



Architecture

PRELIMINARY
IMAGE FPO

Burj Khalifa

Dubai, United Arab Emirates

Building instructions are available on: Die Bauanleitung finden Sie auf: Vous pourrez trouver des instructions de montage sur : Encontrarás las instrucciones de construcción en: Encontrar instruções de construção em: Az építési útmutatót a következő helyen találod meg: [Architecture.LEGO.com](https://www.lego.com/en-us/lego-architecture)



Adrian D. Smith

With notable supertall skyscrapers such as the Buri Khalifa, Jin Mao Tower and the Trump International Hotel & Tower to his name, Adrian D. Smith is one of the most recognized and respected architects in the world today.

Born in Chicago in 1944, Adrian moved to the West Coast as a young child and was brought up in San Clemente, California. Growing up next to the ocean and beach instilled in him a respect for the relationship between a building and its environment. And this “sense of place”, as he described it, would later play a major part in his work as an architect.

After studying at Texas A&M University, a chance encounter back in California led him to apply for a job with the renowned architect company, Skidmore, Owings & Merrill (SOM), in Chicago. In 1967, Adrian began his thirty nine year career with the company working on the John Hancock Center. From 1980 to 2003 Adrian was a Design Partner in the Chicago office of SOM and a Consulting Design Partner from 2004 to 2006. Adrian also served as the SOM's Chief Executive Officer (1993 to 1995). He was the Chairman for the SOM

Foundation (1990 to 1995) which serves to recognize and nurture students in architecture, design, urban design and structural engineering.

After nearly four decades with Skidmore, Owings & Merrill (1967–2006), Smith left to found his own firm (Adrian Smith + Gordon Gill Architecture) with Gordon Gill and Robert Forest.

Projects under his design direction have won over 90 major awards for design excellence, including five international awards, eight National AIA awards, 22 Chicago AIA awards, and two ULI Awards for Excellence. Smith's work at SOM has been featured in major museums in the United States, South America, Europe, Asia and the Middle East. He is a Senior Fellow of the Design Futures Council.



Adrian D. Smith (Image: Emaar Properties)

Placeholder (Adrian Smith)

Burj Khalifa

Envisioned as the tallest structure in the world and the flagship building for the Downtown Dubai development, Skidmore, Owings & Merrill was selected to carry out the architecture and engineering of the Burj Khalifa project, and gave Adrian D. Smith the role of the chief architect. In 2003 Adrian said *“Burj Khalifa is an interesting project because there is very little context for a building of this height to draw from in Dubai. The city has a heritage similar to Bahrain – it’s a historic Middle Eastern trading port with lots of desert and the same water conditions, but here I am trying to connect on a more organic level.”*

The structure is all reinforced concrete below the spire. The spire above the observation floors are steel. Architecturally, the building is transition from a solid base expression to a vertically expressed middle section of polished stainless steel projected metal fins and glass. Adrian wanted to use only vertical elements here because the fine dust in Dubai’s air would build up on any horizontal projecting elements. They have sandstorms quite frequently so in order to reduce maintenance costs the tower has virtually no horizontal ledges.



Burj Khalifa is the tallest man-made structure ever built, at 828 m (2,716.5 ft). Construction began on 21 September 2004, with the exterior of the structure completed on 1 October 2009. The building officially opened on 4 January 2010.

The decision to build Burj Khalifa was based on the government's decision to diversify from an oil-based economy to one that is service and tourism-oriented. According to officials, it is necessary for projects like Burj Khalifa to be built in the city to garner more international recognition, and hence investment. Sheikh Mohammed bin Rashid Al Maktoum wanted to put Dubai on the map with something really sensational.

In 2007, several records fell as the Burj Khalifa climbed above the city-state's skyline. In May 2007, the Burj surpassed the height of the tallest building in the United States, the Sears Tower (recently renamed the Willis Tower), designed by Skidmore, Owings & Merrill in the 1970s. Adrian Smith designed the Burj in the early years of the new millennium, but by the time the new skyscraper zoomed past Sears (at 1,450 feet, or 442 meters), Smith had left SOM.

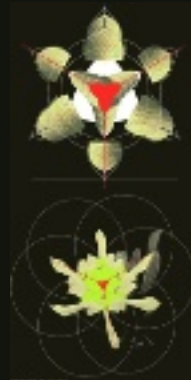


In July 2007, the Burj became the tallest building in the world, at 512.1 meters (1,680 feet), pushing past Taipei 101, which had held the title of the world's tallest for only six years. By September, the Burj had broken another record: at 555 meters (1,821 feet) it was now the world's tallest freestanding structure, nosing past the CN Tower in Toronto by just two meters (6.6 feet). The Burj reached its final height at 828 meters (2,716.5 feet), just 172 meters shy of a kilometer, and over half a mile tall.

No stranger to Middle Eastern design, Adrian Smith incorporated patterns from traditional Islamic architecture. But his most inspiring muse was a regional desert flower, the Hymenocallis, whose harmonious structure is one of the organizing principles of the tower's design. Three "petals" are arranged in a triangular shape and unified at the center, and instead of repeated identical patterns, the architectural plan appoints successively receding and rotated stories. The Y-shaped plan is ideal for residential and hotel usage, with the wings allowing

maximum outward views and inward natural light.

Viewed from above or from the base, the Y-shape also evokes the onion domes of Islamic architecture. During the design process, engineers rotated the building 120 degrees from its original layout to reduce stress from prevailing winds. At its tallest point, the tower sways a total of 1.5 m (4.9 ft).



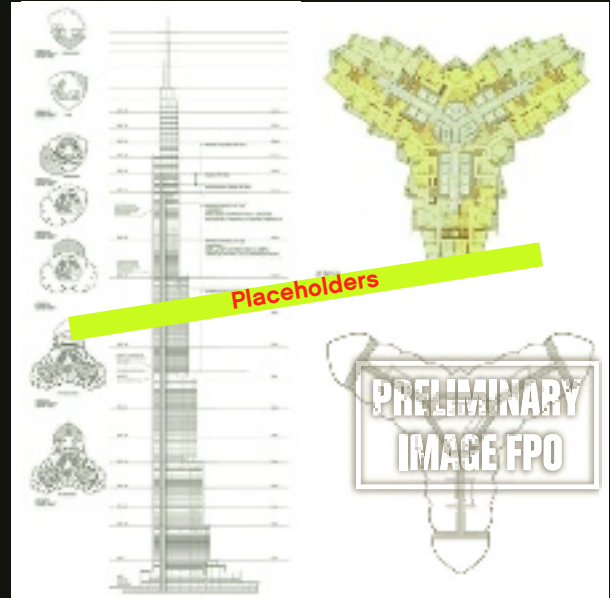
Dome shape and Dessert Flower (Image: Emaar Properties)

The structural system

To support the unprecedented height of the building, the engineers developed a new structural system called the buttressed core, which consists of a hexagonal core reinforced by three buttresses that form the 'Y' shape. Each wing, with its own high performance concrete corridor walls and perimeter columns, buttresses the others via a six-sided central core, or hexagonal hub. The result is a tower that is extremely stiff laterally and torsionally. SOM applied a rigorous geometry to the tower that aligned all the common central core, wall, and column elements.

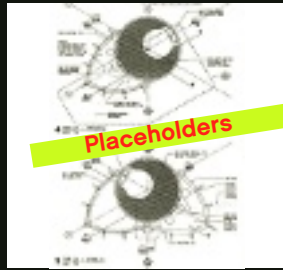
Each tier of the building sets back in a spiral stepping pattern up the building. The setbacks are organized with the Tower's grid, such that the building stepping is accomplished by aligning columns above with walls below to provide a smooth load path. This allows the construction to proceed without the normal difficulties associated with column transfers.

The setbacks are organized such that the Tower's width changes at each setback. The advantage of the stepping and shaping is to 'confuse the wind'. The wind



vortices are never allowed to build up because at each new tier the wind encounters a different building shape. This structural system enables the building to support itself laterally and keeps it from twisting.

At the top, the central core emerges and is sculpted to form a finishing spire. The design architect, Adrian Smith, felt that the uppermost section of the building did not culminate elegantly with the rest of the structure, so he sought and received approval to increase it to the current height. It has been explicitly stated that this



change did not include any added floors, which is fitting with Smith's attempts to make the crown more slender. The spire of Burj Khalifa is composed of more than 4,000 tonnes (4,400 ST; 3,900 LT) of structural steel. The central pinnacle pipe weighing 350 tonnes (390 ST; 340 LT) was constructed from inside the building and jacked to its full height of over 200 m (660 ft) using a strand jack system. The spire also houses communications equipment.



Burj Khalifa has “refuge floors” at 25 to 30 story intervals that are more fire resistant and have separate air supplies in case of emergency. Its reinforced concrete structure makes it stronger than steel-frame skyscrapers.

Designers purposely shaped the structural concrete Burj Khalifa - “Y” shaped in plan - to reduce the wind forces on the tower, as well as to keep the structure simple and foster constructibility. It went through three wind tunnel tests, and one of the important things they learned was that the taller legs needed to be on the sides of the prevailing wind rather than the front face because it sheds the vortices more effectively. The texture of the façade and the weight distribution also affect how wind impacts the structure – for instance how much weight is at the top of the building, and where the columns are placed. The structural system can be described as a “buttressed” core.

The building utilises high-speed, non-stop shuttle elevators to sky lobby floors where passengers transfer to local elevators serving the floors in between.

Burj Khalifa has 58 elevators and 8 escalators, which include 20 Gen2 flat belt elevators and two double deck observation deck cabs with a capacity for 12-14 people per cab. Travelling at 10 metres per second, they will have the world's longest travel distance from lowest to highest stop. The building service/fireman's elevator will have a capacity of 5,500 kilograms and will be the world's tallest service elevator.



Inside the high-speed elevator

Burj Khalifa is also the first high-rise building to contain controlled evacuation elevators for emergency situations. The tallest tower in the world also has the world's highest elevator installation — the spire maintenance elevator — situated inside a rod at the very top of the building.

The water system supplies an average of 946,000 litres of water per day. At the peak cooling times, the tower will require approximately 10,000 tonnes of cooling per hour, which is equivalent to the capacity provided by 10,000 tonnes (22.4 million lbs or 10.2 million kg) of melting ice in one day.

The tower also has a condensate collection system, which uses the hot and humid outside air, combined with the cooling requirements of the building and results in a significant amount of condensation of moisture from the air. The condensed water is collected and drained into a holding tank located in the basement car park. This water will then be pumped into the site irrigation system for use on the tower's landscape plantings. This system

will provide about 15 million gallons of supplemental water per year, equivalent to nearly 20 Olympic-sized swimming pools.

There are unconfirmed reports of several planned height increases since its inception. Originally proposed as a virtual clone of the 560 m (1,837 ft) Grollo Tower proposal for Melbourne, Australia's Docklands waterfront development, the tower was redesigned with an original design by Skidmore, Owings and Merrill. Marshall Strabala, a SOM architect who worked on the project until 2006, said that it was designed to be 808 m (2,651 ft) tall.



The design (& height) changes Burj Khalifa went through

Facts about Burj Khalifa

Location: Downtown Dubai,
Dubai, United Arab Emirates

Architect: Adrian D. Smith for Skidmore,
Owings & Merrill

Building type: Supertall skyscraper

Materials: Reflective glazing, aluminum
and textured stainless steel

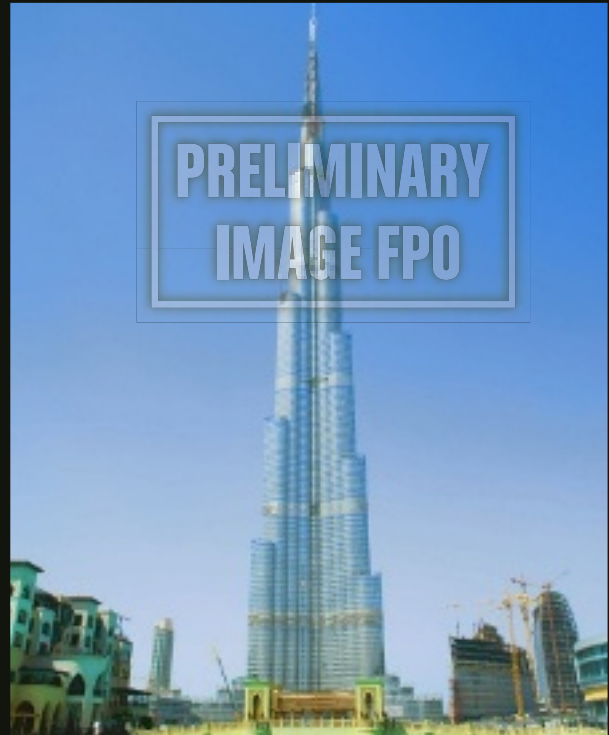
Construction: Reinforced concrete and steel

Date: From 2004 to 2009

Floor area: 5,000,000 sq. ft. (464,511 m²)

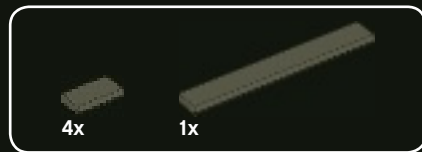
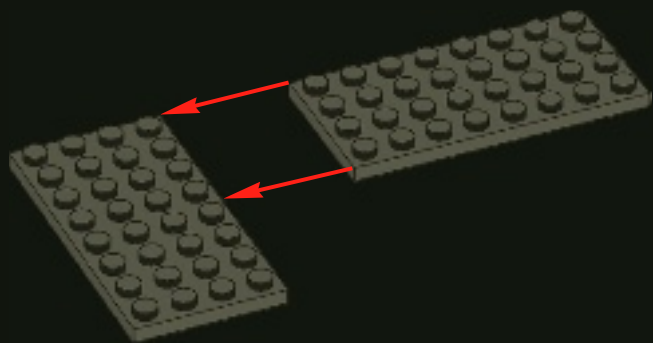
Height: 2,716.5 ft. (828 m.)

Stories: 160 habitable floors plus 46
maintenance levels in the spire
and 2 parking levels in the
basement

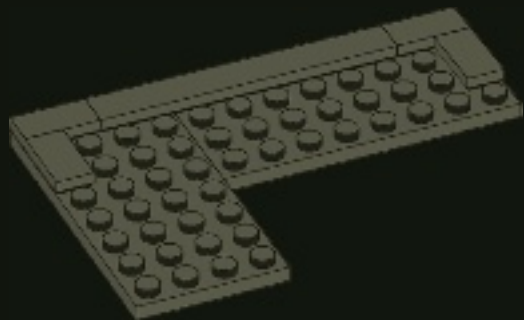




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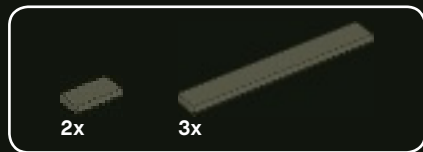
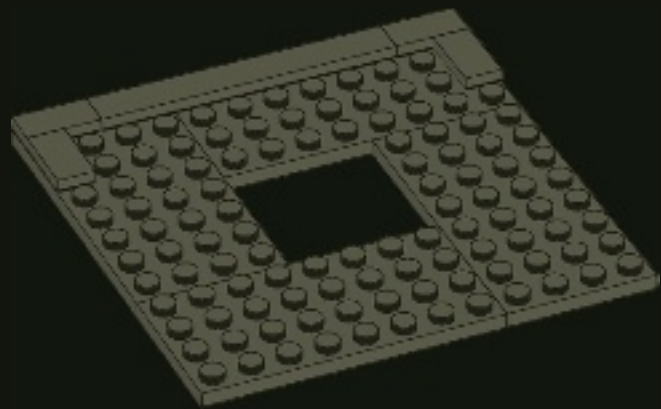


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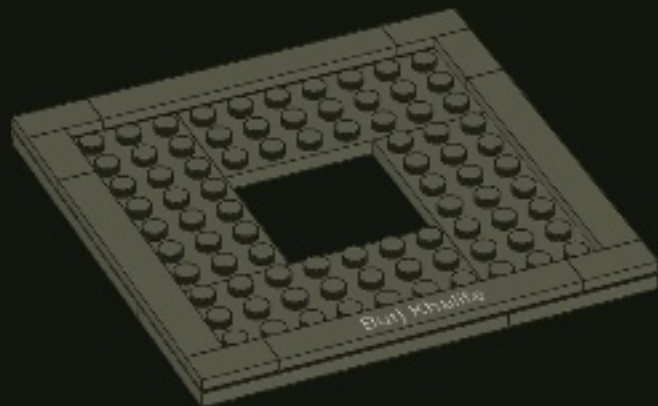




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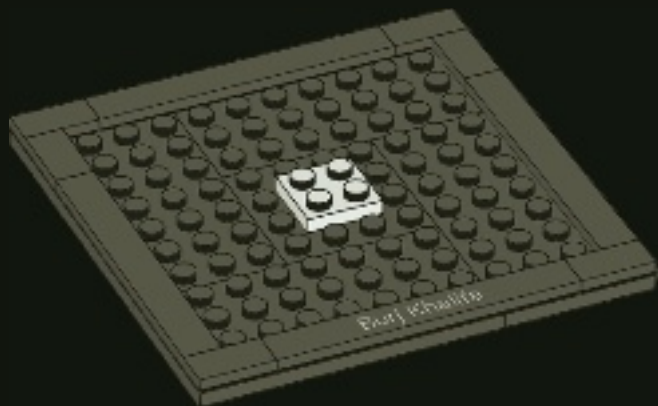


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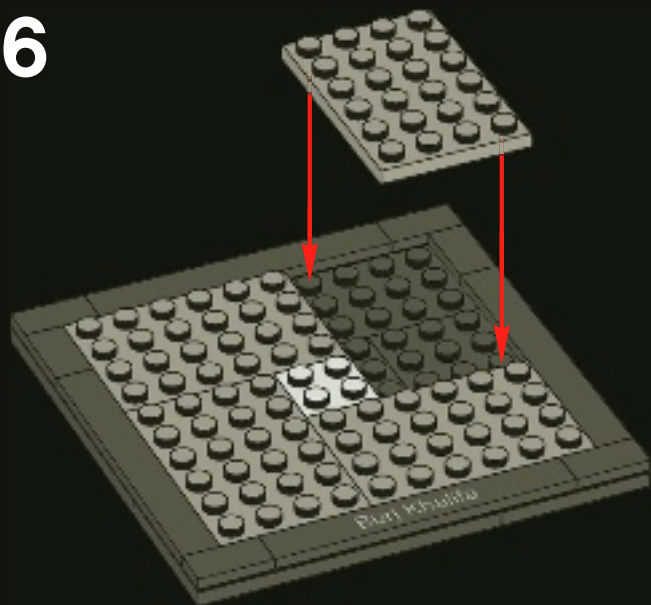




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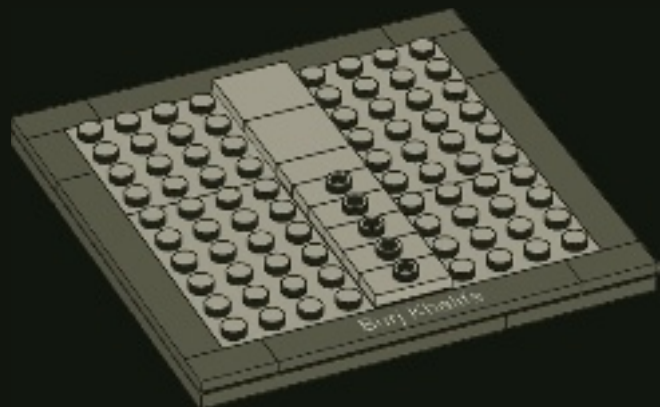


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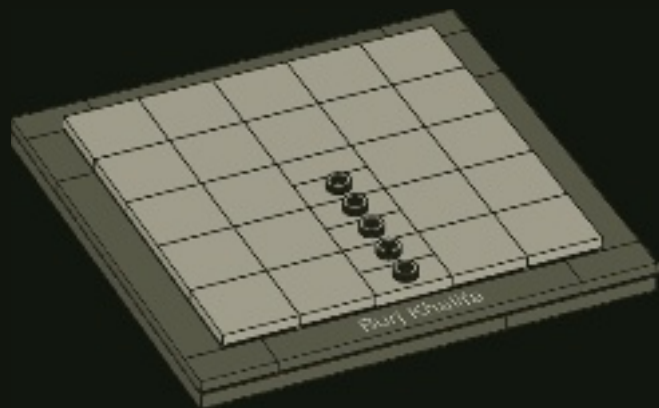
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9

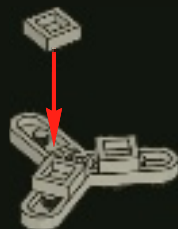




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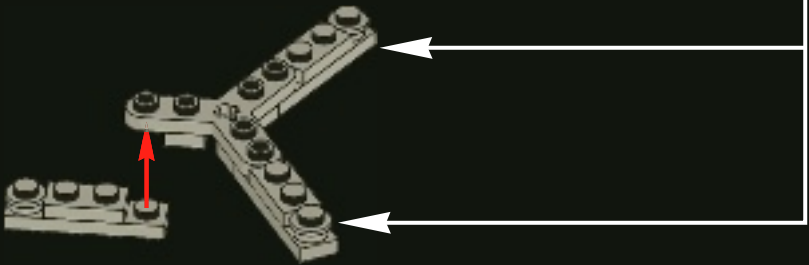
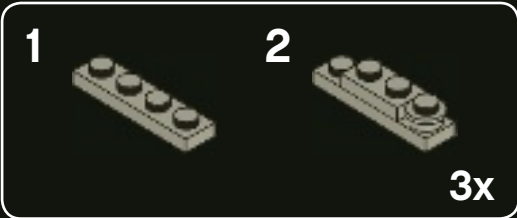


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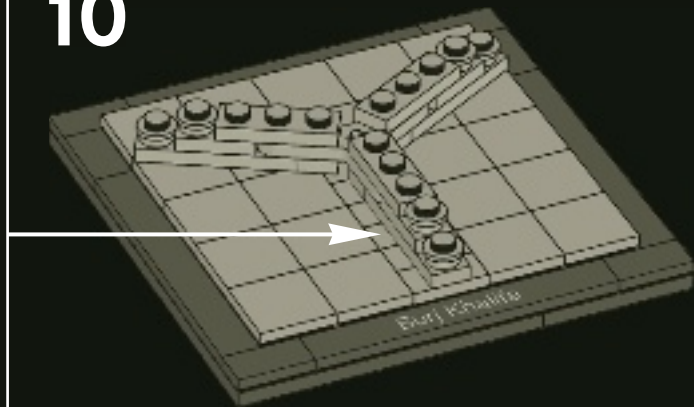


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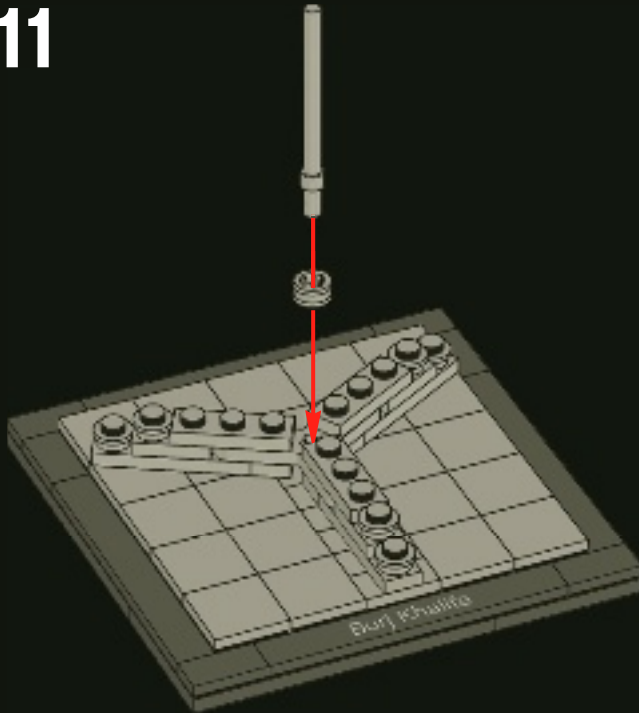


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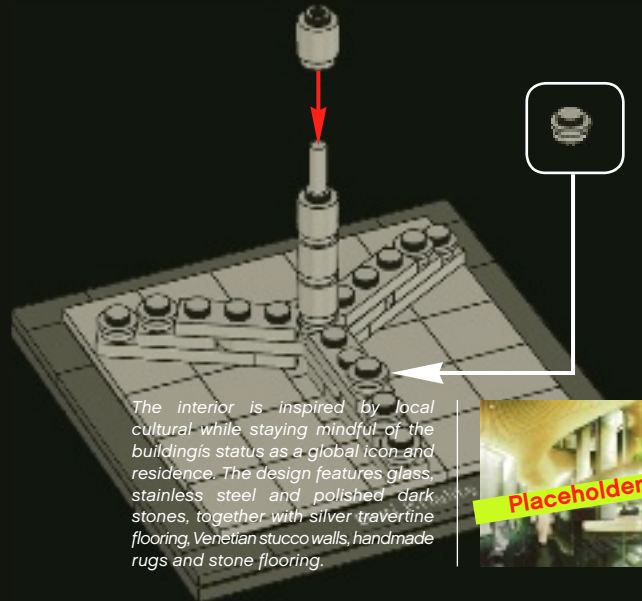


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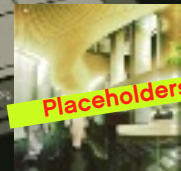


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12



The interior is inspired by local cultural while staying mindful of the building's status as a global icon and residence. The design features glass, stainless steel and polished dark stones, together with silver travertine flooring, Venetian stucco walls, handmade rugs and stone flooring.



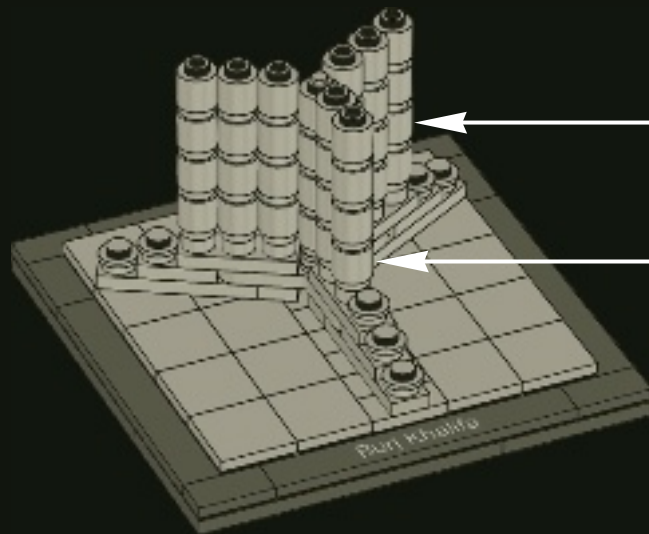


32x



8x

13



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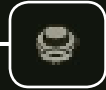
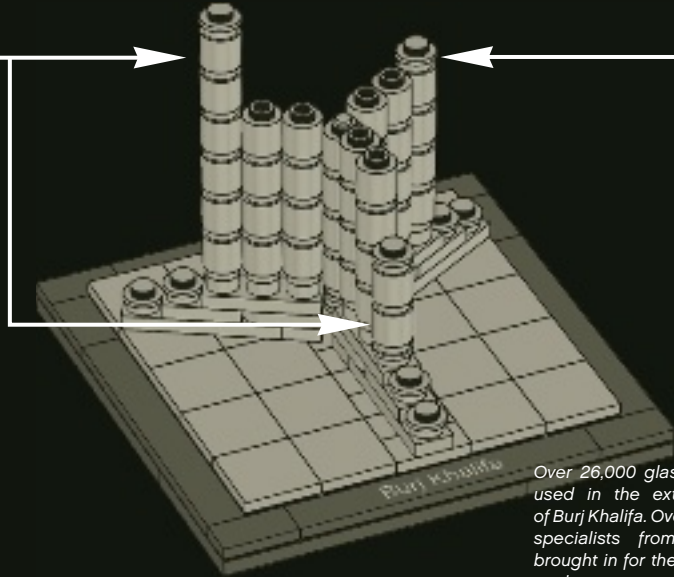
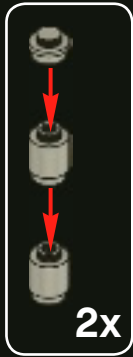


4x



3x

14



Over 26,000 glass panels were used in the exterior cladding of Burj Khalifa. Over 300 cladding specialists from China were brought in for the cladding work on the tower.



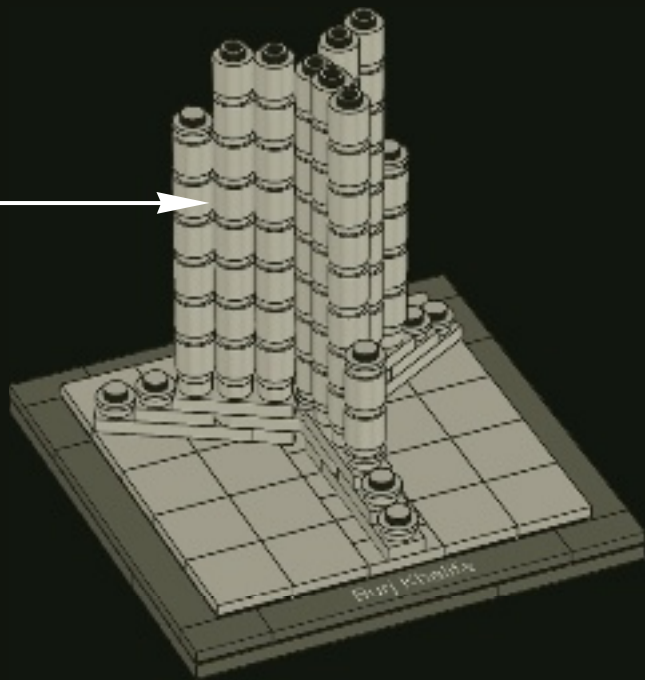


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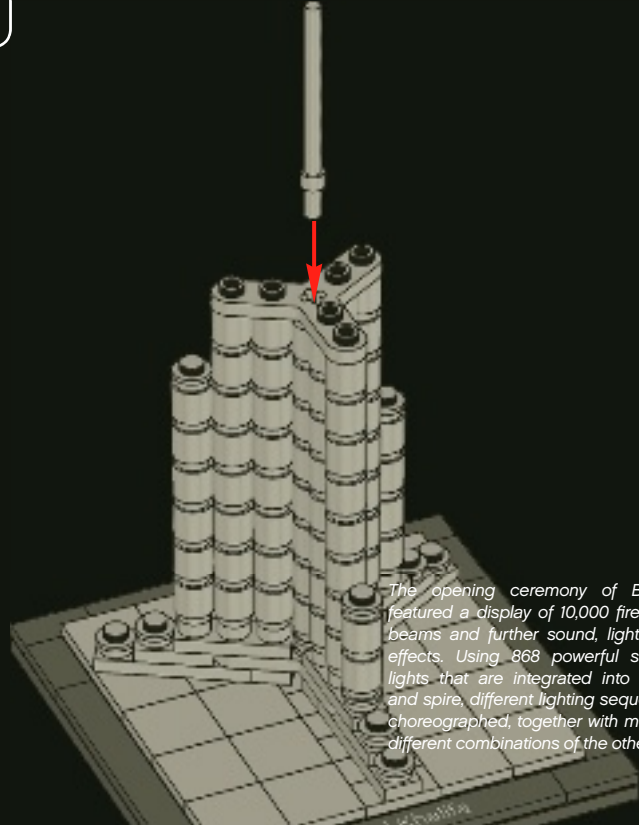


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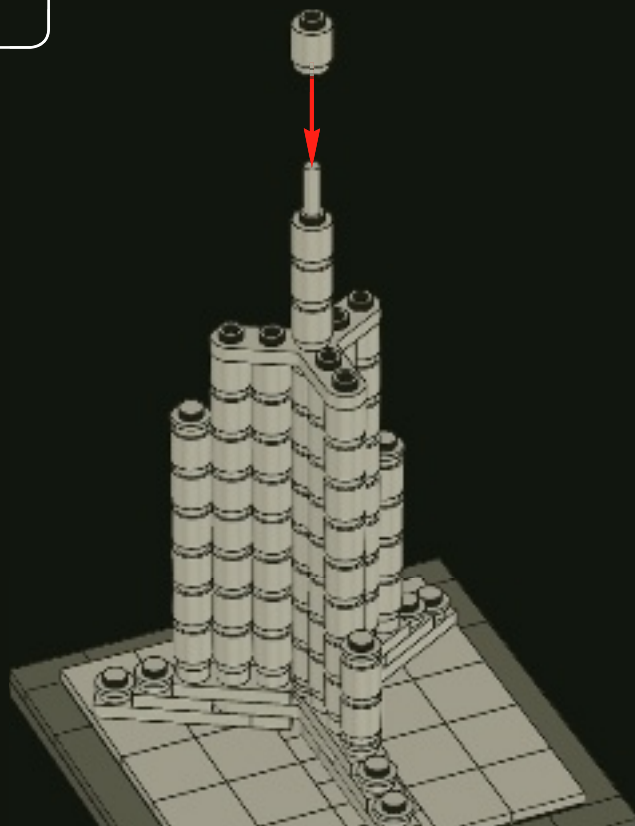
The opening ceremony of Burj Khalifa featured a display of 10,000 fireworks, light beams and further sound, light and water effects. Using 868 powerful stroboscope lights that are integrated into the facade and spire, different lighting sequences were choreographed, together with more than 50 different combinations of the other effects.





4x

17



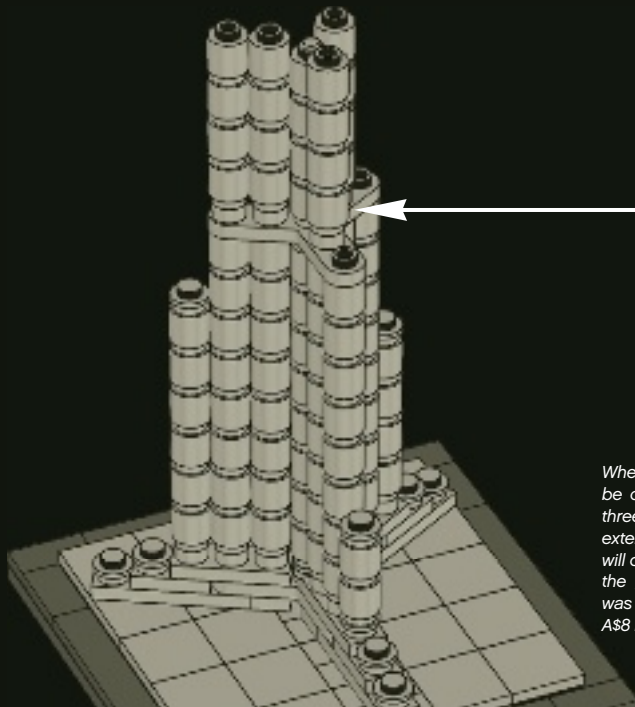


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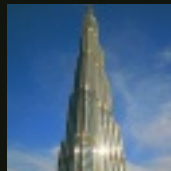
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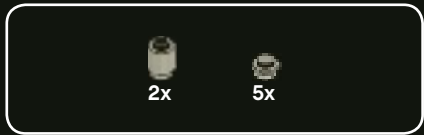
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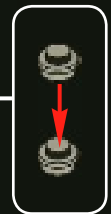
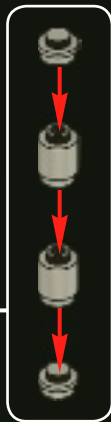
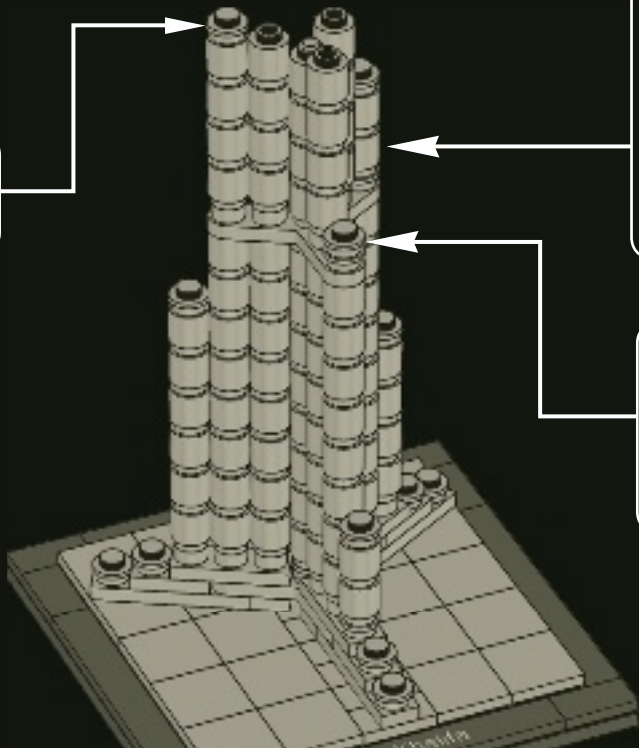
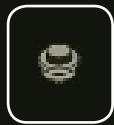
4x

When all building maintenance units will be operational, it will take 36 workers three to four months to clean the entire exterior facade. Unmanned machines will clean the top 27 additional tiers and the glass spire. The cleaning system was developed in Australia at a cost of A\$8 million.





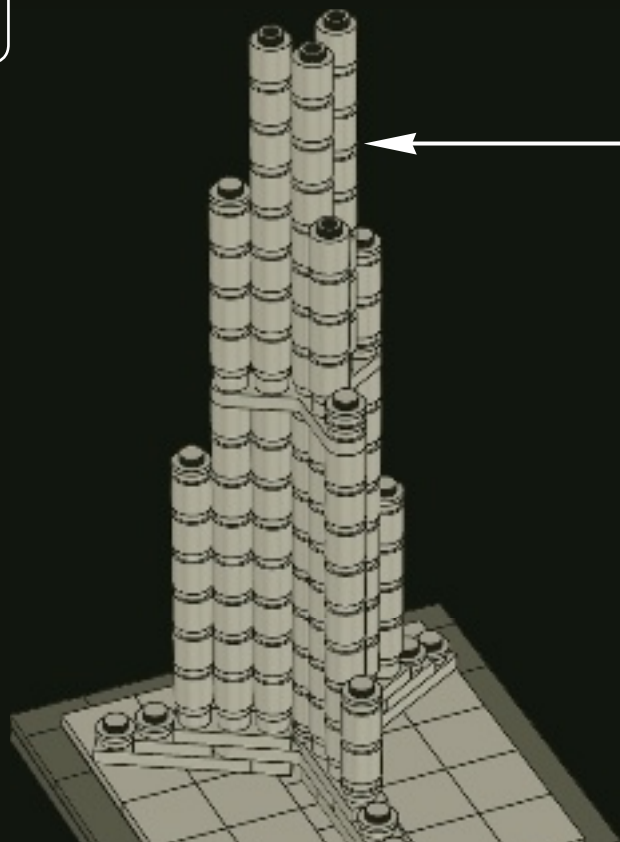
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12x

20



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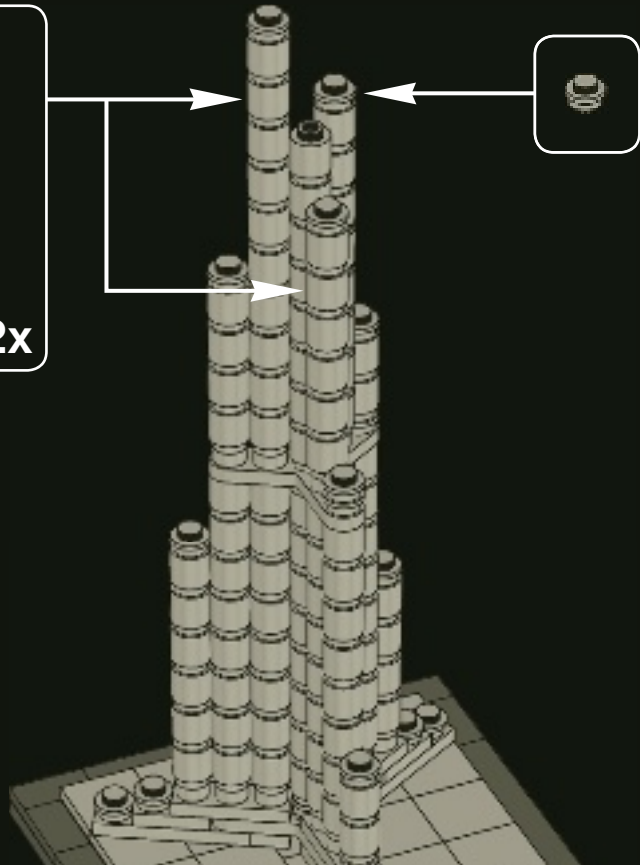


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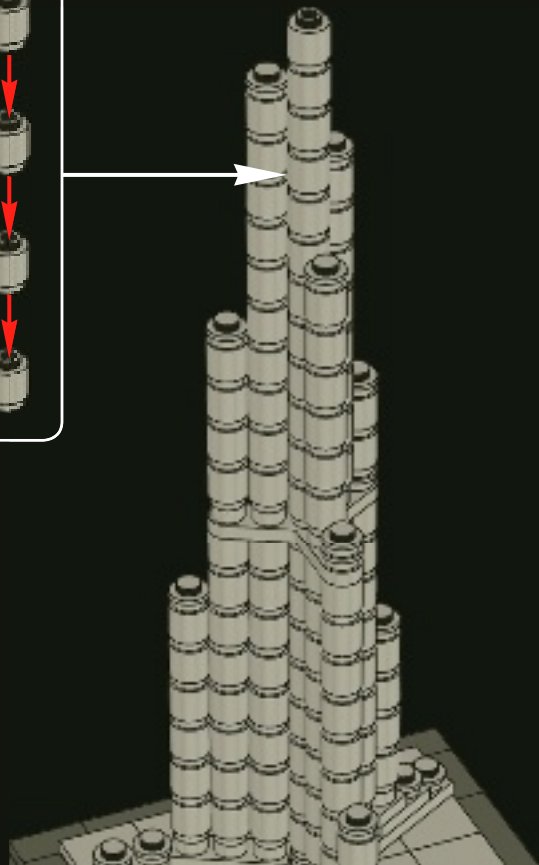
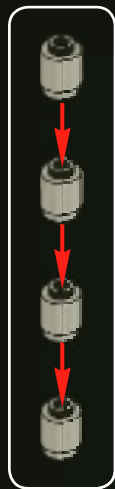
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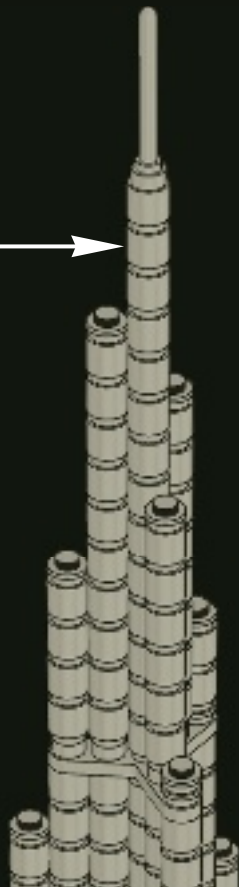
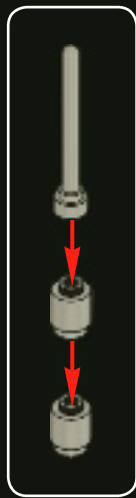


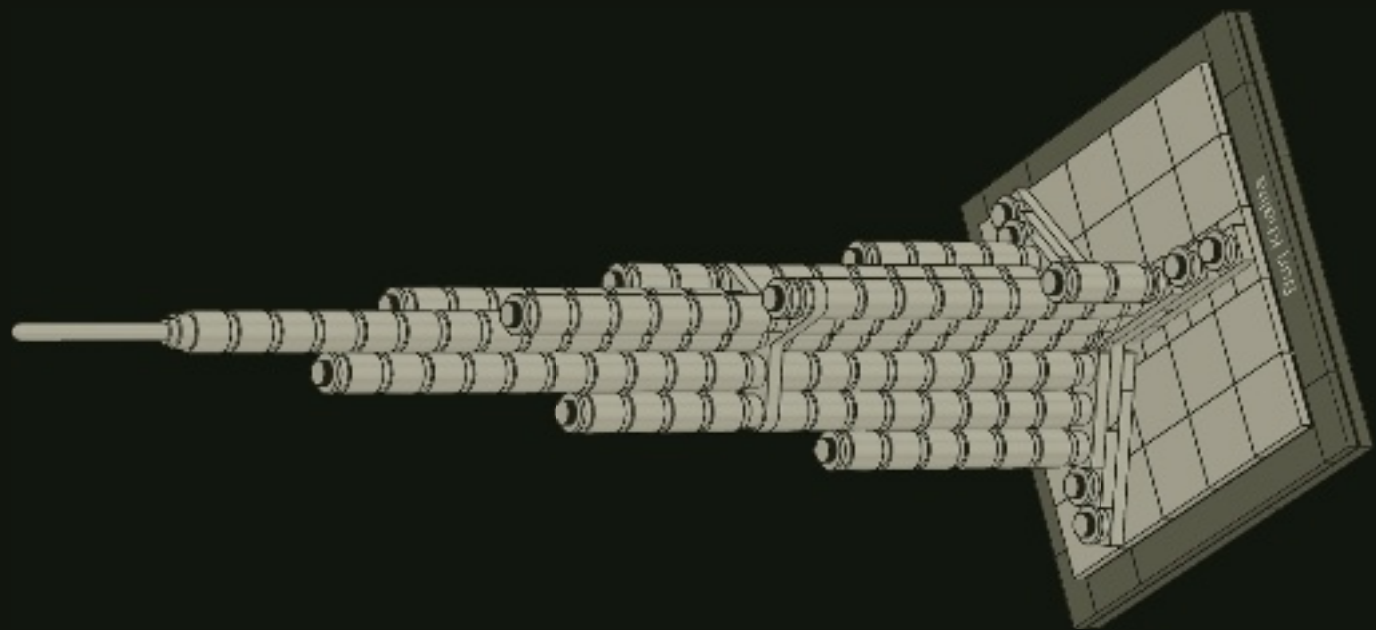
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23





A Word from the Artist

As an Architectural Artist my desire is to capture the essence of a particular architectural landmark into its pure sculptural form. I first and foremost do not view my models as literal replicas, but rather my own artistic interpretations through the use of LEGO® bricks as a medium. The LEGO brick is not initially thought of as a material typically used in creating art or used as an artist's medium. I quickly discovered the LEGO brick was lending itself as naturally to my applications as paint to a painter or metal to a blacksmith. As I explore how to capture these buildings with the basic shapes of the bricks and plates, I find the possibilities and challenges they offer almost magical.

Burj Khalifa

This model has two unique details surrounding its launch. It is the first International model to be showcased in the LEGO Architecture line and it is also the latest skyscraper since the Seattle Space Needle in continuing the Landmark theme. In terms of design challenges this model really only had a few. As impressive as the real structure is, when captured in its

smaller LEGO form the only discernable form is its 3-spoke geometry. Y-shapes & triangular shapes can be tricky to construct using square bricks. However, in this case the use of a single Technic 3-bladed rotor propeller establishes the basis of the entire model. From there I was able to have 9 points and 1 in the central core totaling 10 nodes from which to build upward vertically, while expanding the propeller to add 2 downward vertical points from each blade totaling an additional 6 nodes. So, that single propeller piece anchors all 16 radial nodes and thus capturing the essence of the entire design.



– Adam Reed Tucker



“Architecture — a wonderful game”

This was the title, or rather a paraphrase of the French title (“L’architecture est un jeu ... magnifique”) of a 1985 exhibition hosted by the Pompidou Centre in Paris, where 30 young European architects were given the opportunity to play with the famous Danish LEGO® bricks. The original idea was actually Dutch, Rotterdam’s Kunststichting arranging a small event the previous year where ten local architects were let loose on a large number of LEGO bricks. Such was the success of this first initiative that the Pompidou Centre decided to expand the idea to include 30 young aspiring architects from across Europe—their goal: to each draw an imaginary villa which would then, brick by brick, be built at LEGO HQ in Billund.

During the event, many a quotation was used from the history of architecture. For example, the Italian Renaissance architect Palladio was quoted alongside modernists such as Mies van der Rohe and Gerit Rietveld, the quotes relating to architectural projects from oil platforms to romantic ruins. It was a case of “no holds



barred” and even though some of the projects produced by the 30 talents ended in weird and wonderful pseudo-philosophical comments on opportunities, or rather the lack of same in the Eighties, it was all, nevertheless, a wonderful game.

Construction Highlights

Over 45,000 m³ (58,900 cu yd) of concrete, weighing more than 110,000 tonnes were used to construct the concrete and steel foundation, which features 192 piles buried more than 50 m (164 ft) deep. Burj Khalifa's construction will have used 330,000 m³ (431,600 cu yd) of concrete and 39,000 tonnes (43,000 ST; 38,000 LT) of steel rebar, and construction will have taken 22 million man-hours.

In November, 2007, the highly reinforced concrete corewalls were pumped using 80 MPa concrete from ground level; a vertical height of 601 metres. Smashing the previous pumping record on a building of 470m on the Taipei 101; the world's second tallest tower and the previous world record for vertical pumping of 532 metres for an extension to the Riva del Garda Hydroelectric Power Plant in 1994. The concrete pressure during pumping to this level was nearly 200 bars.

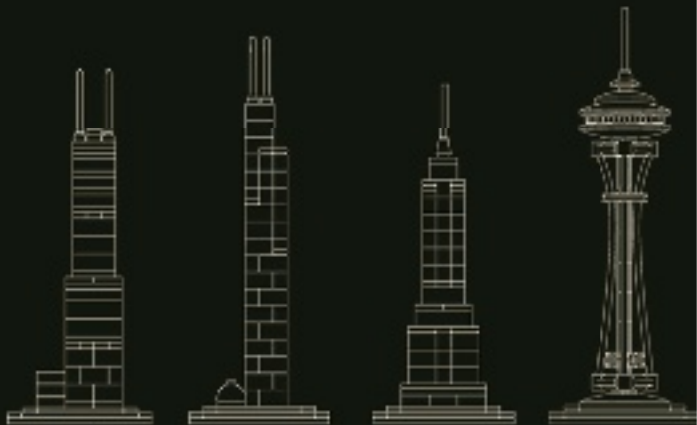
The tower accomplished a world record for the highest installation of an aluminium and glass façade, at a height of 512 metres. The total weight of aluminium used on Burj

Dubai is equivalent to that of five A380 aircraft and the total length of stainless steel bull nose fins is 293 times the height of Eiffel Tower in Paris.

The amount of rebar used for the tower is 31,400 metric tons – laid end to end this would extend over a quarter of the way around the world.

Exterior cladding of Burj Khalifa began in May 2007 and was completed in September 2009. The vast project involved more than 380 skilled engineers and on-site technicians. At the initial stage of installation, the team progressed at the rate of about 20 to 30 panels per day and eventually achieved as many as 175 panels per day.





1x
302201



6x
306926



1x
4243819



3x
416226



1x
4638309



4x
303526



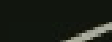
4x
4211404



2x
4262978



13x
4211473



2x
4538098



3x
4211445



3x
4211429



22x
4211413



5x
4211451



112x
4211412



3x
4211399



3x
4211398



1x
4211414



18x
4211525



1x
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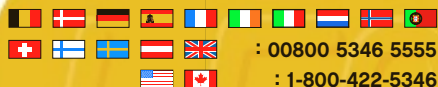
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