WELCOME

We are in a global age of tall and super-tall buildings. It’s important to consider all of the implications.

Engineering is not just about science and technology, but experience. We have been designing iconic, efficient tall buildings for more than 50 years, and it’s that experience that makes us unique. Around the world, we are combining the latest tools and technologies with an in-depth understanding of how tall buildings behave to create the next generation of towers.

In this magazine, we discuss many of the engineering and architecture challenges, but also speak to architects, planners, developers and clients for a more complete overview of the requirements and economics of tall buildings and what they will mean for cities.

Many of these discussions took place in the WSP | Parsons Brinckerhoff host room at the 2015 Council for Tall Buildings and Urban Habitats conference in New York. We would like to thank everyone who spoke during the event, and the many attendees who came to join us over the two days. We have tried to distill the best of the content here – we hope you will find it interesting.

Ahmad Rahimian
Director of Building Structures, USA

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AS MORE AND MORE OF THE WORLD’S POPULATIONS MOVE TO CITIES, THOSE CITIES ARE EXPANDING EVER SKYWARDS. BUT THIS GENERATION OF TOWERS WILL BE NOTHING LIKE THE LAST. WE EXPLORE FIVE OF THE KEY TRENDS

THE RENAISSANCE OF TALL

As more and more of the world’s populations move to cities, those cities are expanding ever skywards. But this generation of towers will be nothing like the last. We explore five of the key trends.

The next golden age of skyscrapers is upon us. 2015 was a record-breaking year for high-rise completions, with 138 new buildings over 150m, but this will quickly be beaten by the 142 expected in 2016. The race is on to build high, with a frenzy equalling that of northern American cities in the 1920s. Except that, this time, it’s on a global scale. Between 1924 and 1934, 49 buildings over 150m in height were completed, all in the US. Between 2006 and 2016, there will be a total of 2296, with new towers on every continent.

This high-rise boom is intimately related to urbanisation. In 2014, more than half of the world’s population lived in urban areas, but by 2050, it is predicted to rise to two-thirds, with 2.5 billion new city dwellers – the equivalent of constructing five cities the size of Beijing every year until then. And with this growth comes an increasing share of the global economy: according to analyst McKinsey, 60% of global GDP is generated by the top 600 cities.

“We are living at the crossroads of two significant trends: urbanisation and climate change,” says David Cooper, president of buildings at WSP | Parsons Brinckerhoff. “Cities are responding by reaching for the sky, as a more sustainable forward path than continuing horizontal expansion.”

With so many new urban dwellers needing space to live and work, cities can either grow outwards or upwards, and they will inevitably have to do both. The advantage of vertical expansion is that it minimises the distances and travelling times between homes, jobs and essential amenities, and maximises the value of prime central sites.

But that’s not the whole story. Tall buildings also exert a powerful emotional force that familiarity seems to do little to diminish. Their sheer size in relation to the human scale and the views they afford from the top continue to inspire a sense of awe and wonder. They are a show of strength, demonstrating mastery of the elements, wealth and power. Expanding cities build landmarks to signal their ambition and communicate their arrival on the world stage. Established cities build them not to be outdone.

The symbolic role of high-rise buildings was demonstrated in the hours after the terrorist attacks on Paris in November 2015. As the lights of the Eiffel Tower were extinguished in mourning for the dead, world cities lit up their own landmarks with the colours of the Tricolore. The Auckland Sky Tower, One World Trade Center in New York, the Oriental Pearl Tower in Shanghai and Calgary Tower in Canada were among those glowing blue, white and red.

The current boom is not just producing taller versions of 20th-century towers, but breaks with the past in several important ways. A striking difference is where these new towers will be located. While urbanisation is a global trend, 90% of new urban dwellers will be living in Africa and Asia and more than a third in just three countries: China, India and Nigeria. Since 2000, China has built 43% of all the world’s new towers. On the other hand, India and Nigeria have barely started.

Then there’s the kind of towers being built. Before 2000, two-thirds were purely commercial. Since the turn of the millennium, just under half have been apartments or hotels, and a further 19% mixed-use. Iconic architecture, high-quality construction, pioneering structural systems and state-of-the-art mechanical and electrical services are revolutionising the concept of high-rise living. From our homes to the public services we use, to where we spend our leisure time, life is shifting from a predominantly horizontal plane to a much more vertical one. Over the following pages, we look at the features that will define the next generation of high-rise buildings.
A city’s skyline is its signature. But it’s what happens at street level that defines its soul. Previous generations of towers were predominantly places to work. They were hives of activity by day, and dark and silent by night, set in downtown areas that became ghost towns after working hours and at weekends. The new tower is a far more sociable place, buzzing well into the night, if not 24/7. It plays a more active role in the local community, and perhaps even functions as a community itself.

High-rise buildings are increasingly combining a mix of different kinds of space, at least some of it publicly accessible. The taller a building is, the more likely this is. According to the database of the Council for Tall Buildings and Urban Habitats, 17% of buildings over 150m are mixed-use. But this rises to nearly half of all super-tall towers over 300m, and three-quarters over 500m.

Mixed-use makes sense for economic reasons – there’s a lot of space to fill in a mega-tall tower and selling residential units can help to finance the rentable elements – and also practical ones, because higher floorplates tend to be smaller and so less suited to commercial use.

But it also makes sense because life in cities is changing. The new generation of workers are returning to urban areas, rejecting suburban lifestyles in favour of vibrant neighbourhoods with a range of amenities. Millennials already make up half of the US workforce, points out Andrew Cantor, vice president at Related, co-developer of the Hudson Yards regeneration scheme in New York. “By the time that it’s complete, they’ll make up 75%. They’re looking for a mixed-use experience in their neighbourhood. Millennials increasingly want a dense urban quarter with a real mix of uses – areas that are buzzing and active at all times, and where the lines between your office, your hotel, your restaurant or your residence are blurring.”

This blurring won’t just be a lifestyle choice, it will be a necessity, he adds. “As space becomes more and more precious, shared amenities that have a higher utilisation will be more important, compared to lots of individual amenity spaces or private spaces. Strategies that increase the utilisation of space will be important, whether that’s shared amenity spaces, hotel lobbies that serve as restaurants or office lobbies that serve as meeting areas.”

Older towers provided little at ground level beyond hostile, high-security entrances and high winds. Today, planners are demanding much more, and developers are increasingly aware of the value of a high-quality experience at ground level. Even pure commercial towers are likely to include some food and beverage or retail space at their base. Or they may be just one component of a more varied development, as at Hudson Yards, linked by a shared plaza or publicly accessible podium.

“IN OUR REKINDLED LOVE AFFAIR WITH SKYSCRAPERS AND THE CITY, WE NEED TO THINK ABOUT THE SPACES AND COMMUNITIES WE’RE CREATING AT GROUND LEVEL,” SAYS KEN McBRYDE, PRINCIPAL AT HASSELL IN SYDNEY. “THE SKYLINE OF A CITY IS PREDOMINANTLY AN ABSTRACT THING – IT EXISTS IN THE DIGITAL OR PHOTOGRAPHIC REALM BUT YOU NEVER ACTUALLY EXPERIENCE IT UNLESS YOU’RE IN A HELICOPTER. WE NEED TO ADDRESS THE CHALLENGE OF CREATING MEANINGFUL AND MEMORABLE PUBLIC DOMAINS, AS THAT’S WHAT WILL DETERMINE WHETHER THE BUILDING BECOMES AN IMPORTANT SOCIAL AND COMMERCIAL ASSET TO THE CITY.”
A high-rise building not only changes the skyline today, it also forms part of the legacy that we leave to future generations. Conventional real estate wisdom gives a commercial building a lifespan of around 30 years. But the sheer scale of high-rise structures and the quantity of materials and energy that go into them means they will be around for much, much longer, with lifespans measured not in decades but in centuries.

Super-tall and super-slicker buildings need to be extremely strong. Elements such as cladding or mechanical and electrical systems may be upgraded, but their immense structures are effectively permanent features of the urban landscape. In this way today’s state-of-the-art towers have more in common with medieval cathedrals than with their low-rise contemporaries. “In the history of the world, only four buildings taller than 150m have ever been demolished,” says Bill Price, director at WSP | Parsons Brinckerhoff in London. “For a large building in an urban setting, studies show that it will cost more to put it up. That means that when we’re thinking about something we want to use in ten years, we need to make sure towers can adapt to the start. But more immediately, they might eventually be demolished from the inside out.”

Price suggests that designers should think more carefully about how a building might eventually be demolished from the start. But more immediately, they need to make sure towers can adapt to change, and consider a range of interlinked technological, social and environmental factors that will impact on the built environment.

There are good commercial reasons for designing flexible spaces too. Office buildings need to be able to accommodate different occupier groups to make them as lettable as possible. Because corporations are increasingly seeking more locations that offer more diverse experience for their workers, they need to attract novelty-seeking millennials and to spur cross-disciplinary thinking and innovation.

One of the most significant challenges that all buildings will face in the relatively near future is the impact of climate change – a moving target as the century progresses. How will buildings and their surroundings be affected by much heavier rainfall or more frequent droughts, what will tomorrow’s most extreme events take on and how to maintain comfortable conditions for building occupants when average temperatures could be much higher than today?” The challenges that climate change will pose need to be considered in every building, but particularly those that will be around for a long time,” says David Symons, director of Environment & Energy at WSP | Parsons Brinckerhoff in the UK. “In 50 years, peak summer temperatures in London are forecast to be 6.5°C higher than they are today. By 2100, they could be around 10.5°C higher. Our research shows that today’s building design codes are wholly inadequate to address these future temperatures. Over 80% of Londoners already claim their flats are too hot in summer, with newer homes having more of a problem.”

To address hotter temperatures, mechanical and electrical engineers could design larger cooling systems. But that will create massive extra energy demand – for cities and for building owners. That’s challenging when energy prices are forecast to be about 50% higher in the UK by 2050. So energy bills will be much higher too.” The alternative is to use emerging techniques that use fresh air from outside and the thermal mass of buildings to maintain comfortable temperatures. “That becomes even more of an option in a future world which is anticipated to be purely electric. By 2050, some cities will all be electric for heating, for power, for travel. At a stroke, that transforms the air quality and reduces noise levels.” In temperate climates today, windows remain shut against the noise and pollution of city streets, and because buildings are designed to rely on air conditioning systems. “But why would you do that into the future? You could imagine a world in which there’s no reason not to open the windows.”

Driverless cars promise to change patterns of land use in cities too. “At the moment, quite large areas of valuable space are given over to car parking,” says Symons. “In the future, at the very least you could imagine high-rise parking spaces because the cars park themselves. At best, you don’t have car parking at all in the building – if you do drive yourself somewhere else and come to you when you need it.”

The ability to respond to fast-changing workplace trends is also key to maintaining the longer-term value of a building. Technology is already removing the need for large support spaces, points out Andrew Cantor, vice president at New York developer Related. “There will be no need for large file rooms or storage rooms as there has been in the past, and even servers have diminished in size as they have been moved off site into the cloud. So the amount of space each person needs to work is smaller and there’ll be more people on each floor, putting pressure on elevators and washrooms.”

The challenge is not just to size building systems for potentially greater loads but to keep structural elements as unobtrusive as possible, with no columns on the floorplates and floor-to-ceiling windows so that spaces can be reconfigured any way a tenant wants. “The same goes for residential towers – internal columns interrupt views and limit buyers’ options.”

The economic challenges of mega-tall towers mean that they may sometimes undergo drastic changes of use even when the design is well advanced – keeping building systems engineers on their toes. Now under construction, 52-Storey China Zun Tower in Beijing was originally planned as a mixed-use development providing 380,000m² of offices, hotel accommodation and serviced apartments. The biggest challenge for the services engineers was always reconciling the unique form of the building – flared at the base and the top – with the demand for services and vertical transportation created by its mix of uses. Then the decision was taken to convert the whole building to commercial space. “This dramatically increased vertical transportation requirements, but the construction was already fixed, so it wasn’t possible to make any changes to the available space in the core,” says Vincent Tia, managing director of building systems for WSP | Parsons Brinckerhoff in China. “Our solution was to add more sky lobbies, so there are now three double-deck spaces throughout the building.”

There are good commercial reasons for designing flexible spaces too. Office buildings need to be able to accommodate different occupier groups to make them as lettable as possible. Because corporations are increasingly seeking more locations that offer more diverse experience for their workers, they need to attract novelty-seeking millennials and to spur cross-disciplinary thinking and innovation.
Traffic congestion and pollution were almost defining characteristics of the 20th-century city. Urbanisation has been traditionally accompanied by an increase in car travel, choking roads and bringing movement to a near halt for significant portions of the day. The most valuable development sites were ones that could be easily reached by car from the suburbs and had ample room for parking.

As more and more people move to cities, the challenge of mobility is only becoming more acute. UN-HABITAT estimates that by 2050, city dwellers could travel three or four times as many passenger-kilometres as in the year 2000, and that freight movement could rise more than threefold over the same period. Without investment in sustainable alternatives to cars, the places where three-quarters of the world’s population live, work and play will be intolerable to function.

“Higher-density cities won’t work without investment in transport,” says Peter Weingarten, principal at Gensler. “As the world is getting flatter and there’s a war for talent, people will migrate like they’ve never migrated before. Cities that don’t have good infrastructure will lose out to places that do.”

One of the major themes of 21st-century urbanisation will be investment in systems such as metros, light rail and bus rapid transit, as city planners search for more sustainable ways to support growth. The population of a super- or mega-tall tower can easily rival that of a small city in itself, so it needs to be integrated closely into these networks. “Mass transit links are critical to successful high-rise development,” says Greg Kelly, president and CEO of WSP | Parsons Brinckerhoff in the US, Central & South America.

In many places, towers are being deliberately sited on top of or next to existing transport hubs, he notes, while investment in new infrastructure is creating opportunities for high-rise development. London’s Shard is right next to a major interchange for overground and underground trains and buses, while San Francisco’s future tallest building, the 524m Salesforce Tower, will be part of the new Transbay Transit Center complex. This includes more than 6 million ft² of office space, 4,400 homes, a hotel and retail space, as well as a 5.4-acre rooftop park.

Developers are also looking afresh at previously unappreciating sites close to transport hubs. Areas that were once lighted by their proximity to rail lines or left as underused expanses of industrial space are now prime opportunities for high-rise development. They are able to support sustainable high-density development, and the potential returns from building tall mean that overcoming the challenges of such sites becomes an economically viable proposition.

These transport nodes do present technical challenges because you have to keep a railroad running while you’re building around it,” says Kelly. “That takes time and may involve additional cost, but by being in that location, there’s a greater long-term value that’s created. People may have been a little bit reluctant in the past, but I think they now truly see the value of it and they’re moving forwards with these types of project.”

This is the story of the US’s largest ever real estate project, now underway at Hudson Yards in New York. The extension of the subway to the western edge of Manhattan has suddenly opened up the development potential of a neglected industrial site. Over the next ten years, it is set to become a 28-acre mixed-use development of office, residential, retail, school and public space and no fewer than 16 skyscrapers.

“When you provide mass transit access to a neighbourhood, it spurs tremendous development opportunities,” says Kelly. “The absence of access really limited that neighbourhood for a very long time. After the decision was made to extend the subway, development naturally followed.” WSP | Parsons Brinckerhoff is also involved in similar railyard projects elsewhere, such as the 22-acre Atlantic Yards site in Brooklyn, now renamed Pacific Park, and another project in Boston.

For best results, the interfaces between infrastructure and buildings are considered at the earliest possible stage, says Kelly. “That’s vitally important. Obviously you don’t want to preclude future options to maximise the buildout that could occur over a subway station, but it’s also about creating successful communities. You have to look at the pedestrian flows, how the traffic interacts with the pedestrians and how that knits together with the high-rise development. The sooner you can bring those two together, the more efficiently you will be able to incorporate both parts of the development and the better the outcome will be. With little or no additional cost you can enhance what that neighbourhood looks like.”

The integration of transport and high-density development is good news not only for those components but for the success of cities themselves, believes Kelly. “I think the industry is getting very smart at how we plan cities. It goes beyond the transit infrastructure. We’re looking also at how we plan the environment, at how we maximise the overbuild that could occur at the earliest possible stage, says Kelly. “The absence of access really limited that neighbourhood for a very long time. After the decision was made to extend the subway, development naturally followed.” WSP | Parsons Brinckerhoff is also involved in similar railyard projects elsewhere, such as the 22-acre Atlantic Yards site in Brooklyn, now renamed Pacific Park, and another project in Boston.

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The typical 20th-century skyscraper was most likely to be an office, and probably built out of steel. It’s much harder to characterise the 21st-century model.

Encompassing a diverse range of uses and a multitude of unusual shapes, every one of today’s towers is a prototype, demanding constant innovation. Structures need to perform better than ever before, but also be less obtrusive. The structural engineering of skyscrapers was a source of pride and wonder in the early 20th century, proudly flaunted on steel column façades. Now the engineer’s greatest feat is to keep well out of sight, creating super-strong structures that betray no trace of the massive forces at play.

This requirement for hidden strength has contributed to a radical shift in what towers are constructed from, says Bob Halvorson, executive vice president at Halvorson and Partners. In 1984, Halvorson wrote a paper on the structural solutions most commonly used for tall buildings. "If you looked at all the tall buildings up to that point, particularly office buildings, they were structural steel. They’d have either diagonal bracing or closely spaced columns and a moment frame round the perimeter, and that seemed to be the way of the future." But when he repeated the exercise 20 years later, the world had completely changed.

The tallest buildings were either concrete or of composite construction using both steel and concrete, and the structural systems had almost universally switched from the perimeter of the building to structures hidden in the core.

Halvorson says this has partly been driven by advances in building core construction, specifically mechanisation which reduced the amount of labour involved and made concrete or composite structures more economical than pure steel. "But an even more important driver is that architects, owners and occupiers wanted more glass and more windows without those big structural obstructions on the perimeter.” A concrete core provides a strong but discreet backbone for the building, while protecting essential services and means of egress and concealing key structural elements such as outriggers on plant floors.

Halvorson thinks hybrid structures will continue to evolve, as engineers keep up with the computer-aided ingenuity of an ever more ambitious architectural profession. "If you look back to the 1960s or earlier, buildings were rectangular and they were largely prismatic – they were constant from top to bottom or they had a constant slope or regular setbacks. Geometries were very simple. Now we’re trying to develop structural concepts for buildings that taper and slope, that have 3D curved or irregular surfaces, or large openings through them. The biggest challenge we have is adapting structural tools to more creative, taller and thinner architecture.”

Another major factor in the shift from steel to concrete is the increasing proportion of towers designed wholly or partly for residential use. Concrete is the natural choice for apartment buildings, because it offers better acoustic and fire separation between apartments and enables shorter floor-to-floor heights so developers can fit more storeys within a constrained building envelope. "Apartments are always going to be concrete-framed,” says Mark Hennessy, director of structures at WSP | Parsons Brinckerhoff in Melbourne. "Floor-to-floor heights can be pretty lean and mean, whereas steel just doesn’t work from that point of view.”

Many more towers also combine a mix of uses, which is giving rise to innovative hybrid structures. London’s Shard, for example, features a highly unusual combination of both steel and concrete floors around a concrete core. The first 40 storeys are offices, supported by steelwork spanning from the core with steel columns. As the floorsplates shrink, the use switches to hotel and luxury apartments and the frame to post-tensioned concrete, before reverting to steel for the spire. Using concrete for the middle section enabled the addition of two extra storeys within the overall height.

In New York’s new super-slimmer residences, high-strength concrete cores and frames maximise strength without restricting internal layouts or blocking views. But for the most extreme aspect ratios, strength alone is not enough. Engineers cannot keep adding structure indefinitely – they have to think laterally. A key innovation of recent years is the use of dampers, which function in a similar way to the shock absorbers on a car to help buildings perform better under wind and seismic events. “We used to design structures that were basically passive,” says Halvorson. “Today there are a lot more options open to the engineer for ‘active’ buildings with dynamic elements that modify their behaviour in positive ways.”

As towers get taller and thinner, the biggest challenge for the engineer is not making them sufficiently strong and resilient, but cost-effective, says Silvian Marcus, director of building structures at WSP | Parsons Brinckerhoff in New York. “Any engineer can design a structure that will stand. The brilliant part is to do it in an efficient way.”

“NOW WE’RE TRYING TO DEVELOP STRUCTURAL CONCEPTS FOR BUILDINGS THAT TAPER AND SLOPE, THAT HAVE 3D CURVED SURFACES, OR LARGE OPENINGS IN AND THROUGH THEM”

BOB HALVORSON, HALVORSON AND PARTNERS
In tomorrow’s denser cities, people will spend a much greater proportion of their lives in tall buildings. But having a connection to the outside will be more important than ever. Traditional office towers are sealed against the elements and use building systems to create a comfortable environment, but the next generation will be far more permeable, a trend driven by both employers and workers themselves.

“One of the most important things we can do as buildings get taller and higher and further from the ground is let the occupants keep in touch with the outside so they can understand what time of day it is and what it’s like before going out,” says Ken McBryde, principal at HASSELL in Sydney. “That’s a real challenge in tall buildings, because if you can’t open the windows, you really lose touch with the environment.”

Quality of life has taken on much greater importance among the millennial generation – and as they spend so much time in the office, that means quality of the working environment. It’s becoming about much more than temperature,” says David Cooper, president of the US buildings division at WSP | Parsons Brinckerhoff. “It’s about total environmental comfort – access to natural light, glare control, air motion and humidity; the freshness and quality of the air. This is absolutely, increasingly important to a successful occupancy.”

There is also a powerful business case for better environments that can boost workers’ productivity – staff costs can account for as much as 90% of a company’s outgoings, so even a small improvement can make a big difference. Studies have found that office workers with a window seat sleep an average of 46 minutes longer per night and that doubling the supply of outdoor air to an office reduces short-term sick leave by 35%. In 2014, the World Green Building Council brought a growing body of evidence together in a landmark publication called ‘Health, Wellbeing & Productivity in Offices’, the next chapter for green building, which received enthusiastic backing from industry clients including Tishman Speyer, British Land and Grosvenor.

There’s even a new certification, the WELL Building Standard, which focuses exclusively on human health and wellbeing. In March 2015, the developers of 425 Park Avenue committed to build New York’s first WELL-certified office tower. Cooper says that clients have begun to ask about the standard, and a couple have requested that their buildings comply, but it’s still some way from achieving widespread adoption.

In a tall building with a huge population, creating a healthy environment starts with the building envelope. “The envelope is the critical juncture for thermal performance, access to daylight and views, glare control, and all of those things really affect comfort,” says Cooper. “There are many opportunities, depending on the climate – dynamic façades, operable façades, triple-wall façades, dynamic and static shading. That’s where engineering and architecture meet.”

Maximising fresh air in office spaces also requires a different approach to the façade – as a permeable skin rather than an insipid barrier. Simply opening the windows is not an effective ventilation strategy for buildings with deep floorplates, says Nick Offer, director at WSP | Parsons Brinckerhoff in London – the air current will either be too strong by the windows or too weak further in. “What we need is an equivalent to operable windows, without actually opening them. We need to link the building to the façade, floor by floor. Then we can channel air in through the façade, into rooms on each floor, and then push that fresh air through the floors or ceilings to service the space.”

The Salesforce Tower in San Francisco will be ventilated with outdoor air for 80% of the time, supplied from under the floor. It has been pre-certified LEED Platinum, making it one of the world’s most sustainable tall buildings. In temperate climates, using outside air also reduces the energy that a tower consumes, which will make it an increasingly appealing strategy as energy costs rise in the future and targets on carbon emissions become tougher. In most parts of the world, it is possible to completely ventilate a building using external air for 70-80% of the year, says Offer. “There is a great future in thinking differently about how we design true low-energy buildings.”

Introducing higher levels of fresh air makes denser working environments possible – typical occupation densities have fallen from 10m² per person to 8m². “Because of changes in screen and lighting technology, we are able to squash up and people accept it because they like collaborating and working together,” says Offer. “But they also need access to other types of great space, so they can break away from their desks and meet other people or find a quiet place to work. It’s about the building giving something back other than office space.”

Green spaces make vertical cities much more pleasant places to be, just as they do horizontal ones: Shanghai Tower, China’s tallest building at 632m and one of its greenest, has winter gardens at the edge of every floor, open spaces with trees and planters.

From a developer’s point of view, this is a significant space sacrifice, which is why the most advanced buildings are typically one-off landmarks or constructed for owner-occupiers, says Cooper. “Most innovation happens in owner-occupied buildings,” he says. “But then it catches on and becomes something that other tenants are looking for because they see the advantages, and developers follow suit.”
THE SKY AND OTHER LIMITS

IN ESTABLISHED CITIES, NEW TOWERS ARE NEVER BUILT IN ISOLATION – THEY ARE INTIMATELY SHAPED BY THE BUILDINGS AND SPACES AROUND THEM. DEVELOPMENT IS A COMPLEX JIGSAW OF ZONING RULES, VIEWING CORRIDORS AND AIR RIGHTS. BUT IT’S A CHALLENGE THAT DESIGNERS ARE MEETING HEAD ON.

“IT’S A FANTASTIC CHALLENGE, LIKE RACING A 12m YACHT. YOU’RE ALWAYS TRYING TO UNDERSTAND THE RULES AND WHAT THE POSSIBILITIES ARE.”

DAVID PENICK, HINES

For developers, the challenge is to carve out viable schemes from a constantly diminishing supply of land. New towers must be woven into an already complex tapestry of existing buildings, much-loved landmarks, public spaces and transport and utility networks. If buildings define a city, they are themselves shaped by all of the forces in that city.

The profusion of sculpted, chiselled or staggered forms now cropping up in established urban cores is not only an expression of the whims of architects or the quest to create ‘iconic’ landmarks. It’s also because in the most congested cities, attempts by city planners to protect rights to light or signature views often impose very restricted, contorted envelopes into which buildings must fit.

It didn’t take New York planners long to notice that its new skyscrapers were overshadowing the streets below and to restrict building massing at certain heights, at a stroke prompting the distinctive setbacksc of many of the city’s Art Deco landmarks from the 1920s and 30s. Since then, as approaches to planning have become more sophisticated, the challenge for developers has only become more complex. "Government approvals are a huge piece of what we do," says David Penick, managing director of Hines, developer with Goldman Sachs and Pontiac Land Group of the super-tall 53W53 tower above New York’s Museum of Modern Art. "To create something like this, we spend a tremendous amount of time getting everything in place so we can proceed with construction."

Penick welcomes the complexity that the city’s detailed planning guidelines bring. "An exciting thing about developing in New York is that there is a great set of rules. It’s not a matter of going to City Hall and saying, ‘Gee, I wish I could do this.’ Every neighbourhood is precisely zoned, and for each plot, it says how big the building can be and what its use can be. It’s a fantastic challenge, like racing a 12m yacht. You’re always trying to understand the rules and what the possibilities are, and then someone comes up with a clever new idea that everyone learns from."

One of the most striking features of 53W53 is its high height-to-width ratio – a feature of many new towers in Midtown. As developers seek to achieve the greatest possible value from very narrow yet very expensive plots, advances in structural engineering are enabling increasingly slender forms. But 53W53 also lies in three different zoning districts, each with its own permitted densities and shapes. Architect Jean Nouvel’s design is an elegant solution to a complex geometrical problem, with different parts of the building tapering at different angles as it rises from 53rd and 54th Streets.

Penick had to negotiate the transfer of air rights from surrounding buildings that had not consumed their full entitlement, says Penick. "Then there are other air rights transfers within the project to allow for the intended uses to occur at their correct locations within the building. It’s a very demanding process."

The plan also had to be signed off by a number of parties including the Museum of Modern Art, which will occupy the lower floors, the Landmarks Preservation Commission and the NYC Transit Authority because of the nearby subway tunnels. The project will be occupied in 2018, 11 years after Hines originally purchased the land.

New York is already renowned as a skyscraper city, but London is only now becoming one. Around 70 buildings above 20 storeys are under construction, and almost 200 more have been proposed. But even while some Londoners may feel uneasy at what seems like untrammelled development, there is a well-defined set of rules governing the placement and form of towers, intended to preserve views of the city’s landmarks from surrounding public spaces. As these new towers take shape, London’s planning rules are being writ large on the skyline.
“DEVELOPING IN LONDON IS QUITE A CHALLENGE BECAUSE THERE’S A VERY HISTORIC STREET PATTERN AND BLOCK SIZE, AND A LOT OF PROTECTED VIEWS. IN THE RECENT PAST, A LOT OF BUILDINGS HAVE BEEN SHAPED TO DEAL WITH THOSE CONSTRAINTS”

GEOFF HARRIS, TH REAL ESTATE
The protected view of St Paul’s Cathedral from Fleet Street is one of the biggest reasons why the 220m-high Leadenhall Building tapers at a 10° angle, earning it the nickname the ‘Cheesegrater’ and why its future neighbour at 52 Lime Street, ‘The Scalpel’, leans back in the opposite direction. In this way both remain hidden behind the cathedral dome. This same view was also a key consideration in the design of 40 Leadenhall Street, a 910,000ft² development of between seven and 34 storeys that sits to the east of The Scalpel.

But here, developer TH Real Estate wanted to take a different approach, as head of development Geoff Harris explains: “Developing in London is quite a challenge because there’s a very historic street pattern and block size, and a lot of protected views. In the recent past, a lot of buildings have been shaped to deal with those constraints. We were looking for a building that is beautiful, unique and distinctive in its form, that takes us back to 20th-century US tower design – a building that expresses its verticality, mixes solid and clear and uses terracing.”

Working with Make Architects, Harris’ team completed 89 separate design studies, modelling all the constraints in 3D to produce an envelope in which the building had to sit. But rather than shaping the building to fill that space, they considered it from the inside out, looking at how form could follow function. “We ended up with a terraced building that is arranged in slices,” he says. “It deals with all the constraints, but it’s still a very clean form that is rectilinear.”

“40 Leadenhall has to be unseen from Fleet Street, by sitting behind the dome of St Paul’s Cathedral in the same way as The Scalpel”, adds James Taylor, partner at Make. “But we didn’t want the architecture to be defined by this requirement. Our focus was on creating a group of simple, well-proportioned elements which work on the skyline. The Fleet Street view requirement was handled by working a set of terraced set-backs into the overall composition, which also enhance the workplace with external amenity spaces.”

There is a long history of city-dwellers giving irreverent nicknames to new buildings. Now with an array of irregular forms rising above their hoardings and a constant stream of proposed towers coming to market, Londoners have gone into overdrive. Within minutes of a building’s launch, there will be a heated competition on social media to coin an appropriate name. In future, London’s towers may be less easy to name as architects and developers take a more understated approach.

Gwyn Richards, the City of London Corporation’s head of design, said in a recent interview that he wanted to see “less scenic buildings, less provocative buildings, fewer buildings which might have nicknames.” But that hasn’t saved 40 Leadenhall Street from becoming known as ‘Gotham City’, a moniker coined by Richards’ predecessor Peter Reeve, Harris says he doesn’t mind. “Actually I quite like it. It’s interesting because we were aiming for that 20th-century US architecture and that has come through. But we won’t be writing ‘Gotham City’ on our hoardings.”

Sometimes a building’s owners may adopt a nickname officially, as Sellar Property Group did at The Shard – originally coined by conservation body English Heritage as an insult. If it does stick, a nickname can be a badge of genuine landmark status. Few would recognise the Gherkin by its official name of 30 St Mary Axe.

Developers themselves may now come to market with a brand already formed, as WRBC has done for The Scalpel. This is partly a way of heading off any less flattering suggestions. But naming these giant buildings also makes them relevant on a human scale, and somehow less threatening. "People don’t do this to the same degree in New York because it’s already an established high-rise city," points out Bill Price, director at WSP | Parsons Brinckerhoff in the UK. “They’re more blunt in London, it’s a relatively new phenomenon but in time the novelty will wear off here too.”

Few cities are densifying as rapidly as Toronto, which has more than double the number of high-rise buildings under construction than New York, with as many as 180 tower cranes complementing a burgeoning forest of skyscrapers. Over the last decade, its skyline has been transformed under the close eye of Jâmes Parakh, urban design manager at the City of Toronto Planning Division. “We think very hard about the role of each tall building on the skyline,” he says. “That’s really important. Is every building supposed to be an exuberant top or should some be more conservative?”

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Parakh has noticed some common characteristics among the most successful global skylines. “Very often, there is a series of buildings, and then one landmark that’s different, and then a natural feature.”

San Francisco has the Golden Gate Bridge and the bay; Hong Kong has two International Financial Centre, Victoria Harbour and The Peak in the background; Rio de Janeiro is instantly recognisable for its statue of Christ the Redeemer and Sugarloaf Mountain.

Toronto’s official plan identifies centres in which growth will be concentrated, on which streets the tallest buildings should be located, and sets viewing corridors to protect landmarks such as the dome of the Rogers Centre.
DESIGNING SKYSCRAPER CITIES

Sydney Opera House is universally recognised as a symbol of the city, and transition down to lower-scaled buildings and open space is as important as skylines, says Parakh. “We’ve spent a lot of time thinking about the scale of the individual in relationship with the tall building.” Buildings must fit within their context and transition down to lower-scaled buildings and open space. Wind-tunnel testing is mandated on all projects. “Parks and historic landmarks are very much part of our style, and even though they are dwarfed by tall buildings, there has to be some balance. Thinking about one without the other is not making a great city.”

Centre stadium. It’s designed into the city at ground level. “Placemaking” has become an important pastime for developers in recent years, not only to satisfy planners but also because they recognise the commercial benefits of making a location more ‘sticky’. After all, potential office tenants or apartment buyers have an increasing choice of rooms with a view, and an attractive neighbourhood at ground level can be a crucial point of differentiation.

“As these buildings get larger and more and more dominating, it think it’s incredibly important that we talk about this more,” says Ken McBryde, principal at HASSELL in Sydney. “To make our cities habitable, buildings need to work on a community level.”

For McBryde, groundlines are as important as skylines, and it is a building’s presence at street level that determines whether it is a successful addition to a cityscape. He uses the example of the Sydney Opera House, a world-famous landmark. “It’s universally recognised as a symbol of the city; the most successful thing is the ground plane; the podium and the way it sits in the city. At all times of the week, this place is really buzzing.”

He thinks that’s also why Londoners have embraced The Shard, even though it’s on an unprecedented scale for the city. “The success of The Shard is that it’s not an impenetrable tower; it’s actually highly permeable. There’s a whole range of mixed uses that the public can explore at multiple levels, starting with the transport interchange. It’s access to the public that makes this a well-loved building.”

WE LIFTED THE BUILDING UP 9m SO THAT A PUBLIC STREET CAN RUN THROUGH THE SITE UNDERNEATH

Nick Jackson, Eric Parry Architects

“We reorganised the streets, we replanted it and put seating in, and we lifted the building up 9m so that a public street can run through the site underneath. Rather than the building lobby occupying the middle of the site, it connects the square and the street. You can walk through there, sit down, get a drink of water and no one will stop you.”

EPA is now applying this concept to a much larger project: No 1 Undershaft, a super-tall tower opposite the Gherkin. Though the 294m-high project will be the tallest building in London’s financial quarter, the starting point is the human scale. “In a city like London, you’ve got to understand how people move. We carry out pedestrian studies to map that movement, and the challenge for us is how to change it.”

The scheme will see the redevelopment of an older tower completed in 1969. a 10th high block inserted clumsily into the winding street pattern. EPA wants the new building to work more harmoniously with the existing city, and restore some of the older connections between the surrounding spaces. “There are two 16th-century churches that probably haven’t seen each other for 500 years,” says Jackson. “We want to remove that blockage and replace it with a more delicate footprint.”

A super-tall giant that towers lightly on its surroundings—perhaps that should be a model for high-rise development everywhere.

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There’s a proliferation of public space at the top of tall buildings in London, as a requirement of many planning approvals. For a building services engineer, the impact of that space on the building is absolutely huge.

When I was working on The Shard, this was a major challenge because of the shape of the building. The floorplates shrink as the building gets taller but there are massive peaks in occupancy at the mid-level restaurant and the viewing gallery at the top – so the greatest concentration is where the floorplates are smallest. If we had followed standard fire escape provisions by using multiple stairs, there wouldn’t have been much room left for anything else. Our solution was that some of the lifts would be used in a fire or emergency. That too had a massive knock-on effect, and introduced a range of constraints because we needed to provide pressurised lobbies where people can wait for lifts, and install an independent cooling system for the lift motor rooms and other elements that would ensure the lifts could be safely used in an emergency.

The shapes of many London towers are influenced by viewing corridors to St Paul’s Cathedral. But this also determines the internal layouts of a building and even its ventilation philosophy. When buildings lean, that has a significant effect on the mechanical and electrical services. There is only one vertical side on the Cheesegrater, for example, which almost dictates where the core has to go. The public space at the base and the need to keep that free of columns impacts the structural engineering, and that pushes the core further to the back of the building. Once you offset the core, that creates a little bit of lower value floor space. So instead of a ventilation strategy where there are central air-handling units at the top and at the bottom, feeding up through risers, you end up with on-floor handling units serving each tenant separately.

The Shard’s façade is meant to resemble pieces of broken glass leaning together, so rather than having a standard band of louvres to get air in and out of the building, we had to do something a little bit different. As the shards overlap to create fractures, that creates an opportunity for winter gardens on the office floorplates, which are naturally ventilated, and on the plant levels we could use them to get air in and out of the building. Just one of the impacts of that is that you need to designate a particular fracture for bringing air in or out because you don’t want to cross-contaminate it. It may not be immediately obvious to everyone else, but there’s some real gymnastics to get this to work.
IT BEGAN WITH A MULTIBILLION-DOLLAR SUBWAY EXTENSION. NOW ONE OF MANHATTAN’S FEW FORGOTTEN QUARTERS IS THE SCENE OF THE US’S BIGGEST EVER DEVELOPMENT: HUDSON YARDS

“WE WANTED TO GROW MANHATTAN AND THE FAR WEST SIDE WAS ONE OF THE LAST FRONTIERS, BUT WE NEEDED A TRANSPORTATION SOLUTION”

GREG KELLY, WSP | PARSONS BRINCKERHOFF

Hudson Yards is a New York story, a skyscraper story and an urban regeneration story. But most of all, it’s a transport story – of how a $24bn investment in infrastructure has given birth to the largest real estate project that the US has ever seen.

A completely new neighbourhood is taking shape on the western edge of Manhattan on an long-neglected railway site next to the Hudson River. Over the next ten years, that thick forest of rail tracks will disappear from view, to be replaced by 20 million ft² of office, residential, retail and leisure space. The masterplan envisages 16 tall and super-tall buildings – all effectively built on stilts, supported by two super-strong, highly complex platforms over the tracks, while the trains continue to roar on underneath throughout construction.

The Hudson Yards scheme is not the first attempt to unlock the potential of this tantalisingly underutilised space, but it is the first to succeed. What has made the difference is the city’s decision to extend the 7 subway line, and the innovative funding mechanism that has been used to pay for it. Infrastructure has driven vertical development in this part of the city,” says Greg Kelly, president and CEO of WSP (Parsons Brinckerhoff in the US), “Central & South America, which led the planning and design of the subway extension and the land use strategy at ground level for joint developers Related Companies and Oxford Properties Group. “That was really the underpinning of this project: using transit as a catalyst for development. Not just to take the subway to the west side, but to use it to create real growth and an economic benefit for the region.”

It all began around the turn of the millennium. Although the site was only a mile and a half from the lights and energy of Times Square, it couldn’t have felt further away. The problem was accessibility. There was no subway line and it was, at best, a 10 or 15-minute walk from Penn Station, trekking across four long city blocks. The Far West Side was lagged behind the rest of Manhattan on residential, commercial and retail use, with around one-third of the density elsewhere in the city, and almost double the amount of low-grade garage and storage space. On a small island with some of the most sought-after real estate on the planet, it stood out as a major missed opportunity. “We had a challenge,” says Kelly. “We wanted to grow Manhattan and the Far West Side was one of the last frontiers, but we needed a transportation solution.”

Extending the 7 line was deemed the most efficient way to connect the site into the existing network. Running east to west, the 7 crosses the Hudson River, serving Grand Central Station. From being one of the worst connected parts of the city, Hudson Yards would suddenly be one of the best. But constructing the first new section of New York subway in more than 80 years did throw up some surprises along the way. The 7000ft (2133m) tunnel had to be threaded through a dense below-ground network of existing tunnels and building foundations – some of which were not on the as-built plans. The bedrock in this part of Manhattan is softer too, so the ground had to be frozen to allow the tunnelling to take place. To minimise the impact of the station at ground level, Kelly’s team also used inclined elevators, believed to be a first for the US.

The extension required significant rezoning, as well as a new funding mechanism because New York’s Metropolitan Transport Authority was already undertaking improvement works across the rest of the network. “The MTA had a pretty full plate with some mega-projects that were very far along, so this one was going to require some innovative approaches,” says Kelly. “The question was how we could capture the value of the land that would be developed over the next 15 years.”

The solution was New York’s first tax increment financed project, and one of the largest undertaken in the US. The Municipal government issued bonds to fund the $24bn project, which will be repaid with property tax revenues from future developments in the area. “That provided certainty that the public sector would deliver the infrastructure improvements that were planned, and that they weren’t subject to the whims of politics or policy,” says Andrew Cantor, vice president of development at Related. Infrastructure projects typically take longer than any single official’s time in office. If bonds are issued there are contractual obligations that must be met and that creates a lot more confidence for investors.”
Today Hudson Yards is a sea of cranes, with phase one of the build well underway. The platform over the Eastern Yard section of the site is almost complete, and 10 million ft$^2$ of buildings are now coming out of the ground. But the Midtown South area around Hudson Yards has already changed beyond recognition. Five years ago, the anticipated arrival of the subway, combined with investment in green spaces including the conversion of an old elevated rail track into the High Line park, began to draw companies including Google, Sony and IAC to locate there. It is now growing five times faster than the rest of Manhattan, and has become the number-one destination for galleries, restaurants and parks. “Business now recognises this as one of the most appealing areas to be,” says Cantor. “The companies that are growing in New York are moving to the west side for a variety of experiences you can have beyond just having a typical office building.” The average household income of the neighbourhood is on a par with the rest of Manhattan, but it’s skewed towards a younger, single demographic, he adds. “Millennials are really driving the neighbourhoods that are coming. They’re looking for a mixed-use experience, and that’s what we’re going to deliver.”

Last year, Related opened Abington House just to the south of the Eastern Yard, a luxury apartment building with 400 units for rent overlooking the High Line. It is fully occupied, and commanding the highest rents in Related’s portfolio. “That’s a dramatic change – it used to be the Upper East Side that had the highest rents.”

Abington House looked tall when it was first built, but not for long. Now under construction, 15 Hudson Yards will offer 70 storeys of apartments, and be one of the tallest residential buildings in the city. 35 Hudson Yards will follow in 2019, more than 1,000ft tall with a mix of residential, hotel, office and retail space. Then there’s the Culture Shed, an expandable structure on rails that will host large travelling art exhibitions and New York Fashion Week, which has committed to relocate from the Lincoln Center uptown. There will also be a seven-storey mall, where Related secured something of a coup when it tempted luxury department store Neiman Marcus to open its first New York store. There are three office buildings under construction. The first, 10 Hudson Yards, will open in March, and be home to tenants including L’Oreal, Coach, SAP and Boston Consulting Group. In 2019, will come 30 Hudson Yards, at 1,296ft (395m) the tallest building on the site and the second tallest office building in the city. Anchor tenant Time Warner has signed up for 38 of its 50 floors, while at the top, the city’s highest outdoor observation deck is expected to draw 2 million visitors each year. Over the subway station itself, 55 Hudson Yards will sit at the centre of the scheme, and is being marketed at tech, professional services and law firms. “Most office space in New York is more than 50 years old, so the idea here was to build something that will be first rate and world class,” says Cantor. “That means floor-to-ceiling glass in every space and as many outdoor spaces as we can build in throughout the buildings. That was a critical requirement.”

Public space at ground level is also a key feature of Hudson Yards. In all, there will be 14 acres, laid out by British designer Thomas Heatherwick. “Getting the public space right is probably one of the most important things to make a project feel authentic and exciting,” says Cantor. The new station at 34th Street opened in September 2015. Taking the 7 line to Hudson Yards is quite an experience – the slick new 34th Street station is more like an airport than a New York subway. Right now, few passengers remain on the train after Times Square, but the considerable size of the station offers a clue as to the plans for the neighbourhood: when the whole scheme is complete in 2024, 65,000 visitors are expected every day. “Beforehand everyone said it’s going to feel too crowded,” says Cantor. “Now everyone says it feels too spacious, which just goes to show that you can’t please New Yorkers. But it’s ready for the development that is forthcoming.”

“GETTING THE PUBLIC SPACE RIGHT IS PROBABLY ONE OF THE MOST IMPORTANT THINGS TO MAKE A PROJECT FEEL AUTHENTIC AND EXCITING”
ANDREW CANTOR, RELATED

DESIGNING SKYSCRAPER CITIES   ///
FAR WEST SIDE STORY   ///
Being close to transport links is usually a major asset for a high-rise development. But from a structural engineer’s point of view, there is perhaps such a thing as being too close.

At 760ft (232m), 55 Hudson Yards is not the tallest building on the site, but it is one of the most complicated. It sits not on the Eastern Yard deck, but on the subway station itself and the brief for the office space was also very specific. Co-developers Related and Oxford Properties Group wanted column-free corners, a 10-foot clear ceiling and no penetrations on the core apart from the openings to the elevators.

“All of these things allowed for much better planning and much more efficient layouts for our tenants, but they compounded the challenges facing the engineers,” says Andrew Cantor at Related. “We wanted to have large openings for future stairs as well as setbacks for double-height terraces throughout.”

They also wanted the building to be constructed out of concrete – unusual for a commercial building in New York. “But that was the easy part,” says Jeffrey Smilow, executive vice president of building structures at WSP | Parsons Brinckerhoff in New York. “The difficult part was what lies underground. Of all the projects we’ve done over the last 30 years, this has been the most complex in terms of integration with infrastructure and complexity below-grade.”

WSP | Parsons Brinckerhoff used several tricks to reduce the weight of the concrete, creating a structure that is light enough to meet strict load requirements while also being very strong. They specified a 12,000psi high-strength mix, using lightweight aggregate, and the floor slabs were post-tensioned – a common technique in other markets but believed to be the first major use in New York. At the very top of the building, a system of outriggers links the core to perimeter columns spaced 10ft apart. All of this allows the floor slabs to be very thin – just 9 inches – even with spans of 40ft and 35ft off the core. The post-tensioned system was carefully planned to leave free areas so that interconnecting stairs could be added anywhere throughout the floor plate.

“Every engineering decision that we made had to keep in mind flexibility for tenants.”

“Of all the projects we’ve done over the last 30 years, this has been the most complex in terms of integration with infrastructure and complexity below-grade.”

JEFFREY SMILOW, WSP | PARSONS BRINCKERHOFF
AN ICON FROM EVERY ANGLE

ONE WORLD TRADE CENTER IS A LANDMARK LIKE NO OTHER. FROM ITS MONUMENTAL ARCHITECTURE AND GROUNDBREAKING STRUCTURE TO THE EMOTIONAL ROLE IT'S PLAYED IN THE LIVES OF NEW YORKERS, THIS IS THE STORY OF THE WORLD’S MOST FAMOUS CONSTRUCTION PROJECT.
The goal was always to "create a better version of New York," says Janno Lieber, president of World Trade Center Properties. Lieber is describing Silverstein Properties’ redevelopment on the former site of the twin towers in Lower Manhattan, an epic 14-year journey that has seen a cast of thousands overcome technical, logistical and, not least, emotional challenges as New Yorkers watched with bated breath.

The 16-acre site will comprise five towers as well as the National September 11 Memorial and Museum, but it was the completion of One World Trade Center in November 2014 that was perhaps the biggest milestone both for the project team and the city. This super-tall tower now stands proudly on the skyline, filling the void left by the destruction of the original World Trade Center on 11 September 2001 and reinstating an important landmark. What is less obvious is the revolutionary impact the project has had on structural engineering itself, redefining the way towers are constructed in New York. As the project team worked to make One WTC, the safest ever built, they have developed new technologies and techniques that have since been adopted into the city’s building codes and buildings worldwide.

There was never any question that the World Trade Center would be replaced. It may have taken almost seven years for One WTC’s superstructure to finally become visible from behind the hoardings, but the rebuilding plans began almost immediately. “That fateful day the World Trade Center was lost was described by many people as ‘putting a hole in our heart,’“ remembers Steve Plate, deputy chief of capital planning and director of WTC construction at the Port Authority of New York and New Jersey. “We needed to replace it as quickly and expeditiously as we could. We needed to make a statement in the form of a building, and most importantly, emotionally connect with New Yorkers eager to see results at the site.”

One WTC begins from a 200ft square footprint – exactly the same dimensions as the original twin towers. From a height of 20ft, it begins to gently taper at the corners. By the time it reaches the uppermost 104th storey, the floor plan is again a square, but slightly smaller and twisted through 45 degrees. At its midpoint, it is a perfect octagon. From base to parapet, the building is also the same height as the twin towers – 1,368ft (417m) – before its crowning mast takes it up to the symbolic height of 1,776ft (544m), reflecting the year of the signing of the Declaration of Independence and making it the tallest tower in the western hemisphere.

“We always thought this building should be about simplicity and geometry,” says architect TJ Gottesdiener, managing partner at Skidmore, Owings & Merrill (SOM), who led the design team. “We tried to make it look as clean, strong, monumental as possible and that meant making it look as simple as possible – although this is far from a simple building.”

One aspect that was always going to be complicated was the structural design. The team had to create a landmark that would restore confidence in tall buildings and make people feel safe – but with New Yorkers eager to see results at the site, the design of One WTC had to proceed while this thought process was ongoing. “After 9/11, construction just stopped,” says Ahmad Rahimian, director of building structures at WSP | Parsons Brinckerhoff in New York, who led the structural design. “We tried to make it look as clean, strong, monumental as possible and that meant making it look as simple as possible – although this is far from a simple building.”

The core is made of ultra-high-strength concrete, at 14,000psi the strongest ever poured in New York. “It’s much stronger than any rock you could find,” says Rahimian. “We needed to make a statement in the form of a building, but driven by people. Now that building has itself become a catalyst for the whole of Lower Manhattan.”

The core contains two interlinked access stairs and a dedicated first-responders’ star – to allow first responders to climb the building quickly in the event of an emergency, while people escape – a feature that is now standard in New York building codes. The core is made of ultra-high-strength concrete, at 14,000psi the strongest ever poured in New York. “It’s much stronger than any rock you could find,” says Rahimian. “We needed to make a statement in the form of a building, but driven by people. Now that building has itself become a catalyst for the whole of Lower Manhattan.”

One WTC begins from a 200ft square footprint – exactly the same dimensions as the original twin towers. From a height of 20ft, it begins to gently taper at the corners. By the time it reaches the uppermost 104th storey, the floor plan is again a square, but slightly smaller and twisted through 45 degrees. At its midpoint, it is a perfect octagon. From base to parapet, the building is also the same height as the twin towers – 1,368ft (417m) – before its crowning mast takes it up to the symbolic height of 1,776ft (544m), reflecting the year of the signing of the Declaration of Independence and making it the tallest tower in the western hemisphere.

“We always thought this building should be about simplicity and geometry,” says architect TJ Gottesdiener, managing partner at Skidmore, Owings & Merrill (SOM), who led the design team. “We tried to make it look as clean, strong, monumental as possible and that meant making it look as simple as possible – although this is far from a simple building.”

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“WE NEEDED TO COMMEMORATE WHAT HAD BEEN HERE AND THE PEOPLE WHO HAD BEEN LOST, BUT WE ALSO NEEDED TO CREATE SOMETHING THAT REPRESENTS THE CHARACTER OF NEW YORK, ITS DYNAMISM AND ITS HOPES FOR THE FUTURE”

JANNO LIEBER, SILVERSTEIN PROPERTIES
The building’s five underground storeys go down 70ft. The masterplan demanded that the tallest tower be built in the north-west corner of the site – but this meant threading the columns through the tracks of the fully operational train station underneath. “There is a whole city below that extends way beyond the footprint of the tower,” says Elion. “One World Trade Center has about half-a-million square feet below grade – that itself is bigger than many tall buildings.”

While this is largely hidden from public view, back above ground the architects were responsible for perhaps the most highly visible façade on the planet. Aesthetics were therefore of paramount importance. Aside from the sheer size of the building, it’s the way that it catches the light that makes the greatest impression, the luminescence of the structure somehow lightening its monumental presence on the skyline. This is thanks to the floor-to-floor glazing – the exterior of the building is composed of 1 million ft² of transparent, with a reflective, mirror-like coating that creates a constantly changing kaleidoscope. The corners are clad in laser-finished stainless steel that glints in the sunlight. “It reflects the sky and the buildings around it, and when the light hits it in a certain way you can see right through it,” says SOM’s Gottesdiener. “Sometimes it glows a bright orange or red. It’s got a very beautiful quality to it.”

Of course, notwithstanding its symbolic and monumental role, One WTC is a commercial office building. On entering, workers are immediately faced with the interior’s most impressive feature: a 25ft-high atrium. Above that, there are four levels of mechanical space, before the office floors begin on the 20th storey. After 71 storeys, there are further mechanical floors topped by a three-storey public observation deck on levels 100-102. “It has to function as a very stable, very efficient environment where people want to come and work,” says SOM’s Gottesdiener. Key to this appeal are generous 9ft 6in ceiling heights and column-free expanses of up to 45ft from the core to the perimeter, as well as the floor-to-floor glazing. “We wanted to allow as much natural light to penetrate the building as possible. People don’t have to turn on the lights 90% of the time, because there’s so much natural light flooding in.”

Fittingly, the new World Trade Center performs a vital civic role too. The masterplan created by Studio Daniel Libeskind envisaged a diverse district, with the National September 11 Memorial & Museum at its heart. “More than half of the site is now given over to public space, and the historic streetscape has been reinstated to make the development much more permeable. As well as office space, there are retail and leisure uses to create a thriving, vibrant community throughout the day and evening and at weekends too. A new transportation hub is under construction, expected to serve 200,000 commuters each day. “We wanted to make the World Trade Center a model of what New York can and should be, and I think we accomplish that by creating a more dynamic streetscape with great accessibility,” says Lieber. “That’s what makes it different and special.”

This is already clearly visible in the buzz around the site, which has become a focal point for both New Yorkers and visitors to the city. “In the last 10 years, downtown has evolved tremendously,” says Eric Engelsma, vice president of leasing for One WTC at the Dust Organization. “When I started in real estate, downtown always became a bit of a ghost town when everyone went home. Now it become a 24/7/365 live-work-play neighbourhood. It’s attracting tenants from a wide range of industries, from financial services to law firms, technology, advertising and publishing.”

The towers that these new tenants will occupy have been designed by a prestigious list of international architects. SOM designed not only One WTC but also the first building to complete in 2006, 7WTC. November 2011 saw the opening of 4 WTC, by Pritzker Prize winner Fumihiko Maki; Richard Rogers, another Pritzker Prize winner, has designed 3 WTC, due for completion in 2018; 2 WTC has been designed by Bjørke Ingels, and will be the second-tallest on the site at 1200ft (367m). As well as One WTC, WSP|Parsons Brinckerhoff is the structural engineer for towers 7, 2, 3 and the memorial and museum, and conducted a peer review on tower 4. The WSP | Parsons Brinckerhoff team also ensured the overall stability of the enormous bathtub perimeter walls that encircle the entire site below ground to keep the waters of the adjacent Hudson River at bay.

“What you don’t see below ground is just as massive as what’s above ground,” says Jeff Smelw, executive vice president of building structures at WSP | Parsons Brinckerhoff. “The bathtub is roughly 78ft below grade, and it’s composed of multiple levels with multiple components.”

Rebuilding the World Trade Center has been a vast undertaking, made possible by an unprecedented level of collaboration and cooperation. “One of the challenges on any project is making sure that you have the right people on your team and that they can all work together,” says Rahimian at. “But on this project, we all knew it was a once-in-a-lifetime opportunity. Bringing everyone together was easy.”
IT HAD TO STAND TALL WHILE AVOIDING ANY APPEARANCE OF HUBRIS

— A JANUS TASK FOR A 104-STOREY TOWER

For more than a decade, One World Trade Center has occupied centre stage in the global imagination. Its structural challenges were those inherent in the realisation of any super-tall, but were exacerbated at this location by a number of tangible and intangible factors that made the project unlike any other.

One’s massive size, encompassing 3.1 million ft² (319,400 m²), was determined by the need to replace the office space lost on September 11. The masterplan placed the tower in the most damaged corner of the site. There, below-grade conditions were complicated further by the need to build over four curving rail lines, which had to stay operational during construction, and by constraints imposed by the adjacent structures, with which One shares foundations and mechanical systems. It had to meet security parameters that had never been demanded of any skyscraper, anywhere.

Infinitely more challenging was One’s duty as a symbol of all that was lost, and reconciled, on September 11. It had to provide solace and inspiration to millions, most of whom had wildly divergent opinions of how that could be accomplished. It had to stand tall, while avoiding any appearance of hubris, a Janus task for a 104-storey tower. Some 8 million New Yorkers actively debated its design and clamoured to help. That too was gone in their wake, leaving a gap that was felt viscerally. New Yorkers wanted their skyline restored – yesterday. Consequently, One’s progress was closely scrutinised, with any delay fanned by the media, creating additional stress for those involved. Few understood the sheer size of the substructure, which, at a half-million ft² (46,451 m²), is larger than many buildings.

Architecture, contractors and tradespeople – everyone spoke of the relief they felt when the superstructure finally emerged above ground on 17 May 2013. The larger site, similarly intricate, is a subterranean Rubik’s Cube of nine interdependent structures, with shared foundations, utilities and mechanical systems. Dozens of designers, contractors and owners had to weigh in on every wall and opening.

Given One’s height and slenderness, WSP | Parsons Brinckerhoff had devised a concrete-core structure, an effective solution that would shield internal systems and mitigate shearing forces. However, in New York, because of jurisdictional issues peculiar to its powerful unions, which govern how steel and concrete crews work together, concrete cores were less frequently used. Ultimately, the unions agreed that the concrete core could be constructed ahead of the steel framing – one of the biggest technological advances in how towers are built in Manhattan today.

Set in a public plaza in one of the most solemn places in the city, One had to appear dignified and approachable, while disguising the reality that it is an impenetrable building. Moreover, while many towers have retail shops on the street level, which naturally attract people, One did not have that advantage. Instead, its 186ft-high (56.7m) concrete podium is covered in sparkling glass panels. Its four transparent entrances, oversized to convey hospitality, are ingeniously threaded with a flexible cable-net grid that will deflect the effect of an explosion. Just beyond them are secondary concrete walls that are clad in dichroic glass, a specialty glass that splits the spectrum of light into shimmering patterns of colour and makes the entrances as welcoming as a spring morning.

One World Trade Center holds our impossible wish to have back everyone who was lost on September 11. Of all the challenges that it faced, perhaps the biggest one is exorcising the ghosts of the structure that it replaced. Spurring innovative design and construction methods, new sustainability standards and groundbreaking safety measures. One also provides thousands with a place to remember, reflect, work, eat and shop. That all these things have been accomplished, thanks to brilliant solutions and strenuous effort, qualifies it as a masterpiece.
THE RISING CONTINENT

Australia has made a name for itself as a country that can accommodate high-rise development on a large scale. It is a country that has been able to do so thanks to its vast population and geographical size. The city of Melbourne, in particular, has become a center for high-rise development, with its skyline being transformed by the arrival of new skyscrapers. The city's skyline has been enhanced by the addition of buildings such as the Eureka Tower and the Southbank Tower, which have become iconic landmarks of the city. Melbourne is not alone in its efforts to develop high-rise structures, as other Australian cities such as Sydney and Brisbane are also leading the way in this regard. The trend towards high-rise development in Australia is not only driven by economic factors but also by cultural and social changes, such as the desire for more efficient use of space and the increasing popularity of urban living. The rise of high-rise development in Australia is a testament to the country's adaptability and willingness to embrace new forms of urban development.
One of Melbourne’s tallest and most prestigious developments, this project is best known for its inspiration: the Beyoncé video ‘Ghost’, which features writhing dancers tightly shrouded in fabric. The result is an elegant, amorphic form, designed by Elenberg Fraser, that sits on an island site opposite the city’s main train terminal. Expected to rise to 78 storeys, it will include no less than 1 million ft² of space, comprising 780 one- and two-bedroom apartments and 180 hotel suites, as well as a range of leisure facilities.

Recreating those sinuous curves in glass, concrete and steel was no mean feat for the structural engineer, especially while minimising intrusion on the usable floor area and internal layouts.

“It’s in a prime location, and it’s got a very distinctive variable form,” says Peter Hindmarch, director at WSP | Parsons Brinckerhoff in Melbourne.

Premier Tower is also a slender structure – the ratio of its height to structural width is 8.5 from the ground up, but a much more challenging 10.8 above the podium. To maintain the building’s movement in the wind within acceptable levels, mega-columns on the façade maximise the width of the stabilising structure, and these are tied to the core by two- or three-storey outriggers concealed in party-walls, and secondary outriggers at the mid-height plant floor. “The mega-columns are sized to carry both gravity and wind loads,” explains Hindmarch. “The wind load forces can be equal to the weight supported by the column. Controlling the acceleration is the most important thing for a residential building, so we tested it extensively in a wind tunnel.” There is provision for a tuned mass liquid damper at the top of the building, to further slow the movement, and this will also double as the fire tank.

Melbourne’s construction industry is predisposed to concrete. This is always post-tensioned, reducing floor-to-floor heights and adding strength – spans of 8m x 8m are typical for apartments. At Premier Tower, the flat plates are 200mm bonded post-tensioned slabs, allowing floor-to-floor heights of 3m, with ceiling heights of about 2.7m. The shape of the floorplates varies throughout the building, so walking columns were used to transfer loads to different parts of the structure. At the deepest curves, the slab edge on the line of the corner columns varies by 5m. The internal edge of the columns remains in the same place, while the external is stepped to support the longer cantilevers. The result is that the corner columns change in section from 800 x 800mm to 3,950mm x 300mm in six steps. Along the shallower curves, the internal columns walk in and out to fit around internal layouts and doorways.

Below ground, there are four basement levels with car parking. These are broader than the tower, so the columns transition horizontally as they reach the podium, by approximately 4.5m over a height of 18m, or six storeys. “If we’d kept the column locations the same as in the tower above, they would have clashed with the aisle in the car park,” says Hindmarch. “By transitioning them, we can locate them between parking bays instead. This also increases lateral stiffness, and it meant we didn’t use any transfer beams, which reduced structural height and construction time and cost.”
IN THE FACE OF RISING URBAN POPULATIONS AND RAPIDLY CHANGING LIFESTYLES, THE CHALLENGE IS NOT SIMPLY TO BUILD HIGH-RISE STRUCTURES. WE NEED TO BUILD HIGH-RISE COMMUNITIES.

“THE NEW HIGH-PERFORMANCE BUILDING IS NOT JUST A TECHNOLOGICAL MARVEL, IT’S ALSO A CULTURAL TOUCHSTONE, IT’S A BRAND BEACON, IT’S AN INNOVATION ACCELERATOR”

PETER WEINGARTEN, GENSLER
Technology has had a profound impact on how people perceive experience. This is partly through necessity, as recession has diminished the prospects of home ownership for many. It’s also because digital technology makes it easier than ever before to communicate and stay connected. The sheer scale of super and mega-tall towers is a completely new typology for humankind – people have never attempted to live, work or play together at such heights, in such numbers. And the energy and expense involved in demolishing tall towers means that they will have much greater longevity and will have to accommodate much more change than conventional buildings over their lifespan. The towers we build today may still be standing in cities that are almost unrecognisable. This means they need to be designed with one eye on the future, and enough flexibility to adapt to whatever else comes their way.

The future is not just taller. It’s also more crowded, more diverse, more collective – and more solitary too.

Anticipating the future has always been a challenge for designers, developers and planners, but high-rise buildings bring these questions into sharp relief. The sheer scale of super and mega-tall towers is a completely new typology for humankind – people have never attempted to live, work or play together at such heights, in such numbers. And the energy and expense involved in demolishing tall towers means that they will have much greater longevity and will have to accommodate much more change than conventional buildings over their lifespan. The towers we build today may still be standing in cities that are almost unrecognisable. This means they need to be designed with one eye on the future, and enough flexibility to adapt to whatever else comes their way.

One of the most significant trends already influencing designers is the coming-of-age of the ‘millennial’ generation. The generation born towards the end of the 20th century. By 2020, millennials will comprise half of the global workforce, and they already outnumber older colleagues in the US.

Millennials are characterised as footloose city-dwellers, overturning many decades of suburbanisation. They are also ‘digital natives’ who have grown up with the internet, mobile phones and social media, and it is this that will have the furthest-reaching consequences, says Peter Weingarten, principal at Gensler in Oakland, California. ‘It’s not about age, but the cohort you are designing for new lifestyles.” His use of the word ‘product’ is deliberate, he adds. “It’s similar to the analogy of a smartphone, where there are many communal services that allow you to customise your social space and social preferences.”

Weingarten has noticed that millennials have very different priorities to the post-war babyboomers now reaching retirement age. ‘Boomers wanted to own stuff. They were encouraged to value domain. What’s my status at work, where’s my house, do I own a car? Now it’s not about the ownership of things, it’s about the experience of things.’ This is partly through necessity, as recession has diminished the prospects of home ownership for many. But it’s also because digital technology makes it easier than ever before to temporarily acquire things people previously aspired to own. Collaborative consumption apps such as Airbnb and Uber give smartphone users instant access to homes and cars anywhere in the world with just a few swipes and taps. With a world of instantaneous information in the palm of their hands, millennials also demand more from the spaces they occupy physically. They prize quality of life and easy access to shops, entertainment and places to spend time with friends, and prefer to live in urban areas that are walkable and well-connected. Millennials are now luring employers back into cities too. During the 20th century, many firms left downtown areas in favour of suburban campuses – a paper for the National Bureau of Economic Research in the US found that the proportion of jobs in American city centres fell from 65% in 1960 to just 16% by 1996. This trend has begun to reverse – according to the Brookings Institution, the number of city centre jobs grew steadily by 0.5% a year between 2007 and 2011, compared to an annual loss of 0.1% on the peripheries. Not-for-profit Smart Growth America carried out a survey of 500 companies who had moved back into cities, and found that by far the biggest reason was to attract and retain talent: being located in a vibrant, amenity-rich neighbourhood with good public transport links was seen as a key differentiator.

‘Millennial culture is characterised by a blurring of the lines between work and leisure, which is inevitably reshaping corporate structures too. Companies are adopting less hierarchical models, says Weingarten, and workplaces have to adapt. ‘Employees are no longer just workers, they’re entrepreneurs, and there’s much more of a sense of community-based coaching and mentoring in the workplace. We see this all the time when we sit down with our Fortune 500 clients who are looking to go into these mega-towers and super-tall buildings. They leverage mobility and technology, but want to see more true connectivity than just what is offered by technological solutions, so the new high-performance building is not just a technological marvel, it’s also a cultural touchstone, it’s a brand beacon, it’s an innovation accelerator.”

The quest for innovation is also driving higher occupancy levels and much bigger floorplates, says Weingarten. He quotes a famous MIT study that began in the 1970s: “If you work on the same floor as someone, you have a 95% chance of running into them in the course of your day. We know that face-to-face interaction is the key driver behind innovation so that’s a very important statistic.” If people are on different floors, this drops to 5%, and if they’re in different buildings, it’s just 0.02%. “You’re lucky if you see them at all as you’re traversing the asphalt of the parking lot to get to your car.” Where there are no constraints on space, companies would ideally want floorplates to be as big as possible – Apple’s new Cupertino campus will have circular floorplates with a circumference of more than a mile, with approximately 840,000 sq ft of space on each of its four floors – but recent studies show that there is a diminishing return after a certain point. Such expansiveness clearly isn’t possible in the dense grid of a city. But designers are finding other ways to create the interactivity of a horizontal campus in vertical form. Woods Bagot is designing a ‘vertical campus’ for a client in Jakarta, which features a broad range of amenities in the base and a series of interconnecting atria spiralling down the building to bring people together (see page 54).

There will also be a greater range of amenities in the high-rise residential buildings of the future. This is partly down to density – there simply won’t be room to build duplicate spaces for everything. But it’s also down to a combination of demographic and social trends, which are causing household sizes to shrink. Millennials are settling down later, fertility rates are declining, divorce rates are climbing, and older people want to remain independent for as long as possible as life expectancy rises. According to data from Euromonitor, one- and two-person households will see the greatest growth globally between 1980 and 2020 – both up by 18%, compared to an increase of just 8.1% for couples with children. Single-person households are already the dominant group in western Europe and North America, and this will be the fastest-growing profile worldwide between 2014 and 2030. The majority of these households are to be found in cities. The biggest occupier groups for the high-rise buildings of the future will be young singles or couples, successful business people without children, and retirees, says Igor Kebel, design director of Blankerg Fraser, which has a number of tower projects in the booming Melbourne market. “The world is turning around,” he says. “That makes the demographics very specific and sets different parameters for design. It allows us to develop new products for new lifestyles.” He uses the word ‘product’ is deliberate, he adds. “I use the analogy of a smartphone, where there are many communal services that allow you to customise your social space and social preferences.”
These are not necessarily public spaces but hybrids, funded privately and used collectively. Apartments themselves will have elected residents, but there would have to be on-demand access to a larger one if they were throwing a party or having family to visit. “It’s hotel amenities in a residential package, so people live in a hotel-like environment and pay an extra fee for that. Residents will have their own cinema, meeting spaces, dining rooms, living rooms, lounges, spas — you name it. With the aging population, you would not want to go through a hotel lobby.” Gehl typically allows between 2.5-4m² additional amenity space for each apartment. “Clients will pay for it because sales are low.”

The other reason why these spaces will be so important is because the future is potentially a much lonelier place, says David Symons, director of sustainability at WSP | Parsons Brinckerhoff in the UK, who is leading its Future Ready initiative. “Advances in technology mean you could potentially work from home and have your shopping delivered to you — there might be a certain group of people who live on their own and never leave the house. That’s not necessarily a good thing. Interaction then becomes really important — people will value it much more in the future.”

Buildings will need to be designed to compensate for more solitary lifestyles, he says. “In many tall apartment buildings, there is a slit in interaction with other residents — you just get up in the lift, come out into your stairwell and go into your house. That’s not encouraging interaction or providing a design that is good for interaction.” Symons cites the example from a book by Charles Montgomery, principal at urban laboratory Happy City, of a wealthy Vancouverite who swapped the panoramic views from his fabulous but lonely apartment for a cramped townhouse where he could get to know his neighbours. The townhouse neighbours were not inherently more suitable than the apartment dwellers, but they each had a porch overlooking a shared garden, which provided regular opportunities for easy contact with other people. This reflects the soft edges promoted by Danish urbanist Jan Gehl in his seminal 1971 study, Life Between Buildings. He argued that houses should have small private front gardens to bring residents outdoors to engage with neighbours and passers-by. For maximum interaction, they should be small enough to allow conversation but large enough so there is space to retreat — Gehl’s research showed that the optimal size was 10ft 6in.

Translating these lessons from horizontal spaces to vertical ones will be the next great urban design challenge. When cities are denser and buildings much larger, high-rise developments will need to offer more collective spaces, for the good of society and our own sanity. “When we see this kind of density, we immediately think of the need for something more than occupied space, sold space, work space, living space — something more public or collective that could animate such a mass of habitation or work,” says James von Klemperer, president and design principal of Kohn Pedersen Fox Associates. The ideal is to infuse large structures with a series of places where people could wander or congregate, just as they would in a city streetscape. “To create a very complex, inviting and interesting set of sectional experiences.”

In mega-projects, architects can create “vertical cities” by taking advantage of the gaps between different uses to create gathering places. KPF’s JR Central Towers project in Nagoya put almost 5 million ft² of retail, office, hotel and public space stacked on top of a bullet train station — it holds a Guinness World Record as the largest station building in the world. There is a range of public and outdoor spaces throughout the building, as well as Sky Street — a huge concourse on the 15th floor of the podium joining the two towers, which offers panoramic views to anyone who takes the elevator from the station. “Part of the challenge is to show the vertical transportation in a very visible way at the front to bring people up naturally,” says von Klemperer, “so that they feel not compelled but interested in achieving these higher levels where they could do things not necessarily programmed by their rental agreements but by some sort of public street.”

At Hysan Place in Hong Kong, another mixed-use scheme of 716,000 ft², the building is conceived as a series of shifting façades and “beckoning to the crowds to come out of the building, zigzagging up the outside of the building, zigzagging up the façade and beckoning to the crowds to find retail space at the upper levels,” says von Klemperer. “It’s finding opportunities to make spaces. The melange of tunnels and walkways that go through this project becomes a sort of jungle gym for a series of truly public spaces through this mixing chamber of retail, and ends up in pockets of space above that are semi-public. So there’s a pallet of interior spaces that animate this sectionally articulated piece of the city.”

It’s not easy to create genuinely public spaces in mega-projects, but it can be done. KPF’s design for the 155m Lotte World Tower in Seoul includes a cultural centre, kids’ park, jazz bar and aquarium as well as a 2,000-seat concert hall, which will be the home of the National Orchestra of Korea. “It’s not a piece of commercial formula, it’s mandated by the city,” explains von Klemperer. “But the point is that it is possible to provide truly public space of a civic sort within the complex section of a high-rise building.”

A mix of facilities is important for keeping highly skilled workers in cities as they grow older, adds Steve Burrows, executive vice president at WSP | Parsons Brinckerhoff in San Francisco. “We need to consider all the things that make a living city,” he says. “Sport for example — are stadiums civic buildings? Should they be downtown? And how do hospitals and schools fit into vertical cities? In order to capture families, something’s got to change. How are our cities going to become liveable for people throughout their entire life cycle?”

One of the phrases von Klemperer uses is “building community” — a concept that will become more and more relevant as the life of towers extends throughout the day and night and people spend increasing amounts of time in high-rise developments. This is something that Woods Bagot has also been considering in the context of the vertical campus. “You have to think about what makes a strong community,” says global workplace leader Steve Mange. “It’s not just an office — you have to supplement that with all the services and experiences that people need.” In the design of these buildings, he thinks that the role of architecture crosses over into urban planning. “We are in the middle of an unprecedented migration to urban centres, so it’s up to us as a profession to build something that is sustainable, where people want to be, that supports the kind of community life that we’re all looking for.”

“When you think about high-rise office development over the last 20 or 30 years, a lot of the metrics are consistent,” adds Woods Bagot principal John Britton, based in San Francisco. “Critical factors include floorplate efficiency, tightness of the core, effectiveness of elevating, appropriateness of lease spans. Now there’s this increasing focus on the human aspect of a development — a chance to look at buildings through the lens of an occupant, at the quality of life that the building can help them to achieve. For us, that’s a new challenge and a new way to look at buildings.”

JAMES VON KLEMPERER, KPF

THE VERTICAL SOCIETY ///
ACROSS ASIA, INNOVATIVE TOWER DESIGNS ARE INCREASING THE CONNECTIVITY BETWEEN FLOORS TO MEET THE VARIED NEEDS OF MODERN BUSINESS

While 20th-century workplace trends were led by US companies, the high-rise, high-tech offices of the future are being pioneered in Asia. Architect Woods Bagot has designed a ‘vertical campus’ in Jakarta for PT Telkom, Indonesia’s largest telecommunications company. When completed, it will bring together 8,000 staff in 25 corporate entities from three buildings of 16, 22 and 48 storeys, linked by a multi-storey podium. “There needs to be a fabric that links the buildings, so the podium provides all those amenities that you would see across a horizontal campus – everything from gathering spaces, to food and beverage, theatres, medical clinics and gyms. The horizontal spine connects the three buildings, but it’s also the cultural connection,” says Britton. “When the distribution of amenities is mapped out on paper, the vertical campus doesn’t look too different to the horizontal one.”

What really sets a vertical campus apart from a conventional office tower is the connectivity between different floors. “We did a survey with the client to find out the maximum number of floors people would be willing to walk, and it turned out to be about three before they got into an elevator.” The result is a series of three-storey atria spinning down through the building, rotating from the common core to balance the structural loads. Spaces are connected by staircases to encourage free movement between floors, and filled with natural light. “We’ve tried to incorporate active uses, we want them to be very active, very visible areas. We’ve got meeting pods and work areas on the ground floor of the atria, and we want people to come down and collect in these various spaces.”

The PT Telkom tower is a tailor-made response to one organisation’s needs. But Asian developers are also leaping on vertical campus ideas to set their schemes apart from the competition. Woods Bagot is also designing the speculative Tradewinds Square development in Kuala Lumpur, which will comprise 500,000m² and have a population of 18,000. There will be a 625m office tower and a 525m mixed-use tower of residential and serviced apartments, again linked by a podium with 100,000m² of retail and amenity space.

The design envisages the office building as five 15-storey tiers, each one comprising about 40,000m². Between each tier, there are two mechanical floors, and two sky lobby transfer floors. “There is the potential to market a tier as a package to class A international corporate clients and allow them to tailor it to their uses,” says Britton. “So if a company wanted to take a very campus-like approach, with breakout rooms, cafeterias, small theatres, they could capitalise on those interstitial spaces. There’s close to 6,000m² available on each set of transfer floors, so there’s an opportunity in how you develop them.”

“The client was very interested in the application of atria to the project. There are a lot of different strategies for how you do that, and it does not have to apply in every tier if the market demands larger floorplates. But the idea is to get this spiralling connectivity, more collaborative space, breakout space, dynamic space, more light and air throughout the building.”

The campus approach may mean sacrificing office space, but it also helps you to stand out in a crowded market, says Steve Hargis, global workplace leader at Woods Bagot. “There’s quite a lot going on in KL, and there is potential for market saturation. So how do you become the go-to building? What sets your development apart from the rest? It’s a future-proofing discussion.”

The vertical campus may even offer an advantage over the horizontal version, suggests Hargis, especially where it includes apartments too. He has watched Silicon Valley campuses grow from a few buildings to dozens, sometimes hundreds. “It was used to be about being compact and secure, and controlling your future – you could expand across the street, or you could contract,” he says. As companies have grown, distances between buildings become unwieldy and circulation is increasingly about bikes, buses and cars. The distances between spaces on a vertical campus are significantly shorter in comparison.

“The proximity of residential really changes the game,” says Hargis. “That’s something that the corporate world is really struggling with on a horizontal campus. In a denser urban environment, it’s much easier to get that work-live-learn-play model, which is one of the key components of making a campus work.”

“THE IDEA IS TO GET THIS SPIRALLING CONNECTIVITY, MORE COLLABORATIVE SPACE, BREAKOUT SPACE, DYNAMIC SPACE, MORE LIGHT AND AIR THROUGHOUT THE BUILDING”

JOHN BRITTON, WOODS BAGOT
RETURN TO SLENDER

THE WAVE OF SUPER-SLENDER RESIDENTIAL TOWERS RISING OVER MANHATTAN COMBINES THE LATEST STRUCTURAL GYMNASTICS WITH THE GRACE OF NEW YORK’S CLASSIC ART DECO SKYSCRAPERS

You might think that 111 West 57th Street is an extremely thin building. But 111 West 57th Street is undeniably slender in high-rise terms – a super-slim building certainly, and perhaps even a ‘mega-slim’ one. In the global race to build tall, it’s no longer all about height. The other number that everyone wants to know is the aspect ratio: the relationship between a building’s height and its width. 111 West 57th is one of a new breed of towers that are pushing that ratio to previously impossible levels.

New York building codes consider a building to be slender when its height is more than seven times its width at the narrowest point. But the recent crop of luxury residential towers in the city’s Midtown go far beyond this. In 2014, One57 raised eyebrows with an aspect ratio of 8.1, becoming the tallest residential building in the city at 1,004.9 feet (306m). It has been quickly overtaken by 53W53 (12:1), 30 Park Place (10.5:1), and 56 Leonard Street (13:1). But 111 West 57th Street beats them all with a staggering aspect ratio of 24:1. Rising from a plot of just 80ft by 590ft, it is 1,435 ft tall (437m).

“This almost three times more slender than what used to be considered a slender building,” says Silvian Marcus, director of building structures at WSP | Parsons Brinckerhoff in New York, the structural engineer on the project. “It’s going to be a world record. But we are working on others that are going to be even more slender.”

The logic of slender buildings is to derive the greatest possible value from expensive, constrained city-centre plots. So it’s no surprise that the super-slim revolution began in New York, a pioneering skyscraper city with some of the most sought-after real estate on the planet and a clamouring global customer base. “There’s something unique about living in Midtown and having that perfect view,” says Koster. “Everyone understands the beauty and value of being able to build something like this in this location.”

Where these towers differ from previous generations is that they are not commercial but residential – typically, each floor comprises a single luxury apartment. This only adds to the challenge for the structural engineer. High-rise engineering is a very specialised discipline, and many of the technologies used in conventional low-rise construction would be too heavy, inefficient and expensive if applied to tall buildings. But super-slim changes the game yet again. There is no theoretical limit to how tall a building can be, but the taller you go, the stiffer and stronger the structure needs to be. A skinny building will also need to be stronger than a broad one to withstand wind and seismic forces – but the structural components must also be kept as unobtrusive as possible to maximise usable space and uninterrupted views. A building’s core is an important source of stiffness but this can be proportionally smaller in a residential tower than a commercial one. Conversely, the higher a tower and the more people living there, the greater the elevator capacity needs to be, and the amount of mechanical, electrical and plumbing infrastructure increases. “All of this can swell the core and encroach on living space,” says Fatih Yalniz, vice president of building structures at WSP | Parsons Brinckerhoff in New York, who carried out analysis to establish the most effective frame for 111 West 57th Street.

Hundreds of metres above the ground, wind flows are completely different – more akin to what an airplane would experience. In managing the building’s response, their goal is not to eliminate all movement, but to control the pace of acceleration. Marcus likens it to being in a car: passengers only sense the movement when accelerating or braking, not when travelling at a constant speed. “It’s impossible to stop a building from moving, but we can control that movement so the majority of people will not feel it.” As residential buildings, these towers must meet more stringent standards than offices: there is no question of evacuating an apartment tower in the event of a hurricane, and people need to feel safe and comfortable in their homes no matter the weather. “A person coming home to the 50th floor does not expect to move in the wind,” he points out. “Slender towers have such a small plan area, we have to mobilise everything possible to achieve that.”

“IT’S GOING TO BE A WORLD RECORD. BUT WE ARE WORKING ON OTHERS THAT ARE GOING TO BE EVEN MORE SLENDER”

SILVIAN MARCUS, WSP | PARSONS BRINCKERHOFF
"THERE'S SOMETHING UNIQUE ABOUT LIVING IN MIDTOWN AND HAVING THAT PERFECT VIEW"

SIMON KOSTER, JDS DEVELOPMENT GROUP
In the last golden age of New York skyscrapers, every developer wants to set their building apart with an iconic design as they compete to attract the attention of a very discerning global client base.

"Every building is unique and it needs a unique structural concept," says Hezi Mena, senior vice president of building structures at WSP | Parsons Brinckerhoff in New York. "There is no set formula."

There are however some proven strategies, which Mena and his colleagues have refined as they have achieved increasingly slender designs. The first step is to stiffen the structure. For this reason, super-tall buildings are invariably concrete rather than steel. Using concrete for the core of the building and connecting shear walls enables the engineers to minimize structural elements within the apartments themselves, giving the occupants maximum flexibility on layouts and preserving those all-important views.

But strength alone is not enough. "Brute force does not work here," says Jeff Smilow, executive vice president of building structures at WSP | Parsons Brinckerhoff in New York. "We have fewer engineering opportunities so we have to be more innovative. We have to work with the wind instead of fighting it. The goal is to find out what works, what shape responds best to the wind and reduces the acceleration, not just to add structure unnecessarily."

One option is to adjust the shape of the building to make it more aerodynamic, introducing openings to allow the wind to pass through or adding curves at critical locations along the façade to minimize the "vortex shedding" response which causes high acceleration. WSP | Parsons Brinckerhoff works closely with architects to refine the shape of a building, using wind tunnel analysis.

The engineers can also reduce the acceleration of the movement by using a damper, similar to the shock absorbers in a car. This is a heavy weight placed high up in the building to absorb the shock and reduce the acceleration of the building. However, if the building moves too much, the damper can be activated to reduce the acceleration of the building, similar to the shock absorbers used in the wind. This is achieved by using a tuned mass damper at the top of the building, which is a weight that moves in sympathy with the movement of the building, reducing the acceleration of the building.

For 111 West 57th Street, WSP | Parsons Brinckerhoff has achieved the necessary stiffness with two shear walls running the height of the east and west elevations of the building. This leaves the others completely clear, so that residents can enjoy unimpeded views of Central Park to the north and Midtown and downtown Manhattan to the south. There is also a tuned mass damper at the top of the building, concealed by the lightweight steel structure that completes its delicate tapering form.

Dana Getman, associate principal at SHoP Architects, the lead designer, argues that far from being a new typology for New York, super-slim is just a return to its classic era of skyscrapers. "That’s what’s interesting about this new generation of towers," she says. "Pre-war, before air-conditioning, buildings tended to be thinner to get people closer to light and air. In these new buildings, because they’re residential, light and air again becomes an issue and we have an opportunity to look back to historic buildings and what makes those so special."

With this in mind, SHoP has approached 111 West 57th Street with the ambition of creating a classic Manhattan skyscraper. In fact, while the building’s super-slim form may look startlingly new, it is itself a heritage project. As well as the construction of the tower, the scheme involves the complete restoration of the 1957 Stairway building, an Art Deco landmark for the city. The tower has been carefully located in deference to its historic neighbour. "We could have built a tower directly adjacent to the Stairway building without city approval, but it wasn’t what was right for the landmark and it wasn’t right for the tower," explains Getman. "So we worked with the Landmarks Preservation Commission to relocate the tower further back on the site. It’s really set back so you don’t really perceive it from the street, and instead we’re creating a very open atrium that frames the landmark building to be read in its historic context."

The building is very finely tuned. When SHoP looked around at the city’s best-loved buildings, a common theme was “their shadow, their depth, their solidity,” says Getman. This is what they have tried to recreate with the material palette of 111 West 57th Street. These amazing shear walls gave us some solidity to play with, so we had the opportunity to do another style that wasn’t just glass,” she explains.

The building is very finely tapered. Getman describes it as “feathered” rather than stepped back – which gives it a human scale despite its giant size. Each of these small steps is marked by a solid terracotta pilaster, with a curving bronze filigree stretching between the pilasters to climb the building. The pilasters are made from 25 unique shapes repeating across the façade in an undulating pattern, which will create a pattern of shadows from a distance. The filigree adds a level of detail that only will be revealed as you get closer, as a homage to the rich façades of New York’s classic Art Deco buildings. "We’ve been working hard to find that balance between the ‘hardness’ that you find in the old buildings - so the terracotta has five different glazes to give it a bit more texture - but at the same time, it’s developed using state-of-the-art technology to track the pattern across the façade,” says Getman. The bronze has also been left unfished so that it will age gracefully with the building.

Enormous care has been taken over the appearance of 111 West 57th Street, and the whole design team has a role in play in ensuring the integrity of these finishes over the life of the building. "The structure itself will be able to flex, but other elements are not as flexible unless we coordinate their design and engineering,” says Cynthia Liu, senior vice president at WSP | Parsons Brinckerhoff in New York and project manager for 111 West 57th Street. "We don’t want to see cracks on plaster, or glass, or leaky windows because the building is moving too much."

The ultimate success for the engineer is when their art goes unnoticed. The goal is for building occupants to live in total comfort, unperturbed by any movement. But as people are living greater distances above the ground, there is an increasing awareness of the systems and the strategies that make high-rise living possible.

Koster says that while office occupiers rarely concern themselves about the structural systems of their workplaces, these are exactly the sorts of thing that prospective residents want to know. "Future homeowners ask questions about where they’re going to live," says Koster. "We’re having conversations about the structural damper, shear walls, the overall stiffness of the building, movement, sway, slenderess... All these things are just starting to become part of the residential buyer’s lexicon in New York.

"SUPER-SLENDER IS A RETURN TO THE PROPORTIONS OF CLASSIC NEW YORK SKYSCRAPERS. WE HAVE AN OPPORTUNITY TO LOOK BACK TO HISTORIC BUILDINGS AND WHAT MAKES THOSE SO SPECIAL”

DANA GETMAN, SHoP ASSOCIATES
Apart from its extreme slenderness, it is perhaps the simplicity of 432 Park Avenue’s structure that has already made it a favourite landmark on the skyline.

Designed by Rafael Viñoly, the building is a perfect square, with sides of 28.5m, and this regularity is echoed by the 3m x 3m windows punched into the frame, six on each side of the building. “It’s quite astonishing to see a structure so pure,” says Hadi Mena, senior vice president of building structures at WSP | Parsons Brinckerhoff in New York. “We tried to simplify the structure as much as possible so as not to conflict with the architect’s vision.”

The structural solution developed by the WSP | Parsons Brinckerhoff team does have a pleasing simplicity, though this belies the extensive testing and refinement that went into developing it: 432 Park Avenue is made of two high-strength concrete tubes. The interior tube forms the building’s core, measuring 9m x 9m, containing the lifts and ingress stairs. This is the backbone of the building. Its reinforced-concrete walls impart considerable stiffness, with the added advantage that concrete also maximises lateral living space. The extra height allowed the engineers to add a second floor to the building’s core, helping to keep the building’s movement and slow its acceleration to acceptable limits.

Floor-to-ceiling heights in the apartments are an extremely high 3.8m, “higher than is conventional in New York. This not only adds to the prestige of the apartments, it also maximises lateral living space. The extra height allowed the engineers to add a second return to the access stairs in the building’s core, helping to keep it compact, and resulting in 250ft² of additional living space per floor.”

SILVIAN MARCUS, WSP | PARSONS BRINCKERHOFF

The slenderness is not the only challenge with these buildings – 410ft is a long way to distribute power and water. If you ran a column of water up the whole length of the building, the pressures would be enormous. At 432 Park Avenue, we’ve essentially broken up the building so it’s really a stack of six smaller high-rise buildings. That way we keep shaft sizes and mechanical rooms smaller, and it allows us to control the pressures better.

Every building is a prototype, but the systems we design for these super-tall luxury buildings will eventually filter down to the more typical ones. We’re setting a new standard.”

“IT’S SIMILAR TO MAKING HOLES IN THE SAIL OF A BOAT… WE FLOW WITH THE WIND”

SILVIAN MARCUS, WSP | PARSONS BRINCKERHOFF

The mechanical or ‘drum’ floors also play a crucial role in making the building more thermodynamic. Early wind-tunnel testing showed that the structure was suffering from significant vortex shedding even under relatively low winds. This effect occurs as wind moves past a building, creating a fluctuating low-pressure area behind it and causing it to vibrate. The engineers’ solution was to leave the glazing out of the mechanical floors to allow air to pass through the building at regular intervals, effectively making it more aerodynamic. “It’s similar to making holes in the sail of a boat,” says Silvian Marcus, director of building structures at WSP | Parsons Brinckerhoff, the principal in charge of the project. “Instead of making the building even stiffer to overcome the movement, we flow with the wind.” There are also two tuned mass dampers on the 84th floor, weighing 1,300 tonnes. Supported on cables and hydraulic cylinders, these concrete weights counteract the building’s movement and slow its acceleration to acceptable limits.

The uniqueness of the building is the result of the wind-matching process of the design. “At every 12th floor these tubes are joined by stiffening beams, accommodated in the double-height plant rooms. The main benefit of the process is the precise matching of the pressures created by wind with the structural response of the building.”

“There’s a very sleek look that has to be maintained and we have to coordinate with the architect’s vision. If you’re comfortable but you don’t see what’s making you comfortable, that’s a good design. One of the toughest parts of what we do is fitting everything into the same space. A building like 432 Park Avenue is put together like a watch. One solution is to put the ductwork or pipework in the ceiling. But with 15ft 6in ceilings, you don’t want to give any of that up because that’s what sells the space. We designed the building systems so that people can set up their homes however they want – they don’t have to work around the systems. But the dimensions of the rooms are very large, so we have to work out how to distribute air around those spaces without breaking them up or putting systems in the middle. You have to do it in a delicate way, rather than blowing air across the room and giving people hair the Einstein look. We carry out extensive modelling to simulate air flows, using the same programs that are used to designing wings on jet aeroplanes. We also have systems to introduce outdoor air into each residence – if you’re 1,000ft up, you can’t open your windows for fresh air because it’s a different climate zone up there. Last winter the temperature in New York didn’t rise above freezing for six weeks. But we have to make sure our design provides comfort everywhere in the space, no matter what. It can’t be a little cold if you’re near the window, and these are big pieces of glass, so condensation was a real concern. We did many, many studies on exactly how to position the air slot so that the air would bathe the glass in warm air to minimise the downdraughts. We even introduced air down low in very concealed devices so that if any cold air does fall down the glass, it hits that warm air on the floor and that warms it back up.”

“ONE OF THE TOUGHEST PARTS IS FITTING EVERYTHING IN THE SAME SPACE. THIS BUILDING IS PUT TOGETHER LIKE A WATCH”

SILVIAN MARCUS, WSP | PARSONS BRINCKERHOFF

SUPER-LUXURY SERVICES AT SUPER-TALL HEIGHTS

BY GARY POMERANTZ, EXECUTIVE VICE PRESIDENT OF BUILDING SYSTEMS, WSP | PARSONS BRINCKERHOFF
DESIGNING SKYSCRAPER CITIES   

56 LEONARD STREET

“EVERY FLOORPLATE HAS TO BE ABLE TO SUPPORT ITSELF, SO WE HAD TO TREAT EACH ONE IN AN INNOVATIVE WAY”
HEZI MENA, WSP | PARSONS BRINCKERHOFF

56 Leonard Street has only just topped out but it’s already one of the most distinctive landmarks on the Lower Manhattan skyline. The building is a staggered series of irregular boxes, with cantilevers ranging from 10ft to 25ft, designed by Swiss architects Herzog & de Meuron – the practice behind the ‘Bird’s Nest’ Olympic stadium in Beijing. When complete, it will provide 145 luxury apartments in the TriBeCa district, conceived by the architect as “houses stacked in the sky.”

The engineering team’s solution is to use a very strong concrete structure, concealed to allow a completely glazed exterior with views from almost every angle. The central core is linked to the external columns by outriggers at the mechanical levels, 32 and 46. At the top, is the ‘swimming pool’ – a slash damper filled with 130,000 litres of water to temper the building’s movement in the wind.

Supporting the cantilevers was one of the biggest conundrums for Mena’s team. For the smaller ones, the thickness of the concrete floor slabs provides sufficient support. For the larger ones above 15ft, there are additional beams, and for the very largest, a Vierendeel truss – a perpendicular column that engages two floors, without obstructing layouts or views. Throughout the structure, there are many walking columns, where loads are transferred from one location to another as they progress down the building. There are no dividing shear walls in the apartments at all, to allow residents to lay out their living spaces as they wish, or to combine apartments horizontally or vertically.

The greatest cantilevers are at the top of the building. The uppermost 10 floors each comprise just one apartment, known as a skyvilla. “It won’t feel as if each occupant is living in a high-rise building but in a house in the country,” says Mena. “They will have views all around, and they won’t really be aware of who’s above or below them. It will be a very different experience to your average New York City apartment.”

53W53 is not just a super-sleender tower but a work of art – as befits a building that will sit above New York’s Museum of Modern Art, and even house 50,000lft² of additional gallery space in its lower floors. Rising gracefully to a height of 1,050ft (320m) over Midtown, it tapers at gently shifting inclines. Randomly spaced diagrids roam freely up the façade, to be reflected in the unique geometry of each of the 139 apartments.

But that diagrid is not only an aesthetic flourish. The slenderness of the building means that there is no room for superfluous structure. High-strength concrete and reinforcing steel will be used to construct a shear-wall core, but the façade has to play an important supporting role too.

This presented an interesting challenge for the engineering team, not least because architect Jean Nouvel was also adamant that the building’s complex façade should be a genuine expression of the structure beneath. “Normally we are the ones dictating where the columns go but this was the opposite,” explains Gustavo Oliveira, vice president at WSP | Parsons Brinckerhoff in New York. “We couldn’t add diagrids in, we had to mimic what was on the façade, so it was an iterative process with the architect. We had never approached a building that way before.”

The other unusual feature of 53W53’s diagrid is what it is made of. Nouvel’s original design was intended to be built in steel. But the floor-to-floor heights of a steel structure would have limited the number of stories too much, so WSP | Parsons Brinckerhoff investigated how to create the same aesthetic in concrete instead – “the first time that a diagrid structure of this magnitude and complexity has been done in concrete,” notes Oliveira.

Aside from the complex structural gymnastics, the team also spent considerable time evaluating how 53W53 could actually be delivered. Because of its complexity, construction will take more than five years, around double the programme for a more conventional design. One of the biggest challenges was designing the nodes where different structural components would join. Reinforcement for perhaps seven or eight elements had to fit into the same node, and then the concrete had to be able to flow freely to enclose it and produce a sound structure. Oliveira’s team worked closely not only with the architect but the construction team, which included commissioning a mock-up of the rebar. Rather than just coming up with solutions that looked good on paper, we assessed the constructability of the job too. That’s not normally part of the engineer’s role but this is such a unique building, it needed a unique approach.”

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But that diagrid is not only an aesthetic flourish. The slenderness of the building means that there is no room for superfluous structure. High-strength concrete and reinforcing steel will be used to construct a shear-wall core, but the façade has to play an important supporting role too.

This presented an interesting challenge for the engineering team, not least because architect Jean Nouvel was also adamant that the building’s complex façade should be a genuine expression of the structure beneath. “Normally we are the ones dictating where the columns go but this was the opposite,” explains Gustavo Oliveira, vice president at WSP | Parsons Brinckerhoff in New York. “We couldn’t add diagrids in, we had to mimic what was on the façade, so it was an iterative process with the architect. We had never approached a building that way before.”

The other unusual feature of 53W53’s diagrid is what it is made of. Nouvel’s original design was intended to be built in steel. But the floor-to-floor heights of a steel structure would have limited the number of stories too much, so WSP | Parsons Brinckerhoff investigated how to create the same aesthetic in concrete instead – “the first time that a diagrid structure of this magnitude and complexity has been done in concrete,” notes Oliveira.

Aside from the complex structural gymnastics, the team also spent considerable time evaluating how 53W53 could actually be delivered. Because of its complexity, construction will take more than five years, around double the programme for a more conventional design. One of the biggest challenges was designing the nodes where different structural components would join. Reinforcement for perhaps seven or eight elements had to fit into the same node, and then the concrete had to be able to flow freely to enclose it and produce a sound structure. Oliveira’s team worked closely not only with the architect but the construction team, which included commissioning a mock-up of the rebar. Rather than just coming up with solutions that looked good on paper, we assessed the constructability of the job too. That’s not normally part of the engineer’s role but this is such a unique building, it needed a unique approach.”
America was the birthplace of the skyscraper. China is undoubtedly the home of the super-tall tower. The Council for Tall Buildings and Urban Habitats defines a tower as ‘super-tall’ when it tops 300m. So far, 97 have been completed around the world and 56 are in China. Of the 41 super-tall towers under construction, 27 are in China too. By 2020, it will be home to 14 of the tallest 20 buildings in the world.

Vincent Tse has a front-row seat for China’s extraordinary high-rise boom, as managing director of building systems for WSP | Parsons Brinckerhoff in the China region. Of the CTBUH’s projection of the world’s 20 tallest buildings in 2020, his team has worked on 11, providing full building systems design consultancy on six and partial consultancy on a further five.

He sees the era of the ‘mega-tall’ building of 500-600m fast approaching. “It’s mainly due to the competition among all major world cities – Seoul, Jeddah, Dubai, New York, Kuala Lumpur, Beijing, Shanghai, Shenzhen, Taipei, Bangkok, Jakarta… Every one of them wants to be number one of some kind, so that the whole world remembers their landmark towers. That’s why developers and city planners are building mega-tall.”

But buildings are not only getting taller, they are also becoming more complex. With architects and developers seeking to stand out, ‘iconic’ shapes are the norm – no two buildings are the same. And while 90% of high-rise buildings were single-use offices before 2000, now 80% of the mega-tall towers under construction are multi-use, combining commercial space with luxury hotels, service apartments, retail and leisure spaces.

This is partly for technical reasons, says Tse, and partly commercial. “All towers will change shape as they get higher to minimise the impact of the wind. The floorplates will be smaller in the upper floors, so most mega-tall towers will have hotels, CEO offices and observation decks at the top. Or there will be apartments in the middle of the tower rather than just offices, to give a higher cash return. Having multiple building functions also gives the buildings life day and night. A pure office tower has no life at night or at the weekend.”

For the services engineer, however, this makes buildings much more complicated. They must overcome not only the gargantuan pressures involved in pumping water up the best part of a kilometre into the sky or the combined resistance of hundreds of metres of electrical wiring, but also serve the potentially conflicting needs of different user groups, while fitting all the kit into the smallest possible space. “As buildings get higher and higher, with mixed-use, it’s like a jigsaw to fit everything within the core,” says Tse. “The majority of buildings have more than 100 storeys and there might be seven different components. What’s more, advances on one project can only ever serve as inspiration for the next one: solutions can never be replicated. ‘If you try to copy, you will make a mistake.’”

Tianjin CTF Financial Centre will be 530m tall, with retail and parking space in the podium and 100 storeys of offices, service apartments, a hotel and club all
stacked on top, providing a total floor area of 350,000m². The problem is that the space is not necessarily where the services engineer would like it to be. “The most difficult thing when designing the services for tall buildings is always the shape,” says Tse. “This is a very slender tower and by the time you reach the top, the whole building shrinks like a bowling pin. At the top levels, the floorplate is very small and the core is only around 19m square.”

The smaller floors lend themselves to hotel accommodation rather than offices, but how to fit the hotel lobby – and its considerable vertical transportation requirements – at the point where the core is at its thinnest?

The solution was to put the hotel at the top, but with the hotel lobby below the service apartments, keeping the core as compact as possible. It is shaped like two square tubes, one inside the other. The inner part of the core contains all the building systems, local lift shafts and the fire escape stairs, and runs the full height of the building. The outer part of the core contains the shuttle elevators. “The big core stops when you get to the hotel lobby, and by the time you get to the hotel floors, everything’s in the small core, which is tiny,” explains Tse.

“THE BUILDING IS TAPERED NOT ONLY AT THE TOP BUT AT THE BOTTOM TOO, SO THE FLOOR AREA IS NOT THAT LARGE AT THE BASE”

EDDIE LEUNG, WSP | PARSONS BRINCKERHOFF

Architect Kohn Pedersen Fox’s crystalline design has chiselled setbacks, so that the floorplates become progressively smaller – which means that the core must too. To make it as efficient as possible, a vertical transportation system of shuttle elevators will whisk building occupants to sky lobbies at different heights. The offices in the lower storeys will be served by a double-deck shuttle and local elevators, while the service apartments, hotel and club on the upper storeys will have their own separate shuttles. “When you need more elevators and better performance, you need to increase the size of the core,” says Herbert Lam, director of building systems at WSP | Parsons Brinckerhoff in Hong Kong. “But the rule of thumb is that each floorplate must have a minimum efficiency of 70% usable office floor area. That’s a constant balancing act for the services engineer. It requires intelligent planning to optimise the central core to make sure the performance of elevators and building systems is excellent, and at the same time that the floorplates are efficient with high rental returns.”

As mega-tall projects are larger and take more time than smaller buildings, they are very vulnerable to changes in the market. Changes of use are not uncommon midway through, even when the design is relatively advanced. Beijing’s 406m CBD Z6 Sino-Ocean Centre will be the city’s second tallest building when it completes in 2018, and was originally planned as a single-use office building. Following a change of ownership, it now includes a six-star MGM hotel on levels 45-62, executive apartments on 65-67 and a club at the top. This meant a radical rethink of the vertical transportation system in order to make the overall building design function as it should. The 36 office floors are now divided into four zones, with the lower two served by direct lift from the base. To access the third and fourth office zones, occupiers will now transfer via a double-deck sky lobby at floors 31 and 32. The introduction of the sky lobbies made all the difference, says Eddie Leung, director of building systems at WSP | Parsons Brinckerhoff. “The building is tapered not only at the top but at the bottom too, so the floor area is not that large at the base. We needed to minimise the number of lift shafts, and introducing the sky lobbies allowed us to eliminate two of them and shrink the core.”
Managing pedestrian flow through the lobby is also critical with such a large building. Leung’s team carried out pedestrian modelling studies to identify any pinch-points as people enter from street level and from the subway below. To avoid overcrowding, the base is divided into three different lobby areas. One is dedicated to the hotel, one to office zones 1 and 2, and the third for the other office zones, the serviced apartments and the club.

A challenge for all mixed-use towers is how to reconcile demand for some functions to remain separate while others are shared. For example, the hotel at the CBD Z6 Sino-Ocean Centre needed separate lift capacity for its guests, but had to connect directly to the communal service elevator too. The hotel also required a separate chiller plant, while the hotel operator imposes even greater requirements on building systems. Achieving a 6-star level of service at such a great height meant overcoming extremely high hydraulic pressures – achieved by splitting water systems into several zones. “At the top, the walls incline at an angle of 4° so the floorplate shrinks every floor,” says Leung. “All the pipework around the guest rooms needed to be inclined. There’s no typical floor.”

Tall buildings are often designed to maximise the potential of tight sites, which leaves little space for essential infrastructure. Their iconic nature also means this must be hidden away. On Beijing’s 528m China Zun Tower, now under construction, the location of the cooling tower gave the engineers a major headache. The building is on a tight site, it does not have a podium and the top is a sealed garden, so the only option was to locate it within the building itself. But a mega-tall tower must also be careful not to attract the wrong sort of attention: “In Beijing, the outdoor temperature in winter will be well below -10°, and if people see the plume from the cooling towers, they will think the building’s on fire,” says Tse. “So we shut off the air-conditioning and open the windows at 7pm, when you come back the next day, I guarantee everything will be wet.”

Instead, the first step is to create a highly thermally efficient building façade to manage energy gain and optimise daylighting, and design innovative building systems to optimise energy consumption inside the building, such as variable speed pumping and fan systems. Power can be regenerated from elevator systems, and grid supplies supplemented with renewable wind and solar energy. “With all of these techniques, it is possible to achieve LEED accreditation,” says Tse.

The most sustainable feature of a high-rise design is adaptability. “The Empire State Building is 84 years old, and when it was designed there was no chilled water, no air-conditioning, no sprinkler systems, no IT,” he points out. “So we need to design buildings that are very flexible. We have to ensure that the space provision for building systems will be sufficient for future changes.”

Maintaining a comfortable internal environment is not easy in a glass tower, especially where it’s not possible to open the windows. In temperate climates, outside air can be used for low-energy night-cooling. But in a humid tropical climate – in Singapore, for example – allowing wet indoor air to enter at night would result in an indoor rainstorm when the air-conditioning comes back on the next morning, as the liquid in the air condenses on the cooler surfaces. “Opening louvres to ventilate a building may work in New York, but not in warm, humid climates such as Singapore, Guangzhou or Taipei,” says Tse. “If you shut off the air-conditioning and open the windows at 7pm, when you come back the next day, I guarantee everything will be wet.”

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China Zun Tower. Image courtesy of KPF

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