How the Burj Khalifa was Built

Standing at a staggering height of 828 meters above the sands of Dubai, the Burj Khalifa skyscraper claims the title of the tallest building in the world. The colossal tower is a marvel of modern engineering and architecture, and is largely responsible for making Dubai one of the world's most popular tourist destinations each year.

Building a structure as grand as the Burj Khalifa was no small feat. Constructing a tower that would be more than 60% taller than the previous record holder required innovative engineering techniques, collaboration between several different organizations, and careful planning in order to suit the client's needs while maximizing structural efficiency.

The idea to build a Dubai skyscraper was originally conceived by the United Arab Emirates government as a method to drive tourism to the economy. The tower was to be the centerpiece of "Downtown Dubai", a series of commercial and residential buildings along Dubai's skyline. After a design competition, the United States architectural firm Skidmore, Owings & Merrill (SOM) was chosen to design the Burj in 2004, with Adrian Smith as the lead architect, and Bill Baker as the chief structural engineer.

The architects and engineers at SOM wanted this skyscraper to become an icon for the city of Dubai. The tower would have to fulfill a number of criteria to achieve this. The Burj Khalifa would have to embody traditional Islamic architecture, be structurally stable while providing enough real estate space, and rise as far into the sky as it possibly could.

SOM used their recently finished project, the Samsung Tower Palace III in Seoul, Korea, as inspiration for the Burj Khalifa's design. The Tower Palace III utilized a buttressed core, a three-winged design which provides the stability needed to build to extreme heights; each wing is stabilized by the other two, and the central core provides torsional resistance. This tripod-shaped design is also ideal for residential and hotel space, as it allows each unit to have a clear exterior view. The Tower Palace III was only 73 stories high, but SOM knew they would be able to build much higher by utilizing a buttressed core system.

SOM elected to take advantage of the three-winged design by creating an organic form based on an abstraction of the Hymenocallis flower, a spider lily found in

Dubai's deserts. The tower's initial geometry was tested in a wind tunnel, but the team encountered that the tower's shape and orientation caused the structure to sway too much under the wind.

To solve this problem, structural engineers gradually revised the design to minimize wind harmonics and utilize the tower's gravity to their advantage. The Burj Khalifa's design consisted of a series of setbacks, which are staggered levels that resemble steps. The arrangement of these setbacks was changed from a counterclockwise to a clockwise pattern, and the shape of the wings was revised. The tower was also oriented in the direction that would best resist Dubai's strongest winds from the northwest, south, and east. When they succeeded in stabilizing the structure, they realized that they would be able to build even higher than they had previously thought.

Excavation for the tower's foundation began in January 2004. The Burj Khalifa utilized a pile foundation, a system necessary for transferring a skyscraper's heavy vertical loads to the ground. A total of 194 piles that were 1.5 meters in diameter and 43 meters long were bored into the ground, filled with concrete, and then used to support a 3.7-meter thick concrete mat. The concrete mat was poured on four different days, one for the central core, and one for each of the tower’s three wings. More than 110,000 tons of concrete were used to build the tower’s foundation, and a cathodic protection system was placed below the mat to prevent corrosion from groundwater.

Construction of the superstructure began in March 2005. The central core and wings were built first, followed by the wing walls and nose columns. This sequence was repeated as the tower rose higher and higher. Three modified self-climbing cranes and a series of construction hoists were used to lift workers and materials to the tower's upper levels. The cranes had to be installed and dismantled to reach the new levels that had been completed. The cranes were typically used to lift steel reinforcement beams, scaffolding, and fuel.

Concrete would have to be pumped to extreme heights to build a tower of this scale, so the German chemical company BASF developed a special concrete mix that could be pumped to a height of over 600 meters, and could be worked on for more than three hours before hardening. Two powerful Putzmeister concrete pumps were used to deliver over 330,000 m^3 of concrete as the tower was erected. In January 2009, the Burj Khalifa’s 244-meter steel spire was completed, officially topping out the structure.

Exterior cladding of the Burj Khalifa commenced in May 2007. The cladding system had to be able to withstand the blistering heat of Dubai's summers, when temperatures can climb as high as 50 degrees Celsius. The cladding work was primarily handled by specialists from China. The tower's panels are comprised of aluminum, stainless steel, and reflective glass. At maximum, as many as 175 panels were installed per day, and a total of 28,261 hand-cut glass panels were eventually added to the tower's exterior. Exterior cladding was completed in September 2009.

The Burj Khalifa's mechanical, electrical, and plumbing systems were designed in coordination with the lead architect and structural engineer. Occurring around every thirty stories, two dedicated mechanical floors house the MEP utilities necessary for the tower's functioning. These mechanical floors service the 15 floors above and below them. The MEP services are distributed efficiently through the central core, where the shape and size of the building remains consistent.

The Burj Khalifa was officially opened to the public on January 4, 2010, and now serves as the physical realization of intricate thinking, careful planning, and over 22 million combined hours of physical labor. This awe-inspiring, record-breaking tower stands as a testament to what the combined efforts of architects, engineers, and construction workers can produce.