

REACHING BEYOND

The innovations driving the next wave of high rise

Burj Khalifa, Dubai, UAE. Architect: Adrian Smith

The engineering profession has achieved extraordinary progress since the first skyscrapers began redefining cityscapes in the late 19th century. Whether scaling seemingly impossible new heights or displaying structural ingenuity that appears to defy the forces of logic, high rise buildings stand testament to the engineering feats that enable them to exist.

Now, as pressure on urban space grows and populations boom, demand for a new generation of skyscrapers is emerging – bolder in design, slimmer in structure, more sustainable and far higher than ever before.

The world's tallest tower is currently the Burj Khalifa in Dubai. But that is to be eclipsed by the soon-to-be completed Jeddah Tower in Saudi Arabia which is set to become the world's first kilometre high structure. How long before engineers are asked to think even bigger still and push towards the world's first mile high tower?

This new wave of high rise building means pushing new limits in structural design. So, what are the biggest challenges – and how are engineers innovating in response?

SMART SENSORS

STAYING STABLE BY BEING SMART

From remotely checking the curing rate of concrete to climate control systems automatically adjusting the temperature of office floors, smart monitoring technology is being used at every opportunity in tall buildings to make construction and operation more efficient.

As developments continue to progress, the ability to more effectively combine sensors with Building Information Monitoring (BIM) will improve facilities management by providing a greater level of accurate information to base decisions on. This will help to ensure a more sustainable future for tall buildings.

“Eventually, the building will tell you what is wrong with it and how it should be remedied. It might even send for a drone to come and repair it for you,” says Kamran Moazami, Managing Director, UK Property & Buildings at WSP. “What you put into a building now has to be future-ready.”

The Lakhta Tower in St Petersburg is a demonstration of this in action. The 462m tower, which is expected to open later in 2019, has around 3,000 sensors throughout the building that act as a deformation monitoring system by collecting information about critical structures and detecting geometric deviations from the central axis¹.



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KAMRAN MOAZAMI
Managing Director, UK Property
& Buildings, WSP



STRUCTURAL TECHNIQUES AND DIGITAL SIMULATION

THE SCIENCE OF SLENDER

Skyscrapers are getting thinner. As land in dense urban locations becomes ever-more scarce, the growing need for high density high-rise developments that maximise the use of space means pressure to build thin will only increase.

This poses additional engineering challenges to skyscrapers with more forgiving width to height ratios. Designed generally as vertical cantilevers fixed to the ground, advanced structural techniques have to be deployed to prevent these skinny buildings swaying in the wind - with stomach churning effects for inhabitants of upper floors.

Super-slender towers require the core to be stronger to withstand wind load and seismic activity. That generally means using concrete rather than steel, according to engineering professional services company WSP.²

WSP provided the structural engineering for 111 West 57th Street in New York, which is due to be completed in 2019. As well as being one of the tallest buildings in the US, it will also be the world's most slender with a width to height ratio of 1:24.³

The required stability was achieved by having two shear walls running the height of the east and west elevations of the building, as well as a tuned mass damper at the top.

But engineers are also working with architects to use the latest computer techniques to find ways of making their buildings more aerodynamically effective in the face of heavy winds.

"Digital simulation using computational fluid dynamics (CFD) can simulate the effect of worst-case and general wind load on built structures," Andrew Watts, Chief Executive at building engineering specialist Newtecnic, told Engineering & Technology.⁴ "We use it to avoid turbulence around the structure, and to break up eddies - both of which produce noise and stress to building components."

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SUSTAINABLE MATERIALS

THE QUEST FOR MORE

The new generation of high rise buildings is facing a range of sustainability challenges, including reducing the carbon footprint associated with the materials they use and having to meet increasingly stringent environmental regulations.

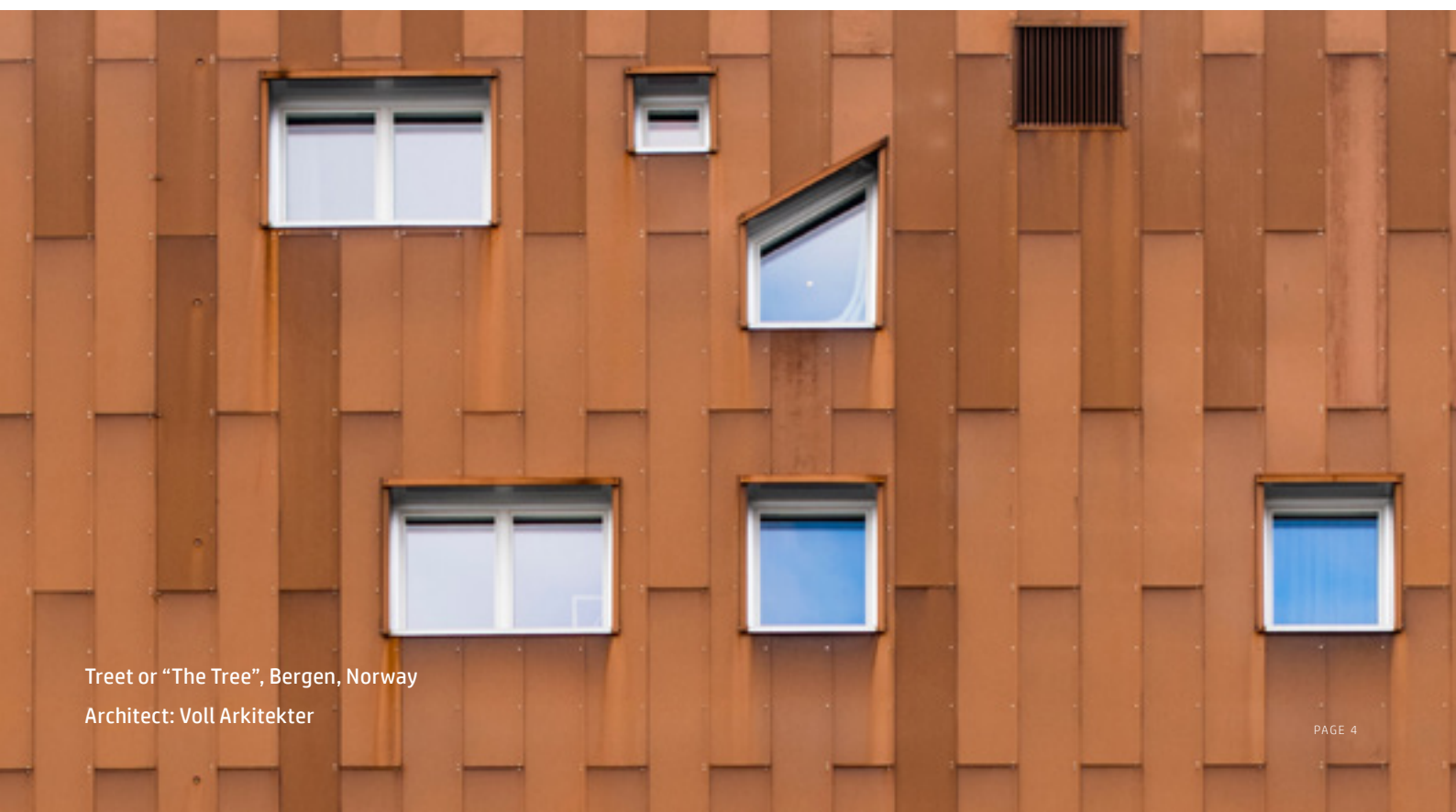
But the materials being used in these structures are evolving, allowing engineers to build taller and with a lower impact.

One replenishable material being increasingly touted as the key to unlocking a more sustainable future for high rise is timber. Timber frames offer a means of reducing the CO2 emissions associated with concrete production⁵ and are being used in the latest wave of high-rise schemes – the most notable example being Mjøstårnet in Brumunddal, Norway, which, in March 2019, was verified as the world's tallest timber building at 18 storeys.

However, timber is unpredictable. It can change shape, adding time, and therefore cost, to the process. As a result, engineers have begun using 3D scanning technology to gain crucial insights about the way it might change during the build.

There are other challenges that material innovations are allowing engineers to solve. For instance, the B1M skyscraper in Frankfurt, Germany, due to open later in 2019, was built quickly and to a tight schedule by using rapid-curing concrete. This allowed construction to progress at a rate of one floor every six days, with a special chemical formulation enabling the concrete to achieve an early strength of 22 Newtons per square millimetre in just 14 hours.⁶

Concrete is also the subject of other innovative developments. Self-healing concrete, developed by Researchers from Delft Technical University in the Netherlands, uses bacteria to solve the problem of cracks in the material. The idea is that when cracks open and water gets in, the bacteria are activated and they produce limestone, filling in the cracks and extending the life of the building.⁷



Treet or "The Tree", Bergen, Norway
Architect: Voll Arkitekter

PRINTING TECHNOLOGY AND DIGITAL COLLABORATION

OPTIMISING PROCESSES

Just as the construction industry is having to find ways to maintain efficient processes at high altitudes, engineers are having to be more agile in the way they work and adapt to faster iteration cycles. There is mounting pressure to optimise workflows, boost productivity and increase efficiency at every stage of the problem-solving process.

A new generation of HP large-format printers has been designed with this in mind, helping to smooth the process right through a project from ideation to inauguration.

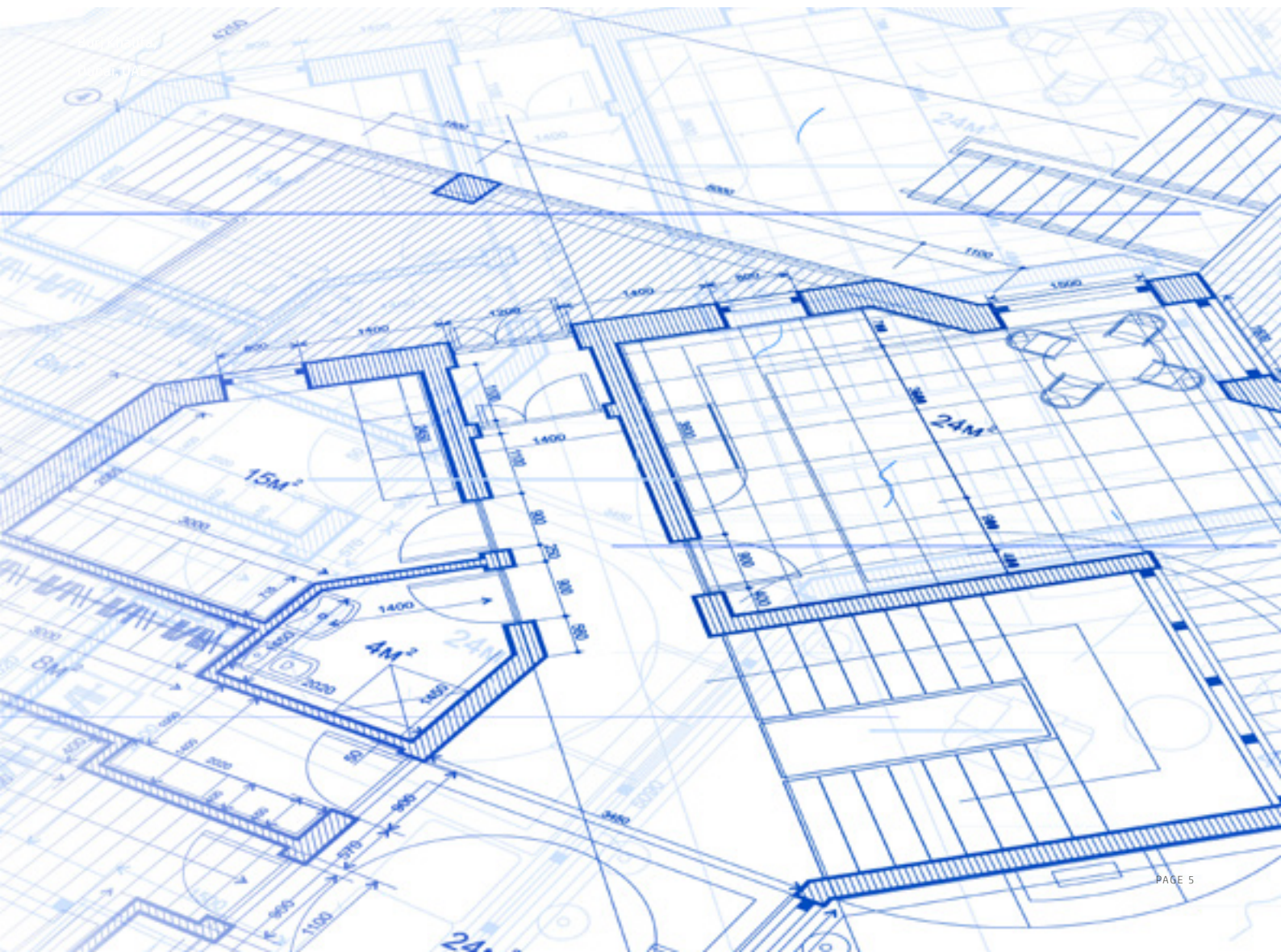
Firms can now push print quality and line accuracy further than ever before while also being able to control costs. This is making the process of adapting and quickly sharing projects much easier, increasing the potential to significantly reduce errors and improve collaboration.

The technology is also helping address one of the biggest challenges facing engineers as they take on even larger scale designs: improving collaboration. HP's range of wireless multi-format printers create their own wireless networks, enabling each team member to work on technical iterations, scan in changes and share quickly among the wider group.

The flexibility to operate alongside modern working lives is built in too, with designers and engineers able to scan, print, copy and share to drive quick decisions and fast results.

[See how HP large-format printers can improve workflows and drive effective collaboration for your business.](#)

[FIND OUT MORE](#)





EXTERNAL SOURCES

1. <https://lakhta.center/en/article/?id=1312>
2. <https://www.wsp.com/en-AE/insights/structural-marvels-make-new-york-super-slender-towers-possible>
3. <https://www.wsp.com/en-GL/projects/111-west-57th-street-new-york>
4. <https://eandt.theiet.org/content/articles/2018/10/tall-storeys-building-super-slender-skyscrapers-for-residential-use/>
5. <https://www.bbc.co.uk/news/science-environment-46455844>
6. <https://www.theb1m.com/video/the-skyscraper-built-with-rapid-curing-concrete>
7. <https://edition.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/index.html>

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