

HISTORIC STRUCTURES

significant structures of the past

The Eiffel Tower at 125 Years

The Symbols of Progress Do Not Have an Age

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March 31, 2014 marked the 125th anniversary of the inauguration of the Eiffel Tower. Erected in 1889 on Champs de Mars in Paris for the Fourth World Exposition, the Eiffel Tower became famous even before its opening.

This technical achievement became a symbol of Paris and all France. Humans, who for millennia tried to achieve more than those who came before, did not succeed for more than 4,500 years to exceed the height of the pyramids in Egypt. The tallest spires of Gothic cathedrals barely stand higher than the Great Pyramid in Giza, but then the Eiffel Tower reached into the sky, twice as tall. Today it is the most visited monument in the world; every year, more than six million people pay tribute to the old “iron lady.” The tower, subject to so much controversy during its planning and construction, is now one of the planet’s most famous structures.

It is normal to ask what makes this tower so popular. While it is easy to understand the admiration caused by an edifice 300.5 meters (984 feet) tall near the end of the 19th cen-

tury, it is more difficult to explain why this old iron lattice structure still has such a strong effect, even though buildings have already reached heights above 800 meters (2,625 feet). If, at its completion 125 years ago, the tower was a sensation, why – even in the age of electronics, satellites, and people walking on the moon – does it still have such a strong effect on us? It cannot be mere skill that has transformed it from a technical achievement to a masterpiece of human effort.

Standing at the base of the tower and looking upward at its elegant lines reaching the sky, one feels proud to be a human being. Perhaps this is the main reason – the Eiffel Tower symbolizes the eternal human striving toward new heights, as the first monument built not to the gods or to an emperor, but to ourselves and to our unlimited human possibilities.

This creation is a result of the development and achievement of metallurgical and construction technologies, experience gained from many bold and complicated structures, and challenges and competitions between engineers, architects, companies and nations. The Eiffel Tower is the materialized symbol of progress during the Industrial Revolution of the 19th century. In the 1870s and 1880s, the favorable conditions for such technical achievements were building fast:

- Significant advancement of the industry;
- Development of construction materials, techniques and technologies;
- Competitions on World Expositions;
- Better structural engineering knowledge and experience;



- A new Universal (World) exposition planned for 1889 in Paris, and strong desire in France to recapture her previous glory; and
- The right man for accomplishing a super task – Alexandre Gustave Eiffel.

Alexandre Gustave Eiffel was born 1832 in Dijon, France. He graduated from L’Ecole Centrale des Arts et Manufactures in 1855 as a chemical engineer. After one year with Nepveu & Cie, a railway construction company, he started working in 1857 as an engineer for the railway company Pauvel & Cie, where he became chief of the construction office.

In 1866, Eiffel established his own company – Eiffel et Cie from 1868, later Compagnie des Etablissements Eiffel from 1879 – with which he designed and built railways, bridges and structures in Europe, Africa, South America and Asia. Eiffel built with his team more than a hundred significant bridges and other structures, gaining a lot of practical experience and establishing his reputation as someone with the greatest structural skills of all his contemporary engineers. Parts of his work are two remarkable bridges that are considered as the general rehearsal for his highest achievement, the Eiffel Tower:

- Maria Pia Bridge, built in 1877 over the Duoro River in Porto, Portugal, with a 160-meter (525-foot) span; and
- Garabit Viaduct, built in 1884 over the Truyere River, France, with a 165-meter (541-foot) span.

Among other well-known projects, Eiffel was also the engineer for the support frame structure of the Statue of Liberty in New York City, *Le Palais*

des Machines for the 1878 Paris Universal Exposition, the *Bon Marché* department store in Paris, the iron framing for the cathedral of Notre-Dame and a revolving cupola for the Nice Observatory. Eiffel's goal was always to build structures that were *lighter, cheaper, and stronger at the same time*.

In 1886, an open competition was announced for the centerpiece of the Exposition Universale in Paris, and all entries had to include a study for a 300-meter (984-foot) metal tower on Champs de Mars. The exposition was organized to show that "the law of progress is immortal, just as progress itself is infinite." After winning the competition, Eiffel's company was awarded the design and construction of the tower. Eiffel was assisted in the project by his leading engineers, Maurice Koechlin and Emile Nouguier, and the architect Stephen Sauvestre.

The tower structure is built with 7,300 tons of wrought iron. Eiffel's design office needed 5,330 drawings for the tower and its 18,038 elements, which were connected with 2.5 million rivets. Horse-drawn carts transported preassembled parts of the structure from the company workshop near Paris to the site. Up to 120 workers on the site and 330 in the workshop were involved with fabrication and erection.

The construction started on January 28, 1887 and was completed after two years, two months, and three days on March 31, 1889. The height of the tower when completed in 1889 was 300.65 meters (986 feet). The tower base is a square, 125 meters (410 feet) per side. In 1957, an antenna was added, which brought the total height to 320.75 meters (1,052 feet). In 2000, the tower's height reached 324 meters (1,063 feet) after the installation of another antenna.

The elegant lines of the tower are purely functional, as the hyperbolic shape of the legs is driven by a design for optimal resistance to wind loads. As David P. Billington states, "The Eiffel Tower's shape expresses visually the engineer's ideal for resisting the forces of wind." This approach to tall structure design was developed by Eiffel during his bridge-building in the Massif Central of France, characterized by very strong winds. The tall piers of the Garabit Viaduct were designed on the same principle.

Eiffel was well aware that his new structure would be more than just a tower:

"...it would symbolize not only the art of the modern engineer, but also the century of Industry and Science in which we are living, and for which the way was prepared by the great scientific

movement of the eighteenth century and by the Revolution of 1789, to which this monument will be built as an expression of France's gratitude."

Eiffel encouraged multiple uses of the tower beyond its original entertainment purpose. He himself used it for research on wind forces and velocity, meteorological observations and air resistance on falling bodies; his cabinet can still be seen on the third level near the top. The tower was used for transmitting radio signals from 1898, and as a military radio post in 1903; it transmitted the first public radio

program in 1925, and has been used more recently for television broadcasting.

The Eiffel Tower remains unique in shape; its pure, exposed forms are elegant and slender, simultaneously providing a feeling of strength and stability. This combined expression of strength and lightness is characteristic of the few truly great structures in the world, and the Eiffel Tower definitely belongs to this group. After 125 years, the Eiffel Tower remains an example of excellent engineering, and a great contribution to the art of structural engineering. There is still a lot to learn from the old iron lady. ■

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