaraseanu, Romanian National Museum, and others. Final agreement was reached to conserve—as opposed to replace—the existing spine and replate the modules with a brass and zinc alloy that replicates the original polished finish.

A Romanian engineering firm, Turbomecanica, was selected through a competitive bidding process to clean and rust-proof the spine and to repair and replate the modules. The column was reassembled with added lightning protection and ventilation in December 2000.

THE ENSEMBLE

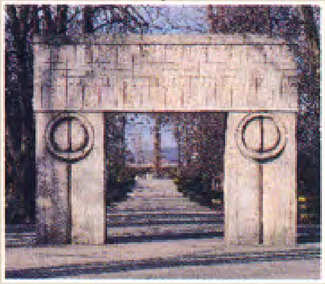
The ensemble, consisting of the Table of Silence, Gate of the Kiss, and the *Endless Column*, extends through the town perpendicular to the Jiu River. The column is connected to the Gate of the Kiss by a 1480-meter-long road running through the center of town called the Allée of the Heroes. A shorter extension of this axis called the Allée of the Seats, runs from the Gate of the Kiss to the Table of Silence. Thirteen travertine stools are arranged along each side of the allée.

The Table of Silence is a low round travertine table surrounded by 12 chairs. The Gate of the Kiss, also travertine, is an arch ornamented by a stylized version of Brancusi's The Kiss.

As part of the overall restoration project, the travertine pieces will be cleaned and the entire area will be landscaped.

SITE PLAN

TABLE OF SILENCE



GATE OF THE KISS

The ensemble as a whole marks the place where heroes died fighting a definitive battle for their country's independence and is linked in the minds of Romanians with the idea of infinite gratitude. When asked why there was such a great distance between the Table of Silence and the *Endless Column*, Brancusi answered, "The way of the heroes is always hard and long."

ACKNOWLEDGEMENTS AND CREDITS

The restoration was a collaboration of World Monuments Fund, the Romanian Ministry of Culture, and The World Bank (through a special Project Implementation Unit in Romania). The project team included Mihai Radu, AIA, Lauster Radu Architects (architect); Turbomecanica (contractor); Plasma Jet (metal plating); and U.A.P. (technical documents). The conservation project was brought to WMF's attention and mobilized by the Constantin Brancusi International Foundation.

WMF is grateful to the donors to this project: The American Express Company, Mr. and Mrs. Gustavo Cisneros, Ms. Hester Diamond, The Charles Engelhard Foundation, Mr. and Mrs. Ahmet Ertegun, Ms. Selma Ertegun, Ms. Sachiko Imagawa, The Hon. Ronald S. Lauder, The Henry Moore Foundation, Mr. Maurice Segoura, Mr. H. Peter Stern and The Ralph E. Ogden Foundation, The International Music and Art Foundation, Mr. Robert W. Wilson and many others.

Special thanks go to WMF trustee Lois de Menil for generously supporting filming by Allen Moore Films, Inc., and to American Express for funding professional photography for World Monuments Watch sites.

WMF thanks Sorana Gorjan for archival photographs from the collection of her father, Stefan Georgescu-Gorjan, the original engineer of the *Endless Column*; Marielle Tabart of the Brancusi Atelier for archival photographs and assistance with the essays; Mihai Radu for the site plan and master plan; Kael Alford for photos of the completed project (additional photos by project participants and consultants); and Eric Neuner, ON Company, for exhibit graphics.

5 Reclaiming Sacred Space, Lanscaping Constantine Brâncuși's «Endless Column» Complex, by Richard Newton

Icon, Summer 2006: 32–39

by Richard Newton

At a time when there is much discussion about landscape as art, the *Endless Column* Complex by Romanian sculptor Constantine Brancusi (1876–1957) holds particular significance for the field of landscape architecture. Completed in 1938, the tripartite ensemble—composed of the *Endless Column*, a 30-meter high column of zinc and brass-clad, cast-iron modules, and two stone monuments, the *Gate of the Kiss* and the *Table of Silence*—was conceived as a tribute to young Romanian soldiers who died defending the town of Târgu-Jiu against German forces during World War I. Its location marks the place along the River Jiu where the young men made their sacrifice and draws out from there as a processional way that continues through the town for nearly two kilometers. It is a sublime creation that suggests the journey from this life to the next, with a sequence of evocative, abstracted monuments placed within the fabric of everyday civic life. Com-

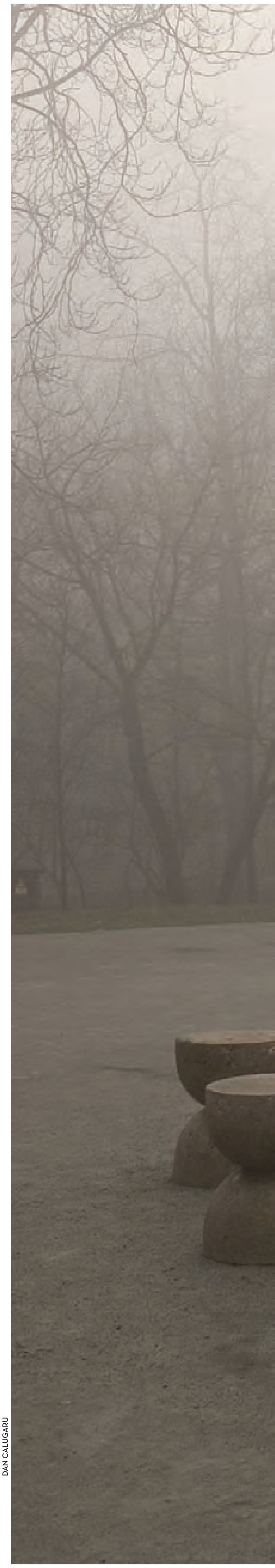
RECLAIMING SACRED SPACE

LANDSCAPING CONSTANTINE BRANCUSI'S *ENDLESS COLUMN* COMPLEX

memorating a profoundly heroic and tragic moment in the history of Târgu-Jiu and Romania as a nation, this seminal work of modern art is regarded as one of the first and most successful public monuments of the twentieth century.

Upon its completion, the ensemble defined a sacred space that stretched from the river floodplain to a haymarket on the edge of town, the monuments punctuating a serene landscape of gently rolling hills, cultivated fields, and farmhouses built of wood and stone, embraced by the snow-capped Carpathians visible in the distance.

Since then, however, the ensemble has lost a substantial amount of its presence, yielding to visual clutter and landscape intrusions as the town continues to expand. The processional way connecting the monuments, known as the Avenue of Heroes, has become a major thoroughfare, now bisected by other streets and lined with Soviet-era buildings, while the sculptures themselves have been isolated from each other. The *Table of Silence* and the *Gate of the Kiss* are located in the Park of the Gate, which bustles with activity throughout the year. The Park of the Column, which is much less used, abuts a school, a relatively tall and grim clothing factory, houses, and, further along the road to Bucharest, army barracks.



DAN CALUGARU

Following restoration of the sculptural elements in 2000 (see page 37), our team of landscape architects from the Laurie Olin Partnership set out to restore the dignity and serenity the work possessed prior to World War II. While it would be impossible to re-create the landscape of Brancusi's day, we could subtly alter the immediate surroundings of the ensemble in such a way that its power could be felt despite a plethora of visual and aural distractions.

PARK OF THE GATE: TABLE OF SILENCE, ALLÉE OF STOOLS, AND GATE OF THE KISS

The table with its 12 vacant stools originally stood on the bank of the River Jiu. However, the relationship between the sculpture and the river has since been visually and physically obscured by a tall, grassy embankment installed as part of a flood control measure when the river was dammed. The embankment itself was planted with black poplars while a visually distracting water feature located at its base competed for attention. Moreover, low hedges had been planted around the sculpture, further diminishing its presence.

Our goal was to create a calm, reflective, and sacred space in which the table could sit quietly apart from the park, making it a destination rather than a through route. To do this, we removed all of the hedges, opting instead for a single, soft-edged ellipse of crushed stone around the table and stools, beyond which we planted a grove of weeping willows, which, with their long hanging branches that move with the gentlest breeze, are associated with mourning and water. In time, the willows will grow together to form a loosely defined and separate space from the surrounding park.

The Allée of the Stools—a 160-meter-long path lined with 15 stools on each side—which connects the *Table of Silence* with the *Gate of the Kiss,* is lined with horse chestnuts. Although they dramatically framed the space, the trees had grown in a way that shaded the stools, placing them in shadow for much of the day. Moreover, small, low clipped hedges had been planted around the stools, making them all but invisible in the surrounding visual clutter. The allée was also crossed by three paths. Two were important park circulation routes, but one, which crossed the allée between the gate and the stools, was particularly intrusive and of lesser importance for pedestrian movement. Beyond the allée, on either side, were dark areas of woodland and, close to the gate, a children's playground. The allée, originally of bare earth, had been paved in the Ceaucescu era with crude concrete containing a decorative pattern and was in very poor condition.

To allow the stools to be clearly seen and to return the ensemble to its

UNLESS NOTED, DRAWINGS AND PHOTOGRAPHS COURTESY OLIN PARTNERSHIP

OPENING SPREAD: HEDGES THAT ONCE OBSCURED THE *TABLE OF SILENCE* HAVE BEEN REPLACED WITH AN ELLIPSE OF CRUSHED STONE AND WILLOWS. DURING THE CEAUCESCU ERA, HEDGES WERE ALSO PLANTED AROUND THE TRIOS OF STOOLS LINING THE ALLÉE, ABOVE, MAKING THEM ALL BUT INVISIBLE. THE ALLÉE ITSELF, ORIGINALLY OF BARE EARTH, WAS ALSO COVERED WITH CONCRETE, WHICH HAD DETERIORATED CONSIDERABLY. THE HEDGES HAVE SINCE BEEN REMOVED AND SOFT BANDS OF SHADE-TOLERANT SHRUBS HAVE BEEN PLANTED AT A DISTANCE TO BLOCK VISUAL CLUTTER, LEFT. THE PATHWAY ITSELF HAS BEEN REPAVED WITH THE SAME CRUSHED STONE THAT NOW SURROUNDS THE *TABLE OF SILENCE*.

more rural character, the hedges were removed and background distractions carefully screened by planting soft bands of shade-tolerant shrubs behind the stools in three rows of increasing height. The species were chosen to provide subtly varying seasonal colors and textures. For the walking surface, the same crushed stone that was used around the table was extended along the allée and edged with a matching colored curb. Carefully proportioned recesses of crushed stone frame each group of three stools, with the remaining areas planted with grass.

Much thought and debate went into the choice of material for the paths. Aside from practical considerations of maintenance, the discussion focused on finding a material that was robust and yet not too sophisticated. We wanted to respond to the primal quality of the work by choosing a material that would reflect light up to the underside of the canopy, yet one that did not have an insistent pattern. After viewing many samples of crushed stone, we opted for the same stone from which the stools were made for all paths within the two parks associated with the ensemble.

NOW FREE OF SUFFOCATING HEDGES AND OTHER VISUAL DISTRACTIONS, THE *TABLE OF SILENCE,* ABOVE, COMMANDS ITS LANDSCAPE. THE TABLE PRIOR TO RESTORATION AND RELANDSCAPING, RIGHT.

RESTORING THE *ENDLESS COLUMN* COMPLEX

The *Endless Column* Complex by famed Romanian sculptor Constantin Brancusi (1876–1957) has been hailed as one of the great works of twentieth-century open-air art. Commissioned by the Women's League of Gorj to honor the soldiers who had defended Târgu-Jiu against a German force in 1916, the tripartite ensemble, erected in 1934, is composed of the *Endless Column*, a 30-meter-high column of zinc and brass-clad, cast-iron modules—15 full and two half—threaded onto a steel spine, and two travertine monuments, the *Gate of the Kiss* and the *Table of Silence*.

Despite the ensemble's artistic importance, decades of exposure to the elements and poor maintenance during the Communist era had taken their toll on the sculptures, which by the mid-1990s were in dire need of conservation. Following the inclusion of the *Endless Column* on WMF's 1996 list of *100 Most Endangered Sites*, WMF and the Romanian Government established a partnership with the World Bank to finance the restoration of all three sculptures.

Although the column's modules had been replated twice since its construction, inspection of the modules revealed that while they were in generally excellent condition, the original surface had failed completely in a number of areas, revealing a rusting substrate. In June 1999, WMF brought together 32 leading architects, engineers, conservators, and Romanian cultural officials to determine the best methods to restore the column. Collectively, they decided to conserve rather than replace the existing spine, and to refinish the modules. Each module was cleaned, repaired—although pitting and small voids original to the cast-iron surface were not filled in—and replated with a polished medium-yellow bronze finish that closely resembles the original. Conservation of the column was completed in the fall of 2000. The travertine sculptures—the *Table of Silence* and its 12 stools, the *Gate of the Kiss*, and the stools lining the Allée—were cleaned of graffiti and biological growth and repaired. Some of the joints between the blocks of stone were fractured, probably due to some small structural movements within the monument. Conservation of the stone monuments was completed in 2004.

Finally the horse chestnuts were carefully pruned to filter more light down to the stools. Continued annual pruning will ensure that there is sufficient light during the day. For nighttime illumination, lights were placed high within the foliage of the trees suspended from discreet poles placed apart from the stools between the tree trunks.

DAN CALUGARU

THE PARK OF THE COLUMN

Originally the site of a hay market outside the town, the Park of the Column today is a long triangular space with roads on each side. Although the column dominates the space around, the park was badly defined and in poor condition. In addition most views of the column invariably had come to have buildings in the background, which detract from the idea of the column's connection with the infinite.

The column, and in particular its connection to the sky, is the culmination of the procession from the river. To reinforce this connection, a variety of large and small trees have been planted at a distance of approximately one and a half times the height of the column to form a seasonally changing backdrop and to screen out the surrounding buildings. Over time, these small trees will grow together to form a woodland around the column, which is open to the axis to the northwest, to provide a view of the distant Carpathian Mountains. When the trees mature, they will frame the column in such a way that it will once again be seen against the vast horizon, distant mountains, and sky.

The earth has been carefully shaped so that the column appears to rise from a high point. As in the Park of the Gate, crushed stone has been used for paths which circumnavigate the column so that visitors see it at a distance and without any adjacent element against which to judge its scale. Paths are located on the periphery in the shade of this woodland edge. The approach to the column is via mown grass paths. The base of the column is a simple circle of crushed stone and the surrounding ground is planted as a native wildflower meadow that in full bloom should be about half a meter in height.

DAN CALUGARU

THE NEWLY RESTORED *GATE OF THE KISS*, ABOVE, AT NIGHT. A SKETCH BY LAURIE OLIN, BELOW, SHOWS THE LANDSCAPING POTENTIAL OF THE AVENUE OF HEROES, WHICH NOW SEPARATES THE ENDLESS COLUMN FROM THE TWO TRAVERTINE ELEMENTS AND WHICH IS LINED WITH UNSYMPATHETIC ARCHITECTURE.

Benches are located along the paths around the perimeter of the clearing and park. Beyond the column to the east, where the park narrows, is a lawn of mown grass for playing and picnicking. The intent is to make this an informal recreational space for visitors and residents alike, one that relieves pressure for recreation and other park activities from the area around the column and which also affords long views toward the sculpture. Within the trees are planned public facilities including bathrooms, a café, a children's playground, and a security and maintenance office.

AVENUE OF THE HEROES

With the exception of a handsome orthodox church that is located in the center of the thoroughfare approximately half way between the two parks, the Avenue of the Heroes is a street that has little to distinguish it from other streets in the town. Between the Park of the Gate and the church, the street is dominated by modern concrete buildings erected during the later years of Ceaucescu's regime. These intrude on the more human scale of the older buildings and on the overall character of the street itself. The avenue is further interrupted by a large open swath of municipal gardens, with roads on either side approximately one third of the way between the park and the church. This strong axial open space and its bombastic buildings distracts from the ensemble's processional axis. The *Endless Column* becomes visible just after passing the church, at which point the street takes on a more rural and coherent character reminiscent of Brancusi's day with one and two story houses with gardens amid traditional fences. This calm approach to the climax of the sequence created by Brancusi is rudely interrupted, however, by railroad tracks and occasional commuter and freight trains. Throughout the length of the street, particularly between the Park of the Gate and the church, automobile traffic detracts from the experience.

We believe that the street should have a distinctive character, with locally available basalt blocks, currently installed around the church, extended throughout the length of the street. To provide a more generous and attractive space for pedestrians, we

WHILE IT IS IMPOSSIBLE TO RESTORE THE RURAL CHARACTER OF THE *ENDLESS COLUMN* COMPLEX, ONCE NEW LANDSCAPING REACHES MATURITY VISITORS WILL BE ABLE TO VIEW THE MONUMENTS WITHOUT THE VISUAL CLUTTER OF THE MODERN WORLD.

have proposed that the sidewalks be widened and that vehicular access be managed so that only vehicles that need to access the street are allowed. We also suggested planting trees on either side of the avenue to give the street a more sympathetic and humane character. This will also provide a consistently attractive edge and reinforce the ensemble's primary axis by providing a "green" link between the two parks.

Beyond this, Mihai Radu of Mihai Radu Architects has completed an urban masterplan for the immediate surrounding area that proposes new buildings and uses that are consistent with the character of the Avenue of the Heroes.

In particular, at the end of the Avenue of the Heroes on the north side, a site has been chosen for a museum and interpretative center that will allow a visitor to learn more about Brancusi, his work, and in particular, the ensemble, and the history of Târgu-Jiu.

While we cannot turn back the clock to an earlier era, the landscape design for this ensemble of abstract sculptures by Brancusi, which was originally placed in a rural setting, allows visitors to view them quietly and without the intrusion of the modern context. The design of the landscape has been an exercise in editing this context and clarifying the situation to allow Brancusi's work to dominate and once again be experienced as the coherent, powerful, and spiritual ensemble the artist envisioned. ■

Name and contact information of
official institution/agency

National Institute
of Heritage

Romania

Organization: Institutul Național al Patrimoniului
National Institute of Heritage

Address: Ienăchiță Văcărescu 16, Bucharest

Tel: +4 021 336 60 73
Fax: +4 021 336 99 04

E-mail: secretariat@patrimoniu.gov.ro
Web: www.patrimoniu.gov.ro
www.brancusi.world