They dominate our skylines, and reflect our hopes and dreams — not to mention our egos. As **Chris Wright** reports, when it comes to the future, the next generation of skyscrapers will, quite literally,

# REACH FOR THE SKY

BURJ KHALIFA IS STUNNINGLY JUXTAPOSED WITH THE SPRAWLING CITY OF DUBAI

COURTESY OF ADRIAN SMITH + GORDON GILL ARCHITECTURE; PHOTO BY JAMES STEINKAMP

IT TOOK GUTS AND DARING TO BE A CONSTRUCTION WORKER IN NEW YORK CITY IN 1950 — WALKS ALONG GIRDERS HIGH UP OVER THE SIDEWALK WITH NOTHING TO BREAK A FALL WAS A FACT OF LIFE

PHOTO: GETTY IMAGES

In 1987, a young architecture student named Timothy Johnson, an undergraduate at the University of Minnesota, visited Chicago, in the US state of Illinois, for the first time. He was overwhelmed by the mighty skyscrapers that rose, muscular, from the city floor — the Sears Tower, the John Hancock Center — and became both delighted and deflated. On his way back to the Midwest farmland where the tallest buildings were grain silos and water towers, he recalls he "was quite depressed, thinking I was born 100 years too late. Wouldn't it have been great to be in a city like Chicago at the turn of the century, when it was all being built — when the United States itself was being built?"

Then he went to Asia. "And then I realised — no, I was born at exactly the right time." Johnson went on to become a design partner for NBBJ, designing buildings including the Sail at Marina Bay in Singapore, one of the tallest residential towers in the world. He also became chairman of the Council on Tall Buildings and Urban Habitat, the leading source of information on supertall towers.

A glance at the council's data tells us that we are, without question, amid a golden age of skyscraper design and construction that is every bit as dramatic as 1930s New York, when the Chrysler and Empire State buildings created the world's most iconic skyline; or the 1970s, when the World Trade Center and Sears Tower (now the Willis Tower) traded world records.

### EMBODIMENT OF POETRY

When asked which building he admires most, Adrian Smith, the designer behind Burj Khalifa and co-founder of Adrian Smith + Gordon Gill Architecture, opts for the city where he works: Chicago, in the United States. "I admire the John Hancock Center in Chicago for its bold, strong statement, its simplicity and its adherence to the orthogonal character of the Chicago grid," he says. "To me, it represents the 'City of Big Shoulders' in the Carl Sandburg poem."

Last year alone, 88 buildings higher than 200 metres were completed, including 17 additions to the 100 tallest in the world. In 2010 Dubai's Burj Khalifa shattered the world record for tall buildings by over 300 metres; it is more than twice the height of the Empire State Building. And plans are well advanced for a building that will reach a kilometre into the sky.

Folly or function? The jury is out. Most architects can make a strong practical case for going tall, but there is no question that we do so too because it fires the imagination. "A supertall tower represents a meaningful step forward and a symbol of success and optimism for the future," says Adrian Smith, the man who designed both the Burj Khalifa and the tower that will take its record, the Kingdom Tower in Jeddah, Saudi Arabia. A busy man indeed, he is also responsible for Shanghai's Jin Mao Tower.

"We must always strive for greatness and find the means to attain it. If not, we will become irrelevant," says Smith. "If cities don't continue to build and improve their conditions, they will die," he says. "When we lose the spirit to reach for glory, we lose our soul."

## LOOKING BACK

So how did we get here? One can make a case for numerous structures as the first skyscraper, all the way back to the Pyramids of Giza, in Egypt. A man called Imhotep, who 4,500 years ago realised that a thick, strong base was essential to building tall — hence the pyramids — is sometimes described as the first structural engineer. Various Chinese pagodas and Gothic French cathedrals also fit into the tradition. "For all of recorded history, mankind's fascination with structures that rise towards the sky has been constant," writes Kate Ascher in *The Heights: Anatomy of a Skyscraper*.

But if we take as part of our definition that skyscrapers are commercial objects, designed to foster commerce and to make money in their own right, rather than just being tall structures, then our story really starts in America — more specifically, Chicago and New York in the 1880s.

TAIPEI 101, WITH ITS IMPRESSIVE ENGINEERING, IS ESTIMATED TO HAVE COST US$1.76 BILLION TO BUILD. IN COMPARISON, BURJ KHALIFA COST US$1.5 BILLION

That's where the prompt to build high came from. Businesses in both cities were getting bigger but needed their offices to be downtown. Since land was scarce, and land values rising, it made sense to go upwards, if only to cover the costs. In Chicago, the need was particularly acute since much of the downtown area was levelled by fire in 1871.

At the same time, technology began to allow people to go upwards more efficiently. If all you do is build high with masonry, your walls have to get thicker and thicker until the lower floors have less and less space, defeating the point. But then came the internal metal skeleton, with cast iron columns within masonry walls. This enabled walls of tall buildings to be thinner, and therefore allowed for more space for commercial use, as well as greater natural light penetration. It is widely accepted that the first building to use this on any meaningful scale was the Home Insurance Building in Chicago, designed by William LeBaron Jenney and built in 1884.

With new buildings came new innovations. The first to be built exclusively on a steel skeleton was the Tower Building in New York. Possibly the first with a frame designed to counteract sway was the Manhattan Building, which oddly, is in Chicago. Next came the first to be built on steel beam-based cages: the Flatiron Building in New York (*pictured right*), still one of the city's iconic sights for its odd shape, alongside the diagonal rise of Broadway. Then Chicago rather ceded the race to New York when an 1893 law limited the height of downtown buildings to 40 metres, roughly 10 floors.

So New York took the torch — and how it ran with it. The turn of the century to the 1930s was one of the true golden eras of construction, and the names of its buildings still stir the soul today: the Singer Building, the MetLife Building, the Woolworth Building, the Bank of Manhattan, the glorious Chrysler Building, and finally in 1931, the almighty Empire State Building. At 102 floors and over 380 metres high, with more than 260,000 square metres of office space, it remains one of New York's top draws, and was the tallest building in the world for 41 years.

## *IF WE DEFINE SKYSCRAPERS AS COMMERCIAL OBJECTS, THEN OUR STORY REALLY STARTS IN AMERICA — MORE SPECIFICALLY, CHICAGO AND NEW YORK IN THE 1880s*

The era also coincided with the mass production of steel. The price of steel dropped from US$167 per tonne in 1867, to US$24 per tonne in 1895, allowing it to replace cast iron as the backbone of new buildings. On top of that, inventions that allowed for safer and more efficient elevators made skyscrapers more practical, particularly when hydraulic power replaced steam. Even Edison's light bulb, and the wider availability of electricity, played a role. "The modern skyscraper was very much a product of the Industrial Revolution — and of a myriad of its most transformative inventions," writes Ascher.

**TOP LEFT:** WORKERS BUILD THE FRAME OF BANK OF MANHATTAN TRUST BUILDING, WORLD'S TALLEST BEFORE THE CHRYSLER AND EMPIRE STATE *(LEFT)* BUILDINGS WENT UP
**OPPOSITE:** THE FLATIRON BUILDING IN NEW YORK CITY

**PHOTOS:** GETTY IMAGES (CONSTRUCTION); AGEFOTOSTOCK (FLATIRON BUILDING); ERIC MAYVILLE (EMPIRE STATE BUILDING)





## FROM THE GROUND UP

Start with a big hole. No, seriously: there's a lot of science in this, first with the blasting and excavation — which may require the underpinning of neighbouring buildings first — and then with a process called sheeting and bracing, which means securing the perimeter so that the sides of the hole don't fall in. One consequence of the destruction of the World Trade Center in New York, United States, was that people saw this usually invisible part of the process: the so-called "bathtub", a diaphragm wall built to ensure that the surrounding earth, and ultimately the Hudson river, did not slide into the site. The "bathtub" survived the destruction of the buildings and is still there beneath the new towers and monument.

Piers, caissons and piles refer to foundations that link the base of the building to the bedrock beneath, which can be a long way down. The foundations of the PETRONAS Twin Towers, built on a concrete mat deep beneath the ground, go down as far as 120 metres.

With foundations complete, structural steel is raised, followed by the pouring of concrete slabs, fireproofing, and then curtain wall installation. Designs vary; tall towers today often use a relatively small number of columns, attached to high-strength concrete cores by big outrigger arms that stretch horizontally across the building. The columns are attached to one another by belt walls which encircle the perimeter of the building. This was the approach with Taipei 101 in Taiwan, for example.

Ever wondered how the glass stays on? Unitised glass panels — those that have been assembled and glazed in a factory — are shipped to the site fully assembled, and lifted by crane. Workers guide each panel into place, then hang it from brackets installed on the building. They are then bolted into place, and the joins sealed with silicone, caulking or gaskets.

Once the curtain wall is up on a particular floor, mechanical plant installation begins. Once the building is "topped out", meaning it reaches final structural height, then roofing installation begins. Traditionally, topping out is a cause for celebration, with the final beam often accompanied by a fir tree or a flag. Often the final beam is painted white and signed by all the workers involved. Sometimes owners, dignitaries and people who will use the building get to make their mark too. Next come the elevators (this may have started already on lower floors), and finally tenant fit-out.

Construction management is no mean feat. Dozens of different subcontractors can be involved on just one project. It is a sign of their efficiency that businesses can move in well before the entire building is complete — at the International Commerce Centre, Hong Kong's tallest building, bankers at Morgan Stanley were already doing deals on the lower floors while there were still bits of steel and glass poking naked out of the top of the tower. As a result, the building was already drawing rentals before it was even close to structural completion.

WHILE THE MIDDLE EAST WILL CONTINUE TO PLAY A LARGE PART IN THE HIGH-RISE INDUSTRY, ESPECIALLY WITH THE MUCH ANTICIPATED KINGDOM TOWER *(ARTIST'S IMPRESSION PICTURED)*, CHINA'S CITIES SUCH AS SHANGHAI *(OPPOSITE)*, WILL ALSO CONTINUE TO BUILD HIGH

IMAGES: JEDDAH ECONOMIC COMPANY/ADRIAN SMITH + GORDON GILL ARCHITECTURE (KINGDOM TOWER); CORBIS (WORKER); LIBRARY OF CONGRESS, PRINTS & PHOTOGRAPHS DIVISION (SINGER BUILDING)

**WHAT'S YOUR FAVOURITE?**

NBBJ's Timothy Johnson nominates three, including one of Adrian Smith's designs, the Pearl River Tower in Guangzhou. The building fits in with his ethos of sustainability, thanks to its many innovative green elements: "It is one of the clearest examples of how the drivers in society today can form a building." Johnson also nominates the HSBC headquarters in Hong Kong. "Turning the building inside out, what an amazing way to look at the building." He also likes Frankfurt's Commerzbank Tower, with sky gardens on nine levels.

used when the Woolworth Building opened almost a century ago in 1913, and still commonly used today — the sky really was the limit.

This was an era of Art Deco style, and bold corporate shenanigans. When the Chrysler went up in 1930, its fabulous spire was built in secret, and raised from within the building in order to make sure that the Bank of Manhattan, being built at the same time, would not be taller. By 1930, practically all of the 100 tallest buildings in the world were in North America, with just one exception in São Paulo, Brazil.

Take a look at a photo from that period. Flat-capped construction workers in vests perch nonchalantly on beams that reach out into the sky, armed with a cigarette and a hip flask instead of a harness. To look at these pictures is to see a city being built: not just its steel and cladding, but its very soul.

Yet nothing lasts forever. Next came the Depression (the Empire State would remain largely untenanted for years) and World War II. The imperative to go tall would not return for decades. By the time it did, new technologies like the glass curtain wall — cheaper, lighter, and allowing better working conditions — had made new ideas possible. A key architect in the late 1960s, when interest was returning to tall buildings, was Fazlur Khan of Chicago's Skidmore, Owings and Merrill. His innovation of a tubed support structure,

***THIS WAS AN ERA OF ART DECO STYLE AND BOLD CORPORATE SHENIGANS. WHEN THE CHRYSLER WENT UP IN 1930, ITS FABULOUS SPIRE WAS BUILT IN SECRET AND RAISED FROM WITHIN***

where instead of steel columns a tall building would be made of several load-bearing tubes, was the method used in both New York's World Trade Center — the new world's tallest in 1972 — and the Sears Tower in Chicago, which took the title in 1974, and would not give it up until more than 20 years later (with some acrimony).

It was to be a brief renaissance. The oil crisis in the 1970s stopped tall buildings in their tracks once again, and this time when they returned to the fray, the centre of the action would move to Asia, and then to the Middle East. This transition happened quickly — 30 years ago, the United States was the only place that mattered in a discussion of tall buildings. Today, only one American building makes the global top 10 (the Willis Tower, in eighth place) and only three make the top 20. By 2020, there will be only one in the entire western hemisphere that makes the top 20. And it's not even built yet: the new One World Trade Center in New York.

First, the PETRONAS Twin Towers in Kuala Lumpur, Malaysia, took, by some definitions, the world's tallest title (*see box on page 62*), before Taipei 101 in Taiwan claimed it in 2004, the first building to pass 500 metres in height. Then all debates about tall structures, whether buildings, masts or towers, were comprehensively ended by the extraordinary scale of Burj Khalifa in Dubai. At 828 metres and 163 floors, it was 320 metres taller (an entire Chrysler Building) than Taipei 101 .

## LOOKING AHEAD

The future is already out there, as written up in a glossy brochure. The Kingdom Tower will be the centrepiece of the US$20 billion Kingdom City development in Jeddah, Saudi Arabia. The claim is that it will be "over

# BUILDING TALL THROUGH THE YEARS

**1871**
FIRE DEVASTATES DOWNTOWN CHICAGO, MAKING OFFICE SPACE SCARCE — AND PROMPTING DEVELOPERS TO BUILD UPWARDS

**1870s**
DEVELOPMENT OF SAFETY FEATURES IN PASSENGER ELEVATORS AND OF INTERNAL STEEL SKELETONS IN BUILDINGS MAKE TALLER STRUCTURES FEASIBLE

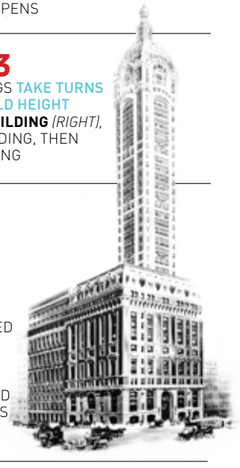
**1884**
HOME INSURANCE BUILDING, BUILT IN CHICAGO, IS WHAT MANY CONSIDER THE FIRST SKYSCRAPER

**1893**
A CHANGE OF LAW IN CHICAGO LIMITS THE HEIGHT OF DOWNTOWN BUILDINGS TO 40 METRES, CEDING THE SKYSCRAPER RACE TO NEW YORK

**1903**
THE FLATIRON BUILDING, A STEEL SKELETON PIONEER AND STILL AN ICON IN NEW YORK CITY TODAY, OFFICIALLY OPENS

**1908–1913**
NEW YORK BUILDINGS TAKE TURNS TO BREAK THE WORLD HEIGHT RECORD: **SINGER BUILDING** *(RIGHT)*, THEN METLIFE BUILDING, THEN WOOLWORTH BUILDING

**1916**
THE BLOCKY AND UGLY EQUITABLE BUILDING LEADS TO THE BUILDING ZONE RESOLUTION, ALLOWING UNLIMITED HEIGHT BUT ONLY OVER A QUARTER OF THE LOT. THIS GIVES RISE TO THE TAPERED SHAPE OF BUILDINGS THAT FOLLOW



## BUILDING TALL THROUGH THE YEARS

**1930–1931**
NEW YORK'S GOLDEN AGE. BANK OF MANHATTAN TRUST BECOMES WORLD'S TALLEST FOR ONE MONTH, BEFORE BEING BEATEN BY THE CHRYSLER BUILDING *(ABOVE)*, WHICH IS THEN DEFEATED IN TURN THE FOLLOWING YEAR BY THE EMPIRE STATE. THE EMPIRE STATE BUILDING WILL HOLD THIS RECORD FOR 41 YEARS

**1972**
WORLD TRADE CENTER IN NEW YORK BECOMES WORLD'S TALLEST BUILDING

**1974**
RECORD RETURNS TO CHICAGO WITH SEARS TOWER *(BELOW)*, BUT THE SUBSEQUENT OIL CRISIS ENDS THE AMERICAN ERA OF TALLEST BUILDINGS

**1998**
IMPETUS TO BUILD TALL MOVES TO ASIA, WHERE KUALA LUMPUR'S PETRONAS TWIN TOWERS TAKE THE RECORD, BY SOME DEFINITIONS. OTHER TOWERS RISE IN HONG KONG AND SHANGHAI

**2001**
TWIN TOWERS OF WORLD TRADE CENTER, NEW YORK, ARE DESTROYED

**2004**
TAIPEI 101 IN TAIWAN BECOMES WORLD'S TALLEST BUILDING

**2007–2010**
SHANGHAI WORLD FINANCIAL CENTER AND HONG KONG'S INTERNATIONAL COMMERCE CENTRE PUT GREATER CHINA IN THE LEAD WHEN IT COMES TO BUILDING TALL. HOWEVER, THE MIDDLE EAST QUICKLY OVERTAKES EVERYONE IN THE RACE. IN 2010, BURJ KHALIFA SMASHES EVERY HEIGHT RECORD FOR ANY KIND OF STRUCTURE

1,000 metres", according to architects, with a total construction area of 53,000 square metres, housing a luxury hotel, offices, condos, apartments and the world's highest observatory. The tower, the architects say, "evokes a bundle of leaves shooting up from the ground — a burst of new life that heralds more growth all around it. The sleek, streamlined form of the tower was inspired by the folded fronds of young desert plant growth."

A kilometre? Upwards? The first question one always puts to architects is, just how high can you go?

"We had an opportunity a few years ago to design a building where the client's requirement was that it was at least a mile and a half (2.4 kilometres)

Structurally, the big issue is wind resistance. Wind vortices build up vertically around buildings, which can have several knock-on effects. They can cause lateral movement, which can move the building uncomfortably for occupants, and can cause wind effects on the ground that are problematic for pedestrians. "To combat this problem, we look for ways to confuse the wind, as we say," says Smith. Wind tunnels make it possible to test structures very specifically and to tweak them to best effect. "With Burj Khalifa, we addressed the problem by developing a stepped pattern of setbacks. With Kingdom Tower, we sloped the building, meaning each floor plate is slightly smaller than the one directly below it."

***WHY BUILD HIGH? "TO PUSH HUMAN INGENUITY, TO SEE HOW FAR WE CAN GO. WE SEND SPACE SHUTTLES INTO FLIGHT, WE SMASH ATOMS APART, WHY CAN'T WE DO THAT?"***

tall," says Johnson, chairman of the Council on Tall Buildings and Urban Habitat. "We asked the question, why would you do that? The response was: we want to push human ingenuity. We want to see how far we can go. We send space shuttles into flight, we smash atoms apart, why can't we do that?"

Nevertheless, there are practical limits along the way. Smith, the architect behind the Burj Khalifa, says that he is often asked, "how tall can you go?" The most common specific question is, whether it is possible to build a mile-high tower (that's around 1.6 kilometres tall). Not surprisingly, he has carefully investigated the issue: "The biggest challenge for a building of that height is the issue of elevators," he says. "To get to the top, you'd have to transfer from one elevator to another at least two or three times, if not more. Which would be extremely time-consuming. So that would be a significant limiting factor, and will have to be addressed by advances in elevator technology before a mile-high building is realistic."

Another challenge is the size of the base that is needed to support the structure. "Within the cavity of the building at the base would be a great deal of space, most of it nowhere near the perimeter of the building — that is, near windows. How would you use all that area? As a giant atrium?" says Smith. "And if you did, would it make economic sense?"

Many architects share the idea that meeting technical challenges is half the fun, and in some places these are more acute than others. When you are next in Taipei, don't miss the opportunity to visit the observation deck of Taipei 101, the world's second tallest building. The views are great — Taipei's surroundings are surprisingly hilly when you are up high — but the really fascinating bit is inside: a huge 660-tonne steel pendulum called a tuned mass damper, suspended from the 91st to 87th floors, designed to offset movements caused by strong winds or earthquakes. Elsewhere in the region, the PETRONAS Twin Towers in Kuala Lumpur have the world's deepest foundations, extending 120 metres down, to deal with the sharply sloping limestone bedrock beneath.

But it is noticeable that the limitations architects refer to on going higher are economic and practical. While it can be done, to do so would at this stage be inefficient. Which is is an important point. Architects are at pains to point out that, whatever trophy value cities take from tall buildings, practicality still has a vital role to play.

While Johnson calls himself a "tall building junkie", when speaking with *DCM*, he revises this to "city junkie". "I love urban environments. The density, the energy, the imperfect nature of a lot of things coming together at that scale," he says. He argues with exponentially rising populations, *(Continues on page 61)*

WHEN IT WAS FIRST COMPLETED, SHANGHAI'S JIN MAO TOWER WAS THE TALLEST BUILDING IN CHINA

IMAGES: GETTY IMAGES (CHRYSLER BUILDING); CORBIS (JIN MAO TOWER); AFP (ABRAJ AL BAIT TOWER)

## WHERE TO GO

Here are some of the world's tallest buildings, with some tips on how to visit them:

**TAIPEI 101**
**Taipei, Taiwan**
The ticket booth is on the fifth floor of the mall in the tower. The observatory includes an indoor section, with views across Taipei, and a smaller outdoor observatory higher up, as well as a chance to see the huge pendulum suspended in the upper floors, to dampen wind and earthquake movement.
*NT$400; 10am to 10pm daily*

**PETRONAS TWIN TOWERS**
**Kuala Lumpur, Malaysia**
Not the greatest arrangement. You often queue first thing in the morning, before being told to come back later in the day for your visit. The skybridge between the two towers is interesting, but the tour brings you to the lower level of the bridge, meaning you can't see much upwards.
*RM50; tickets on sale from 8.30am daily except on Monday*

**JIN MAO TOWER**
**Shanghai, China**
The 88th floor observation deck is a great spot, not just for the view outwards across Shanghai and to the neighbouring skyscrapers, but because of the view inside: 40 floors down into the atrium of the Grand Hyatt Hotel.
*CNY100; 8.30am to 10pm daily*

**BURJ KHALIFA**
**Dubai, United Arab Emirates**
You can either buy a ticket and be told when to come back, or pay four times as much for immediate entry to the world's highest observation deck (called At The Top), 124 floors up.
*AED100 for general admission, AED400 for immediate entry; 10am to 10pm Sunday to Wednesday, 10am to midnight Thursday to Saturday*

And here's one most people can't visit: **Abraj Al-Bait,** or the Mecca Royal Hotel Clock Tower, in Saudi Arabia, is said to have reached structural completion at 601 metres, making it the second tallest building in the world (and the tallest hotel, with the largest clock face, five times bigger than Big Ben) when it formally opens. But most of the world will never see it; the entire city of Mecca is off-limits to non-Muslims.

HEAVY FOG ROLLS IN FROM THE SEA, SHROUDING DUBAI IN MYSTERY. ITS HIGH-RISES ALMOST SEEM TO PEEK OUT OVER THE QUIET, TO THE DAWN

PHOTO: REUTERS

# THE FOUNDATION OF SUPERTALLS

## INTERVIEW WITH ADRIAN SMITH, THE AWARD-WINNING ARCHITECT BEHIND DUBAI'S BURJ KHALIFA, SHANGHAI'S JIN MAO TOWER, AND THE UPCOMING KINGDOM TOWER IN SAUDI ARABIA

**Why build tall?**
More than any other typology, the tall building can address the needs of the future while staying green. Skyscrapers can accommodate a large number of people on a small footprint of land. They also offer efficient vertical transportation systems.

Studies have shown that the denser an urban population, the lower the energy consumption per inhabitant for travel in cars. In fact, there is a direct relationship between the reduction of energy consumption through transportation, and the increase in building density. Furthermore, tall buildings offer significant economies of scale compared to similar amounts of housing constructed in low-rise form. You have to build one roof and one foundation, rather than the multiple roofs and foundations that a group of buildings with the same cumulative area would require.

**What sort of advantages do you capitalise on when designing a green building?**
Tall buildings — including supertall buildings, which I would define as those that contain 60 storeys or more — can take advantage of the faster wind speeds at higher altitudes and drive wind towards building-integrated turbines, to generate power. Because they are less likely to have shadows cast on them, high-rises also make efficient use of photovoltaic systems to absorb solar power. And deep foundations make them ideal for geothermal heating and radiant cooling systems.

**Aside from being greener, what does a supertall building express to you?**
Supertall towers can be a catalyst for growth and prosperity in cities around the world. People create such buildings for a number of reasons: in celebration of a place or people, to create a symbol for an organisation or individual, or to serve as a spark for future development. Landmark supertall buildings also generate publicity and spur economic development and tourism, as we have seen in Malaysia with the PETRONAS Twin Towers.

It established Kuala Lumpur as a tourist destination and enhanced its reputation as a location for business. It also showcased the attractive lifestyle of this part of the world and bolstered the country's economy. We are now seeing a similar effect in Dubai with Burj Khalifa, the world's tallest building, which I designed while at Skidmore, Owings and Merrill (SOM).

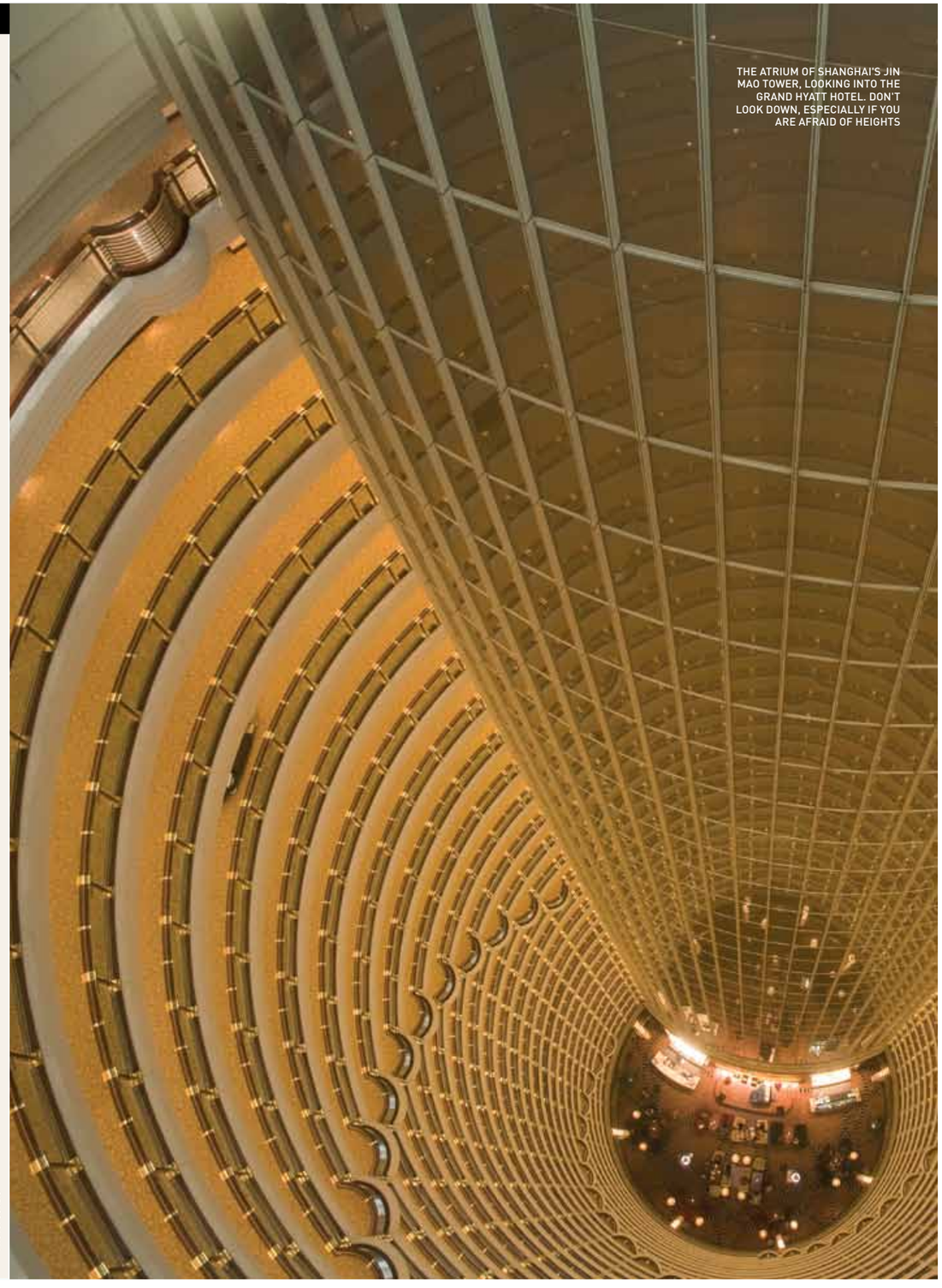
Economically, a very tall tower makes sense as the centrepiece of a larger development. The central tower can increase the value of the adjacent land and the buildings around it, making the overall project financially feasible. This was the concept with Burj Khalifa, where the tower itself made little or no profit, but increased the value and desirability of the land around it — making the overall development very profitable. In Shanghai, the Jin Mao Tower, which I also designed while at SOM, was a similar example.

**Do you learn along the way when you build new towers on this scale? What lessons were learned in the design, construction and operation of Burj Khalifa?**
With every new supertall that gets built — which actually happens more rarely than people think; a lot of supertall building projects get announced that never get built — we add about 10 percent to our body of knowledge of the typology. In the case of Burj Khalifa, it represents a step forward in sustainable design of very tall towers. The building has a great number of sustainable features, including a condensate recovery system that collects about 14 Olympic-sized pools of moisture annually for use in irrigation — very significant in a desert climate.

The design of Burj Khalifa will probably be most influential for its manipulation of form, as a means of addressing wind vortex action that builds up around supertall buildings and causes lateral movement near the top. We were able to reduce the build-up of wind vortices, making the building much more stable than many other supertalls.

**What advances in technology have enabled you to build taller buildings in recent years? Would a project like the Kingdom Tower have been feasible even 10 years ago?**
The advances in technology have been significant but incremental. Mostly they relate to the potential for making tall towers more sustainable, with the use of high-performance exterior wall systems and building-integrated photovoltaics and wind turbines, which are becoming less expensive, more available and more valued by clients.

That said, we're obviously pushing the limits of existing technologies with very tall buildings. The performance of the mechanical, electrical and plumbing systems in these buildings is state-of-the-art, resulting in considerable efficiencies over conventional systems. The high-performance exterior wall system maximises natural lighting while at the same time reducing solar heat gain. It features low-emissivity reflective glass that reduces heat gain as much as possible while at the same time providing the panoramic views that building occupants want. Where the glass is not needed for viewing, we use an insulated "shadowbox" panel that minimises heat gain and has essentially the same thermal performance as a stone panel.



THE ATRIUM OF SHANGHAI'S JIN MAO TOWER, LOOKING INTO THE GRAND HYATT HOTEL. DON'T LOOK DOWN, ESPECIALLY IF YOU ARE AFRAID OF HEIGHTS

PHOTO: CORBIS

*(Continued from page 56)* much of it in poverty, the density of accommodation that comes with high-rises is essential to supporting a reasonable quality of life. "How do we design for the people nobody's designing for? You hear the argument that any building over 60 storeys is just an inefficient ego trip. But if you put them in a collection to create a city and build an infrastructure that's more compact, that is far more sustainable than a suburban model."

City towers, he says, are certainly economically sustainable, otherwise they wouldn't be built. "We have a building in construction in Dalian, China that's almost 400 metres. And I can guarantee you the owner is not building it just for his ego," says Johnson. "It's going to make money." But this sense of social sustainability is important too, he says.

Likewise, Smith argues that tall buildings can "address the needs of the future while having the least environmental impact", especially in

***"YOU HEAR THE ARGUMENT THAT ANY BUILDING OVER 60 STOREYS IS AN INEFFICIENT EGO TRIP. BUT IF YOU CREATE A CITY MORE COMPACT, THAT'S FAR MORE SUSTAINABLE THAN A SUBURBAN MODEL"***

terms of efficient use of space. Skyscrapers are sustainable because they can house a large number of people on a small area of land. In addition, elevators are 40 times more energy-efficient than an average car, he says, and in general, high-rises create more walkable cities.

They also create a catalyst for growth. "PETRONAS Twin Towers made little economic sense and sat two-thirds empty for several years after completion," says Smith. "But the worldwide attention it brought to Kuala Lumpur and to PETRONAS as an oil and gas company was very significant." Burj Khalifa is doing the same in Dubai, he says. Also on this theme, Johnson insists there is an environmental opportunity in building tall. "The skin of a building needs to do more. It needs to create energy. Possibly it can grow things," he says. When he was looking at the mile-and-half-high project, Johnson was intrigued by the difference between the temperature on the ground floor — the building was in a desert — and the top of the tower. "We were working with an engineering firm to create a kind of loop that would allow the use of that difference to create energy. Also, the taller you go, there's more wind pressure. Why don't we harvest that wind?" Other ideas include

**ABOVE:** WHEN THEY FIRST ENTERED THE RACE FOR THE TITLE OF "WORLD'S TALLEST", THE PETRONAS TWIN TOWERS IN KUALA LUMPUR, MALAYSIA, DREW A LOT OF ATTENTION *(SEE SIDEBAR ON RIGHT)*

**IMAGES:** CORBIS (PETRONAS TWIN TOWERS); COUNCIL ON TALL BUILDINGS AND URBAN HABITAT (GRAPHIC)

### SUSTAINABLE BUILDING

The KfW Westarkade, in Frankfurt, won the Council on Tall Buildings and Urban Habitat's Best Tall Building Overall Award last year. It has been described as one of the world's most energy-efficient office buildings. Aside from that though, it also shows that practicality and aesthetics are not mutually exclusive. To quote the council, the KfW Westarkade "has been carefully integrated into its context, forming relationships with its neighbouring buildings, streets and parkland". And as a bonus, its colourful façade brightens up the cityscape.

using elevators' push-and-pull to create the energy they need to run. "Elevators use three to five percent of the energy of an office building. It's not huge. But you start with things like that," he says.

Some of these ideas are already in practice. Burj Khalifa has many green features, such as a system that collects condensation for irrigation. And architects are learning. "With every new supertall, we add about 10 percent to our body of knowledge," Smith says.

One sad postscript is that while towers going up are iconic, so too are towers being brought down. When al-Qaeda wanted to hit America with maximum loss of life and symbolism, it knew that bringing down New York's Twin Towers would give the most powerful possible message. Equally, the message of recovery and rebuilding, and rebuilding higher, is highly symbolic for New York.

September 11 raised safety issues, for sure. Smith says one lasting impact is the appearance of places of refuge every 20 floors in new tall towers, with a higher fire rating. And Johnson calls for greater study of fire situations in buildings, and more prescriptive fire codes in some parts of the world where people are building tall.

But Johnson adds: "I don't think we should be planning on designing buildings that can withstand a terrorist attack of someone with a plane-load of fuel flying into the side of a building. Our optimistic human life would be over at that point." ●

## THE RULES

In 1998, the PETRONAS Twin Towers in Kuala Lumpur became the world's tallest buildings. Or did they? Chicago's Sears Tower wasn't giving up the title without a fight, its backers pointing out that if the antennae on its roof were included, it retained the title. And furthermore, it had a higher occupied floor.

The dispute brought the Council on Tall Buildings and Urban Habitat to popular attention. This organisation is, among other things, the arbiter of rules on height. Indeed, there are actually three categories for height: height to architectural top, which includes spires but not antennae; highest occupied floor; and height to tip, including antennae, flagpoles or signs. Under these specifications, there were actually three tallest buildings in 1998: PETRONAS Twin Towers for category one, and the Sears Tower for category two. Category three was the tower of the World Trade Center, with antenna. Taipei 101 took the first two categories in 2004. All such argument was ended by Burj Khalifa, which didn't just wipe the floor with all competitor buildings but also beat all other things like towers and radio masts.

Timothy Johnson, chairman of the Council on Tall Buildings and Urban Habitat, says these rules matter. "There's a pride to it, a history of mankind to it. People ask, what is the tallest building? It's like, who is the fastest man or woman on the planet. It's a part of human achievement that everyone is interested in. That's why we do things like this. Otherwise we'd still be sleeping in caves and hunting tigers."

## LOOK TO THE FUTURE: TALLEST BUILDINGS OF 2020

The Council on Tall Buildings and Urban Habitat estimated late last year that by 2020, the world's tallest buildings would be ranked as below. In its report, the council suggested that instead of buildings being "tall" and "supertall", there should be a new designation of "megatall", for buildings over 600 metres in height, as these become much more common. The council predicts that China and the Middle East will continue to play a large part in the industry. So if you live in or near these areas, be prepared to be wowed within the next eight years.

- A **KINGDOM TOWER** | JEDDAH | 1,000 METRES
- B **BURJ KHALIFA** | DUBAI | 828 METRES
- C **PING AN FINANCE CENTER** | SHENZHEN | 660 METRES
- D **SEOUL LIGHT DMC TOWER** | SEOUL | 640 METRES
- E **SIGNATURE TOWER** | JAKARTA | 638 METRES
- F **SHANGHAI TOWER** | SHANGHAI | 632 METRES
- G **WUHAN GREENLAND CENTER** | HUBEI | 606 METRES
- H **MECCA ROYAL HOTEL CLOCK TOWER** | MECCA | 601 METRES
- I **GOLDIN FINANCE 117** | TIANJIN | 597 METRES
- J **LOTTE WORLD TOWER** | SEOUL | 555 METRES
- K **DOHA CONVENTION CENTER TOWER** | QATAR | 551 METRES
- L **ONE WORLD TRADE CENTER** | NEW YORK CITY | 541 METRES
- M **CHOW TAI FOOK CENTRE** | GUANGZHOU | 530 METRES
- N **CHOW TAI FOOK BINHAI CENTER** | TIANJIN | 530 METRES
- O **DALIAN GREENLAND CENTER** | DALIAN | 518 METRES
- P **PENTOMINIUM** | DUBAI | 516 METRES
- Q **BUSAN LOTTE TOWN TOWER** | SEOUL | 510 METRES
- R **TAIPEI 101** | TAIWAN | 508 METRES
- S **KAISA FENG LONG CENTRE** | SHENZHEN | 500 METRES
- T **SHANGHAI WORLD FINANCIAL CENTER** | SHANGHAI | 492 METRES

● MIDDLE EAST ● USA ● ASIA