The Tower at Namur —
World’s Tallest Precast
Prestressed Concrete Structure

At a height of 171 m (561 ft), the Namur Telecommunications Tower in Vedrin near Namur, Belgium, is believed to be the tallest loadbearing precast, prestressed concrete structure in the world. The tower has a tripod structure up to the 96 m (315 ft) mark and extends as a single cylindrical shape thereafter. The main structure comprises reinforced precast concrete ring segments, spliced with a special mortar and post-tensioned together. This article describes the conceptual development, design features, precasting techniques and erection procedure involved in building this unique tower.

In its mysterious ways, nature has usually provided the first example. From the Mountains of the Gods to Monument Valley, geological evolution has provided thousands of natural towers around the globe. Since the celebrated Tower of Babel, chronicled in the Old Testament, was built to reach the heavens in 562 B.C., man has sought to build ever bigger towers and attain ever greater world record heights.

Pharos, the legendary lighthouse which guided ships approaching the harbor of Alexandria, Egypt, is reputed to have been 135 m (440 ft) high. This structure was one of the seven wonders of the ancient world. For some 1200 years, until destroyed by a series of earthquakes, it was the world’s tallest tower and served as a standard for many towers to follow.

The tallest religious buildings are the stone cathedrals at Ulm, measuring 161 m (528 ft), and at Köln, measuring 157 m (515 ft), both in Germany. The Lin-He Pagoda in the city of Hang-Zhou, China, built of wood and brick, stands 150 m (492 ft) tall. In France, the cathedral at Rouen reaches a height of 148 m (485 ft) while the cathedral at Strasbourg stands 142 m (466 ft) tall.

The famous Eiffel Tower in Paris, at 300 m (984 ft) in height, was built in 1889 to commemorate the 100th anniversary of the French Revolution. This structure remained the tallest building in the world until the completion of the Chrysler Building in New York in 1930 [319 m (1046 ft)].

Since the beginning of the 20th century, man has built even taller structures, striving to break previous records for height. In Chicago, Illinois, there are the Sears Tower at
443 m (1453 ft), the Amoco Building at 374 m (1227 ft), and the John Hancock Building at 344 m (1128 ft). In New York, the World Trade Center is 412 m (1352 ft) high and the Empire State Building reaches 381 m (1250 ft).

More recently, the Petronas Twin Towers, built in Kuala Lumpur, Malaysia, rises to a height of 452 m (1483 ft), including a 74 m (242 ft) steel spire and pinnacle above the occupiable area. Currently, there are plans to build a 677 m (2222 ft) tower (World Centre for Vedic Learning or India Tower) near the city of Jabalpur, India.

The tallest loadbearing precast, prestressed concrete building in the United States is the 93 m (304 ft), 32-story residential Tannen Towers in Atlantic City, New Jersey. The tallest architectural precast clad (non-loadbearing) building is the 260 m (853 ft), 48-story Transamerica Corporate Headquarters in San Francisco, California. Currently, a 256 m (840 ft), 68-story building (The Park Towers, belonging to Hyatt) is being constructed in down-town Chicago, Illinois. When completed in early 2000, it is expected to be the biggest architectural precast clad (non-loadbearing) building in the United States.

Finally, there are the telecommunications towers. In addition to a tower mast reaching 642 m (2106 ft) in Warsaw, Poland, and the CN Tower in Toronto, Canada [553 m (1814 ft)], the tallest towers are in Alma Alta, Kazakhstan [376 m (1234 ft)] and Berlin [365 m (1198 ft)] and Frankfurt [381 m (1250 ft)], both in Germany. These towers were all constructed using post-tensioned cast-in-place concrete.

There are, today, more than 300 telecommunication towers in Germany alone. The most impressive of these towers have been designed by the brilliant German engineer Fritz Leonhardt and architect Erwin Heinle. Their book, *Towers: A Historical Survey* (published in 1989 in the United States by Rizzoli International Publications, New York) provides the best and most complete summary of the historical significance of towers throughout the world.

Fig. 1.
Observers have compared the completed Tower at Namur to a rocket poised for launching.
Fig. 2.
Elevation of tower.
(Dimensions in meters; 1 m = 3.28 ft.)

-172.20
-163.00
-159.75
-153.75
-147.75
-141.75
-132.75
-120.75
-108.75
-102.75
-96.75
-95.75
-81.00
-80.00
-72.00
-60.00
-56.00
-36.00
-24.00
-12.00
-0.00
-3.75

*2 x 4 T15 in sheath 1-8-12-13*

*RAL 7005 (dark grey)*

*RAL 7030 (medium grey)*

*RAL 7035 (light grey)*
Fig. 3. Plan with details of tower at base of structure. (Dimensions in millimeters; 1 mm = 0.0394 in.)
THE TOWER AT NAMUR

As far as is known, the Namur Tower (see Fig. 1), engineered by Ronveaux, is the tallest loadbearing precast, prestressed concrete tower in the world. In 1991 when Belgacom decided to build a 170 m (558 ft) tower at Vedrin near Namur, the architect sought the advice of specialists in precast concrete construction, to undertake a feasibility study of the project.

Ronveaux situated in Ciney, Belgium, had prefabricated and erected more than 120 towers in the area between Ostend and Arion for the Belgian military, radio and television, and telecommunications industries.

The company used a technique similar to that employed for viaducts and prefabricated arches, i.e., by splicing and post-tensioning precast segments together.

This construction method was recommended for the Namur Tower. The method is particularly economical in terms of materials. For example, 800 m³ (1050 cu yd) of post-tensioned, high strength precast concrete can provide a tower with the same performance characteristics as one made with 2400 m³ (3140 cu yd) of cast-in-place reinforced concrete. There are further benefits in terms of guaranteed high quality, long-term durability and high speed of erection.

Concrete was used from -3.75 m (12 ft) all the way to 163 m (535 ft) where the tower is topped by an 8 m (26 ft) spire with an attached lightning rod. The resulting total height of the tower is 171 m (561 ft). It has a concrete tripod structure up to the 96 m (315 ft) mark and extends as a single cylindrical tube thereafter. Fig. 2 shows an elevation of the tower and Fig. 3 shows a plan with details of the tower at the base of the structure.

The tripod legs are very slender, with an outside diameter of only 2.4 m (7.9 ft). At ground level, they are arranged within an 18.4 m (60.4 ft) diameter circle (see Fig. 3), sloping inward 5 degrees from the vertical. One leg contains a spiral staircase while another holds a ladder and cables, and the third houses the elevator’s counterbalance weights.

Figs. 4, 5 and 6 show early pictures of the erection of the tower. The legs of the tower are connected every 12 m (39 ft) by a three-branched precast concrete “star” (see Figs. 7 and 8) that has a center opening permitting passage of the elevator to the top of the structure. The joint between the tripod and the continuing single cylinder is executed from 84 to 96 m (275 to 315 ft) in elevation with four precast concrete platforms (see Figs. 9, 10 and 11). Connections in this zone are sealed with a special mortar. The four precast platforms include technical offices open to the public and are equipped with antenna anchorages, and windows or guard rails.

The 3.4 m (11.2 ft) diameter concrete core holds the elevator and another staircase which starts in the joint zone. This single tube of concrete carries stairs, cables, and the elevator up to the 163 m (535 ft) level. At the summit, four additional precast concrete platforms (see Figs. 12, 13, and 14) comprise the technical offices.

Several challenges addressed in the design, fabrication, and erection of the structure are described in the following sections.

CONFIGURATION OF THE TOWER

Fig. 4. Precast erection beginning in early July 1995.

Fig. 5. Erection crane attached to tower leg for stability at level 60 m.

Fig. 6. Platforms in the area where the tripod base and upper shaft were connected.
STRUCTURAL DESIGN

The tower is designed to safely resist extreme winds [above 200 km/hr (124 miles per hour)] and attendant vibration effects. The dynamics have been calculated in accordance with modern standards to withstand the effects of a 50-year storm.

The period of vibration calculated according to the exact method of Stodola is 2.5 seconds. This has been verified taking into account movement relative to thermal effects of the sun.

The tower requires a very large stiffness in order to avoid disturbing the signals transmitted and received, and must not deflect more than 0.5 degree (whether from wind or thermal effects). This constraint called for a maximum stiffness modulus (product of moment of inertia and elastic modulus).

In reinforced concrete, the moment of inertia of the section is reduced because of the loss of the area of concrete under tension, while in prestressed
Fig. 10. Overall view of progress at the end of September 1995.

Fig. 11. View looking down on the joint area.

Fig. 12. Top of precast structure at 163 m (535 ft), with precast platforms in place.
concrete the moment of inertia is that of the entire section. The Young’s modulus of elasticity of high quality precast concrete exceeds 40,000 MPa (5,800,000 psi).

PRECASTING
The tower is made of ring segments cast in cylindrical steel molds 1 to 3 m (3.3 to 9.9 ft) high. The molds were oriented vertically for casting to avoid air bubbles in the concrete. The molds available at the precasting plant all have metal stiffeners and are from 1.7 to 6.3 m (5.6 to 20.7 ft) in diameter. The post-tensioning sheaths were fixed in place inside the molds. Each ring segment was reinforced with circular mild steel and wire mesh, conforming to the Belgian Standard BE 50.

The concrete was made with a minimum content of 400 kg/m³ (674 lb per cu yd) of portland cement Grade 50. Introduced at the top of the forms, the concrete was compacted by high frequency vibrators attached to the forms. Anti-corrosion admixtures were put in the mix to protect the reinforcement. Also, whenever possible, fixtures and other accessories were installed at the plant.

ERECTION
The foundation of the tower is 23 m (75 ft) in diameter, with the thickness varying from 0.5 to 2 m (1.6 to 6.6 ft). Comprising about 400 m³ (525 cu yd), the foundation is supported on 24 piles, 24 m (79 ft) long. The ring segments for the tower were transported to the project site on trailers and stacked after applying a coating of epoxy resin to the contact surfaces.

Installation of the components, controlled by laser beam, was done by a crane that was attached to the body of the tower itself for stability (see Fig. 5). Control was particularly difficult because the base of the tower legs moved more than 100 mm (4 in.) due to movements of the crane and the influence of thermal variations.

The ring segments were post-tensioned using only 28 t (31 tons) of high strength tendons. The platforms, connecting gangways, and final cap were joined in the same way. The remainder of the outfitting completed the construction.

Fig. 13. Progress view at the end of October 1995.
CONCLUDING REMARKS

This unique project has been extensively covered in the international press, using such statements as “the tower shoots up like an arrow” and “a rocket poised for launching” to describe the speed of construction and elegant shape.

This record-setting structure in precast concrete was completed in a single season by Ronveaux. Commissioned in December 1994, the tower and its foundation were completed within a year, before the end of 1995.

The tower was erected at a record speed. Each of the three legs increased in length at a rate of 12 m (39 ft) per week, resulting in total erection of 36 m (118 ft) per week or 7 m (23 ft) per working day. A comparable tower built for the same owner in another city required two years to erect using cast-in-place concrete.

The precise equipment and rigorous quality control checks employed in fabricating precast concrete make possible the highest levels of performance and quality. Moreover, this quality comes with economy.

The total cost of the tower at Namur, including the foundation, stairs, and platform, was $3,000,000. This total cost included $1,200,000 for concrete, $600,000 for erection, and $270,000 for post-tensioning.

The tower is prominently situated at the intersection of the Paris to Berlin and Brussels to Luxembourg highways. As such, it serves as an excellent testament to the high performance and speed of construction of precast concrete construction. The structure is also a distinguished landmark that has been admired by the people of Belgium and visitors from around the world.

CREDITS

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