

# CN Tower

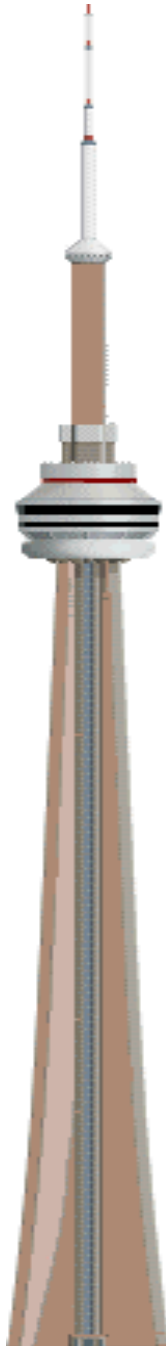
## Canada's Landmark Structure

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# CN TOWER

## *A PRESTRESSED CONCRETE CANADIAN LANDMARK STRUCTURE*

برج سی ان بلندترین برج جهان است. ارتفاع این برج ۵۵۳٫۳ متر (۱۸۱۵٫۳۹ فوت) است. این برج در شهر تورنتو در کانادا قرار دارد و سالانه حدود دو میلیون نفر توریست را به خود جذب می‌کند.<sup>۱</sup>



### **INTRODUCTION:**

Defining the Toronto skyline, the CN Tower is Canada's most recognizable and celebrated icon. At a height of 553.33m (1,815 ft., 5 inches), it is the World's Tallest Building, a Wonder of the Modern World, an important telecommunications hub, the centre of tourism in Toronto and a first class dining and event centre. Each year, approximately 2 million people visit the Canada's Wonder of the World to take in the breathtaking view and enjoy all of the attractions the CN Tower has to offer.

After 40 months of construction, the CN Tower was opened to the public on June 26, 1976 and it was well on its way to becoming the country's most celebrated landmark. It is the centre of telecommunications for Toronto serving 16 Canadian television and FM radio stations, the workplace of 550 people throughout the year, and one of Toronto's premier entertainment destinations.

The 1960s ushered in an unprecedented construction boom in Toronto transforming a skyline characterized by relatively low buildings into one dotted with skyscrapers. These buildings caused serious communications problems for existing transmission towers, which were simply not high enough to broadcast over the new buildings. Signals bounced off the buildings creating poor television and radio reception for residents. With its microwave receptors at 338 m (1,109 ft.) and at the 553.33m (1,815 ft., 5 inches) antenna, the CN Tower swiftly solved the communications problems with room to spare and as a result, people living in the Toronto area now enjoy some of the clearest reception in North America.

## **BREAKING NEW GROUND AND A SYMBOL OF STRENGTH**

The CN Tower was built in 1976 by Canadian National (Railway) who wanted to demonstrate the strength of Canadian industry by building a tower taller than any other in the world. Building the CN Tower was a vast and ambitious project that involved 1,537 workers who worked 24 hours a day, five days a week for 40 months to completion. When engineers started to plan the foundation of the CN Tower, they were breaking new ground in more ways than one. Never before had anyone been faced with the task of designing a base so far into the ground and they came up against many construction challenges unique to this project.

After an elaborate series of tests on the soil to assess the condition of the bedrock and determine how it would react to changes in hydrostatic pressure, the work was ready to begin. Tower construction crews moved in on February 6, 1973, and started to remove over 56,234 metric tonnes (62,000 tons) of earth and shale before pouring a thick concrete and steel foundation 6.71 m (22 ft) deep on a base of hand-and-machine-smoothed shale. Supporting the World's Tallest Building is a tall order and by the time it was finished the Y-shaped foundation contained 7,046 cubic meters (9,200 cubic yards) of concrete, 453.5 metric tonnes (500 tons) of reinforcing steel and 36.28 metric tonnes (40 tons) of thick, tensioning cables. The thoroughness and speed with which the foundation was laid is noteworthy. The complete foundation was in place just four months after the first spade of earth had been turned.

Once the foundation was ready, work began on the CN Tower's 335 m (1,100ft.) concrete shaft, a hexagonal core with three curved support arms. This involved pouring concrete into a massive mold or "slipform". As the concrete hardened, the slipform, supported by a ring of climbing jacks powered by hydraulic pressure, moved upwards, gradually decreasing in size to produce the CN Tower's gracefully tapered contour.

Eight months later, the CN Tower's concrete shaft was the tallest structure in Toronto and by February 1974, it was the tallest in Canada.

## **BUILDING A SEVEN-STOREY BUILDING AT 331 METER**

In August of 1974, workers began building the Tower's crowning glory, the SkyPod, a seven-storey building that would eventually house two observation decks, a 360° Revolving Restaurant (formerly Horizons, now just simply called The 360), a glass floor and various technical areas. This construction in the sky involved lifting 318 metric tons of steel and wood brackets up the sides of the Tower using 45 hydraulic jacks and miles of steel cable. To build the observation level, workers bolted brackets to tensioned steel bars and placed concrete in the wooden frames, then placed a three-foot-high compression ring around the outside. The radome (the donut-shaped collar at the base of SkyPod) protects the Tower's sensitive microwave equipment and is essential to its intrinsic purpose as a broadcast transmission facility. All of the important VHF, UHF and television equipment is located here. Incoming signals are monitored and fed to the antenna for transmitting. The radome is designed to protect this equipment from the elements but still enable it to receive transmissions

The CN Tower approached completion in March 1975, when *Olga*, the giant Sikorsky helicopter (see figure 9) flew into the city to lift the 44 pieces of the antenna into place. The CN Tower was finished on April 2, 1975, and opened to the public June 26, 1976.<sup>2</sup>

When the 44<sup>th</sup> and final piece of the CN Tower's antenna was bolted into place April 2, 1975, the CN Tower joined the ranks of 17 other great structures that had previously held the title of

World's Tallest Free-Standing Structure. Ross McWhirter, editor of the Guinness Book of World Records, was on hand to record the milestone for history and since then, the CN Tower has received numerous mentions in the famous book including the World's Longest Metal Staircase and World's Highest Wine Cellar. Over the years, the CN Tower has been recognized by the Guinness Book of World Records as the World's Tallest Building, Tallest Tower and Tallest Freestanding Structure. Any of these references is correct since there has been no building or freestanding structure on earth that has surpassed the CN Tower's height since it first opened to the public in 1976, 29 years ago and this engineering marvel continues to thrill visitors from all over the world each year.

In 1995, the CN Tower was classified as one of the Seven Wonders of the Modern World by the American Society of Civil Engineers. The World's Tallest Building shares this designation with the Empire State Building, the Chunnel [Ch(annel)+(T)unnel] under the English Channel, the Golden Gate Bridge in San Francisco, Itaipu Dam on the Brazil/Paraguay border, the Panama Canal, and the North Sea Protection Works off the European coast.

Since the CN Tower opened, Canadians and tourists from around the world have made the trip to Toronto to celebrate this marvel of civil engineering. Besides serving as a telecommunications hub, the CN Tower provides world-class entertainment and a wide range of unique attractions, exhibits and food and beverage venues.

In recent years, the CN Tower has supported its vision of Toronto's premier entertainment destination by totally renovating and redesigning 360 The Restaurant at the CN Tower, building the World's Highest Wine Cellar, adding two new elevators, replacing the Radome and installing a \$2 million leading edge security system.

Since 1997, \$40 million has been invested in expanding and revitalizing the CN Tower.

Local, domestic and international guests of all ages now have more to see and do as they venture through dynamic multimedia experiences, entertainment attractions and innovative food and shopping marketplaces before rocketing to the top of the Canada's Wonder of the World.

In June 2006 the CN Tower will celebrate its 30th anniversary as an engineering triumph, a symbol of pride, a critical telecommunications link and a world class entertainment and dining facility.

## **HIGHLY PRACTICAL**

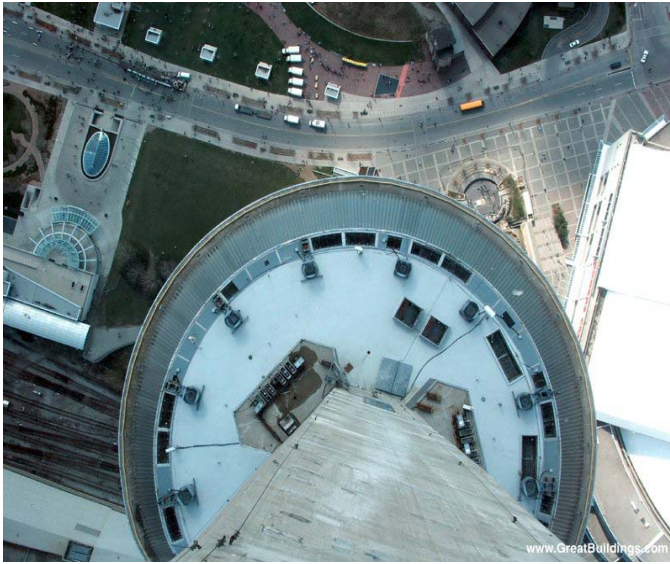
The CN Tower inspires a sense of pride, inspiration and awe for Canadians and tourists alike.

However, its origins are firmly rooted in practicality.

During Toronto's building boom in the early 70's, a serious problem was developing. People were experiencing poor quality television. And it wasn't just the sitcoms. The pre-skyscraper transmission towers of Toronto stations were simply not high enough anymore.

In 1972, Canadian National (CN) set out to build a tower that would solve the communications problems, serve as a world class entertainment destination, and achieve international recognition as the world's tallest tower.

The Tower's microwave receivers are located 338 m (1,109 ft) above the ground in the radome (the donut-shaped collar at the base of SkyPod). The important VHF, UHF and television equipment intrinsic to the Tower's purpose as a broadcast transmission facility are located here. Incoming signals are monitored and fed to the antenna for transmitting. Further up at 360 m (1,180 ft) is the centre of FM broadcasting in Toronto. <sup>3</sup>



**Figure 1: CN Tower, looking down from observation deck**



**Figure 2: Kite flying event**

The transmission equipment, although powerful, is extremely sensitive. The radome (a dome-like shell) designed to protect it from the elements, is a teflon-coated fiberglass-rayon fabric which can hold the weight of an average adult male yet measures only 1/32 of an inch. Its balloon-like shape results from inflating the skin to five times its normal size maintaining constant pressure.

## **SOME QUESTIONS AND ANSWERS:**

### **How much did it cost to build the World's Tallest Building?**

The CN Tower was built for \$63 million (about \$300 million in 1998 dollars).

### **How many people did it take to build the CN Tower?**

1,537 courageous workers toiled around the clock, five days a week, 24 hours a day, to build the CN Tower.

### **Who owns the CN Tower?**

Canadian National (CN) built the tower in 1976, and retained ownership until 1995 when it became a public company. At that point, ownership of the CN Tower was transferred to Canada Lands Company.

### **How much does the Tower weigh?**

The World's Tallest Building weighs in at 117,910 metric tonnes (130,000 tons). This is about the equivalent of 23,214 large elephants.

### **How much concrete is in the Tower?**

There is a full 40,524 cubic meters (53,000 cubic yards) of concrete in the CN Tower, enough to build a sidewalk curb from Toronto to Kingston, Ontario (302 KM).

### **Is the Glass Floor safe?**

Yes. The CN Tower's Glass Floor, opened on June 26, 1994, is 23.8 square meters (256 square ft.) of solid glass and is five times stronger than the required weight bearing standard for commercial floors. It can withstand the weight of 14 large hippos.

### **How many elevators are there in the CN Tower?**

There are now six glass-fronted, high-speed elevators. They travel at a rate of 22 km/hour (15 miles/hour). It takes only 58 seconds to reach 346m (1,136 ft.) level.

### **Does the CN Tower move in high winds?**

Like all tall, narrow buildings, the CN Tower was built to be flexible and wind resistant.

Here is the wind resistance of various parts of the Tower in winds of 120 mph (200km/h), with 200 mph (330 km/h) gusts:

**Antenna** - 1.07 m (3 1/2 ft) from centre

**SkyPod** - 0.46 m (1 1/2 ft) from centre

**Main Pod** - 22.9 cm (9 inches) from centre

## TRIVIA

- The CN Tower is 20 meters taller than Moscow's Ostankino Tower.
- The CN Tower is struck by lightning over 76 times a year.
- The CN Tower has a wind tolerance level of 420km/h (260 mph).
- The elevators go at over 22km/h (15 mph) taking 58 seconds to 61 seconds to reach the Lookout (indoor observation deck) and 360 restaurant levels respectively.
- The CN Tower is almost twice as tall as the Eiffel Tower.
- It is the tallest member of the World Federation of Great Towers.
- In winds of 120mph the tower sways 1.07 m (3 1/2 ft) from centre at the Antenna, 0.46 m (1 1/2 ft) from centre at the SkyPod, and 22.9 cm (9 inches) from centre at the Main Pod.
- A Sikorsky skycrane helicopter nicknamed 'Olga' was used to lower the communications antenna into place on the tower.
- The CN Tower is able to withstand an earthquake of 8.5 on the Richter scale.
- The 2,579-step metal staircase has been moved to the interior of the structure.
- A fine revolving restaurant located at 351 m (1,150 ft.) and offers guests a complete 360 degree view of the city. The floor in the 360 Restaurant rotates once every 72 minutes.
- In 1979, Norman Alexander and Joe Squire hauled a 440 lb. piano up the stairs in 7 ½ hr.
- On July 23, 1999 Ashrita Furman became the fastest person to go up the CN Tower using a Pogo stick.
- In 2001, a group of environmentalists illegally scaled the tower to place a banner protesting the policies of United States President George W. Bush on the tower.

## TOP 10 TALLEST TOWERS OF THE WORLD (as of 2004)

Rank	Tower	Year	Country	Town	Pinnacle height		Remarks
1	CN Tower	1976	Canada	Toronto	553 m	1815 ft	
2	Ostankino Tower	1967	Russia	Moscow	540 m	1772 ft	2000 Fire led to renovation
3	Oriental Pearl Tower	1994	China	Shanghai	468 m	1535 ft	
4	Milad Tower	2003	Iran	Tehran	435 m	1427 ft	
5	Menara Kuala Lumpur	1995	Malaysia	Kuala Lumpur	421 m	1381 ft	

6	Chimney of GRES-2 Power Station	1987	Kazakhstan	Ekibastusz	419 m	1362 ft	Tallest chimney in the world
7	Tianjin Radio and Television Tower	1991	China	Tianjin	415 m	1362 ft	
8	Central Radio and TV Tower	1992	China	Beijing	405 m	1329 ft	
9	Kiev TV Tower	1973	Ukraine	Kiev	385 m	1263 ft	Tallest lattice tower of the world
10	Inco Superstack	1971	Canada	Copper Cliff	385 m	1263 ft	

### ARCHITECTS AND ENGINEERS WHO WERE INVOLVED IN BUILDING OF THE CN TOWER?<sup>3</sup>

Listed here are the architecture and engineering credit:

<b>Architecture</b>	John Andrews and Webb Zerafa Menkes Housden, Toronto - E. R Baldwin.
<b>Structural Engineering</b>	Nicolet, Dressel and Associates Montreal - Dr. F. Knoll Dr. A. G. Davenport – London, Dr. B. Thurlimann – Switzerland, Vibron Ltd. – Toronto, <b>Jamil Mardukhi*</b> , Toronto
<b>Mechanical/Electrical Engineering</b>	Ellard-Willson and Associated Toronto - J. Petrinc and J. Armstrong
<b>Soils and Foundation Engineering</b>	Dr. W. I. Robinsky – Toronto, Dr. A. V. Peglar – Australia, W. Trow Associates – Toronto, John Bickley - Construction Testing Services Ltd. - Toronto
<b>Civil Engineering</b>	Marshall, Macklin, Monaghan Ltd. - Toronto
<b>Broadcasting Engineering and Security Systems</b>	Elder Engineering Ltd. - King City, Ontario



Figure 3: CN Tower under construction in 1976

**• Biography of Mr. Mardukhi:**

Mr. Jamil Mardukhi (originally Iranian), M.A.Sc. P.Eng. is a structural engineer, manager and principal partner of the award winning consulting engineering firm of NCK Engineering Ltd. of Toronto. He has over 30 years of experience in the design, supervision and management of important complex projects in Canada and overseas. His special interests and practical experience are in the design, monitoring and maintenance of tall towers, high-rise buildings and special structures. Mr. Mardukhi obtained his M.A.Sc. degree from the University of Toronto in 1974.

***He has been involved in the design, construction and monitoring of the CN Tower in Toronto, 350 meter tall tower in Mexico, 435 meter tall tower (Milad) in Tehran, a 46 story high rise building in Beirut, The Pyramid of the Louver in Paris and many other complex projects in Saudi Arabia, Moscow, Trinidad and the UAE. Mr. Mardukhi and NCK have also been in charge of all inspections, installations and maintenance work of the CN Tower, since 1976.***



**Figure 5: Mr. Jamil Mardukhi presenting in Sept. 4, 2002 gathering of Canadian Society of Iranian Engineers and Architects (MOHANDES): “Design, Construction and Maintenance of CN Tower”<sup>4</sup>**



**Figure 6: Glass Floor with its 342 metre view**



**Figure 7: Lightning striking CN Tower**





**Figure 8: World's Highest Man-made Observation level located at a height of 447 metres offering spectacular panoramic views of distances up to 160 kilometres**



**Figure 9: CH-54 Tarhe giant Sikorsky helicopter used to lift the 44 pieces of the antenna into place<sup>5</sup>**

## **Appendix:**

### **A-The Canada Life CN Tower Stair Climb for World Wildlife Fund**

Every year CN Tower organizes and hosts a fundraising event to promote public health and environmental conciseness. This year is 16th annual stair climb which is sponsored by Canada Life and the CN Tower to raise money for the World Wildlife Fund. This popular annual fundraising event attracts thousands of people who want to take on the ultimate challenge of climbing the 1,776 stairs of Canada's Wonder of the World and contribute to a very worthy cause. This year annual stair climbs scheduled for:

**1-Thursday April 27 2006**  
TEAM CHALLENGE  
5-8 pm

**2- Saturday April 29 2006**  
PUBLIC CLIMB  
6-11 am

**B-About the WWF ([www.wwf.ca](http://www.wwf.ca)):**

The World Wildlife Fund's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by:

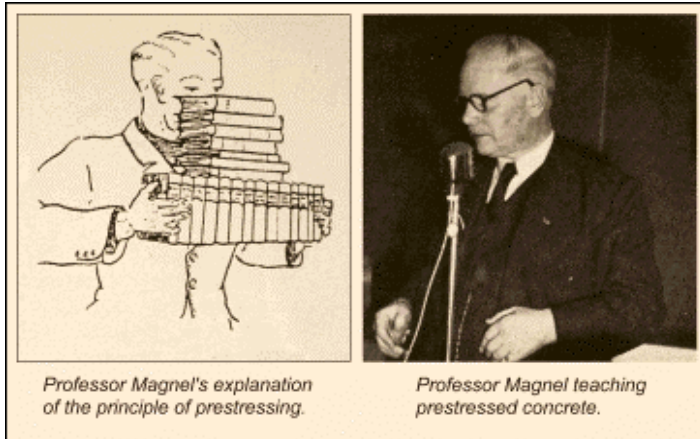
- conserving the world's biological diversity
- ensuring that the use of renewable natural resources is sustainable
- promoting the reduction of pollution and wasteful consumption

**C-OUTSTANDING ENGINEERING ACHIEVEMENTS  
PRESTRESSED CONCRETE IN CANADA**

A Short History:<sup>6</sup>

This short history looks at how prestressed concrete came into use in 1952 in Canada. Research and more accurate design methods helped engineers to better understand the behavior and performance of prestressed concrete. Prestressing materials and technology developed rapidly worldwide. Outstanding bridges, buildings and building systems, stadiums, arenas and other structures that have been constructed between 1952 and 2000 are described. CN tower is one of them.

**1. INTRODUCTION**



**Figure 11: Walnut Lane Bridge – 1949  
Philadelphia, PA USA**

The construction of the Walnut Lane Bridge was a most significant event and is mentioned here even though it was built in the United States. It was the dramatic groundbreaking project that showed North American engineers the practical value of combining the compressive strength of concrete with high tensile strength prestressing steel. The design of the bridge was based on European prestressing technology and design methods introduced to North America after the Second World War. Professor Gustave Magnel (1885-1955) of Belgium gave lectures to engineers in the US and Canada in the mid 1940's to the early 1950's. Magnel's book "Prestressed Concrete" attracted considerable interest in North America of the potential for prestressed concrete.

## 2. DESIGN CODE

The initial design codes used in designing the prestressed structures in Canada are shown here:

CSA (Canadian Standards Association) A135-1962 Standard for Prestressed Concrete

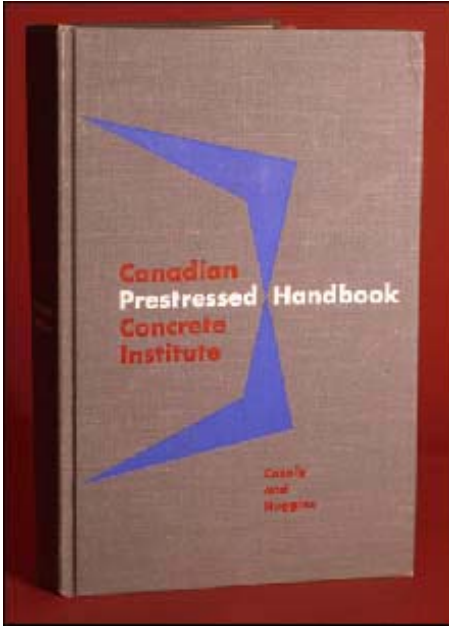


Figure 12: The standard was included in the CPCI Design Handbook by Cazaly & Huggins. Published in 1964, this was the first precast handbook in North America.



Figure 13: This first standard code was published in 1962 25-page 3 mm thick document overcome the last objections to using prestressed concern in Canada.

References:

<sup>1</sup> Wikipedia: [http://en.wikipedia.org/wiki/Cn\\_tower](http://en.wikipedia.org/wiki/Cn_tower)

<sup>2</sup> Official site of the CN tower: <http://www.cntower.ca/portal/>

<sup>3</sup> [http://www.civil.port.ac.uk/comp\\_prog/cntower/Faq.html](http://www.civil.port.ac.uk/comp_prog/cntower/Faq.html)

<sup>4</sup> Canadian Society of Iranian Engineers and Architects (MOHANDES): <http://mohandes.com/aspFile/photo.asp?id=23>

<sup>5</sup> American Society of Civil Engineers: [http://www.asce.org/history/seven\\_wonders.cfm](http://www.asce.org/history/seven_wonders.cfm)

<sup>6</sup> The Canadian Precast/Prestressed Concrete Institute (CPCI): <http://www.cpci.ca/?sc=history&pn=prestressedincanada>