

# Space invaders



The global recession may have delayed construction of some of the world's most ambitious skyscrapers, but new projects continue to soar ever higher. **Mark Jansen** looks at some key challenges these structures pose for specifiers of services

London's skyline has been transformed by the tall buildings that have shot up in and around the City. Notable examples are the cone-shaped 'Gherkin', behind which looms the much older Tower 42 (formerly the NatWest Tower). Left of these is an artist's impression of the even-taller 47-storey Leadenhall Building, yet to begin construction



**S**uper-tall buildings provide building services engineers with the luxury of plenty of room to play with when specifying installations, right? Wrong. A recurring challenge for design professionals working on these structures is that, paradoxically, as they rise higher, so the services tend to demand a bigger share of the available space. And this outcome, not surprisingly, is resisted by developers wanting to maximise the amount of lettable area.

The net-to-gross space ratio in a tall building is usually just 60% to 70% compared with 80% for low-rise

developments, according to Bernard Antieul, regional director at consulting engineer hurleypalmerflatt. Tall buildings need a large core to house the multiple lifts, toilet pipework, heating and chilled water pipework, ventilation ducts, escape staircases and electrical equipment used by the occupants.

Services engineers are usually brought in at the start of design work and are under constant pressure to pare back the space they take up. 'Each time you have a new building layout, you have to go back to square one and redesign those cores, and on a tall building you could >

The proposed Leadenhall Building is to provide sky-high office space in the City of London. Work on the development is due to begin next summer



> easily do that 25 or 30 times,' adds Antieul, whose CV includes work on Land Securities' 38-storey 'Walkie Talkie' at 20 Fenchurch Street in the City of London, and Riverside South, the new headquarters building for JP Morgan at Canary Wharf, which will boast towers of 45 and 37 storeys respectively. The downturn has meant that both projects are delayed, although the design work on each is well advanced.

■ **Solar photovoltaic cells, with their long payback periods, are expensive. Solar thermal may produce some hot water, but the real energy need in tall buildings is for cooling** ■

#### **Pump it up**

The challenge of getting water for sanitation and ventilation systems to the top of a tall building is dealt with by having a series of pumps and valves at intermediate stages along its height. This avoids the need for massive pumping power and pipe thicknesses to deal with enormous water pressures at the base of the column.

However, this process also creates a new space demand, as does the need to have several electricity substations dotted around a tall building, as opposed to a single sub-station in the basement, which would suffice for a low-rise. The result is more plant floors.

Antieul points out that plant floors can require greater floor-to-ceiling heights than is typical for other floors and this irregularity must somehow be incorporated into the external look of the building, rather than crudely concealed with some louvre shading.

In addition to pumps, plate heat exchangers are also placed at intervals up the building to break the pressure in the water column while transferring warmth. However, as Arup associate director James Thonger notes, several degrees may be lost each time the warmth is passed through an exchanger. The solution may be to use bigger exchangers, but this comes at an extra cost, requiring a fresh cost-benefit analysis. There is also a trade-off between the number of pressure breaks that may be desirable and the space they take up.

Building services engineers must compensate for the thermal expansion and contraction of pipework on tall buildings, because the movements become much more significant. Pipework is broken into sections and independently supported at the top, middle and bottom.

Flexible joints resembling a concertina are one way to absorb the movements; another is to fit short horizontal sections, forming a series of right-angled bends, along the vertical length of the pipe, although this takes up more space. Thonger points out that wind-induced movement of a tall building can interfere with the lifts and a great deal of design and calculation work goes into limiting it.

A 500mm riser in a 50-storey building will easily weigh 40 tonnes, so serious thought must go into how it will be supported. The decision will affect the

construction sequence. If a riser is suspended from the top of the building core, there is less need to reinforce the base and there could be big savings in weight and stress on the structure.

However, the advantage of supporting it from the base is that the building contractor can begin installing pipework at the same time as erecting the core, rather than wait for the core to be completed. 'We have to

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weigh one up against the other; it's a very significant question,' says Nigel Clark, technical director at Hilson Moran, which is advising on 288-metre Pinnacle in the City of London, currently under construction, as well as the 67-storey Tameer Towers in Dubai, also under construction.

### Renewable limits

Antieul says it is difficult to incorporate low-carbon features into a tall building. Solar photovoltaic cells, with their long payback periods, are expensive. Solar thermal may produce some hot water, but the real energy need in tall buildings is for cooling. The opportunities for ground-source cooling are limited by the small footprint of the building and, typically, its urban location. Open-source cooling using cold water drawn up from an aquifer is also limited, because the small footprint of the building means that lukewarm water will soon be drawn back into the system.

Plans for the 150m tall Strata residential tower at Elephant & Castle in south London feature three 9m wind turbines built into the top, which the developers Brookfield Europe have claimed will provide 8% of its electricity needs. Antieul says this may well be possible, but believes turbines are unsuitable for commercial towers because they consume much more power than residential towers – as much as 15MW. Even a 60-metre turbine can only generate a maximum of 750kw, he argues.

Office computers create a large cooling load for tall buildings; this load can only be reliably met by mechanical ventilation, Antieul says. High wind speeds and 'deep' floorplates mean that designers (and tenants) tend to reject natural ventilation for such structures.

### Natural option

However, natural ventilation is being offered as an option to potential tenants of The Pinnacle in the City of London, due for completion in 2012. Hilson Moran's sustainability director, Matt Kitson, says tenants who take up the offer will be able to cut their energy consumption by around 5%.

The Pinnacle features a single-glazed outer skin and a double-glazed inner skin, with solar shading in between.

External air circulates between the inner and outer skin to help cool the building. The outer skin also acts as a brake on the external wind speed, which helps to make natural ventilation viable.

A mixture of mechanical and natural ventilation will be offered from floors 12 to 50, after which the external wind speed becomes too high. The lower floors are sealed because of the wind turbulence caused by surrounding buildings, noise and pollution at street level. At the higher levels, the building management system will ensure that the mechanical heating and cooling systems are turned off when the windows are open.

The viability of natural ventilation depends partly on having the correct ratio of building width to floor height, which at The Pinnacle is a useful five to one, Kitson says. The building's orientation is also well suited to London's predominantly south-by-south-west and north-east winds. Kitson is convinced that mixed-mode ventilation has a big future, not least because of tightening environmental legislation. 'All design thinking is going to have to change. The standard office specification is going to look very different in 10 years' time.'

### Logistical test

Antieul says there can be competition for space at the very top of a tall building. Engineers may want the roof for cooling towers, air handling plants, electricity substations and transformers, while the developer wants

A depiction of the Shard, currently under construction near London Bridge station in the capital, presented a challenge to its lift designers (see next page)



> a restaurant or public viewing gallery. If the gallery or restaurant wins, the engineer may be forced to conceal the plant at some mid-point inside the tower, where it takes up more space and has to suck air in from outside and expel it again, using more energy.

Tall buildings also present a serious logistical problem when plant needs to be replaced. How do you move the old plant out and the new plant in when the plant room is 30 storeys up in the air? The goods lift may not be big enough and a mobile crane may be unable to reach the higher floors. The issue must be considered at design stage, yet Kitson says it is frequently overlooked in the Middle East: 'In probably half the high-rise buildings [there], you can see they haven't thought about the plant replacement strategy. When you go around some of these buildings you think, "I wonder how they're going to get that out of there when it breaks down?"'

Antieul says the solution often amounts to bringing a small crane into the building in pieces, using the goods lift, then assembling it on the roof. The small crane is used to hoist a larger crane onto the roof, which in turn lowers the redundant plant to street level and lifts the new plant in. The services engineers must ensure at the building design stage that the spot where the crane will be erected can take the likely loads. Space also has to be left to enable transformers, for example, to be moved through doors and along corridors, should they need replacing. 'You can end up with what looks like wasted space, but actually, it's not,' says Antieul.

Clark at Hilson Moran argues that such strategies can be expensive and says there are alternatives, such as running a goods lift at slower than normal speed, to increase its weight-bearing capacity. 'We've done most of our tall buildings entirely with goods lifts,' he says. ●

## Elevator strategy has its ups and downs

Designing lifts for a tall buildings is complex and time-consuming. Lift design firm Lerch Bates has been working on the 72-storey Shard London Bridge project in central London since 2000: 'It just takes hours and hours of sitting with the architect, working through the core design,' says project director Chris Manning.

The Shard, currently under construction, will have six escalators and 35 lifts to serve a maximum daytime population of 5,855 people. In order to minimise space taken up by lifts in a tall structure, it is highly desirable to locate the bulk of the population in the lower floors. Over half the occupants of the Shard – all office workers – will be located in the first 28 storeys. These floors will be served by nine double-deck lifts, which feature two lift cars fixed one atop the other, travelling up and down a single shaft and stopping at two separate floors simultaneously.

Access to the hotel, located on floors 35-52, will be via another two double-deck lifts which take guests from the ground floor straight to reception on floor 35, where they will transfer to a local lift to reach their rooms. The apartments, on floors 55-65, are also served by express lifts from the ground floor.

While there was continual pressure to save space, the lifts must also retain sufficient capacity to meet industry-wide performance criteria, such as being able to transport 15% of the office population within five minutes. 'It's like a battle – the architect is always asking "How much would we save if we cut back this much here", but we can't because we're working to the performance criteria,' say Manning.

One pinch point was Lerch Bates' insistence on a machine room exclusively for its own equipment, which meant other M&E services had to be routed

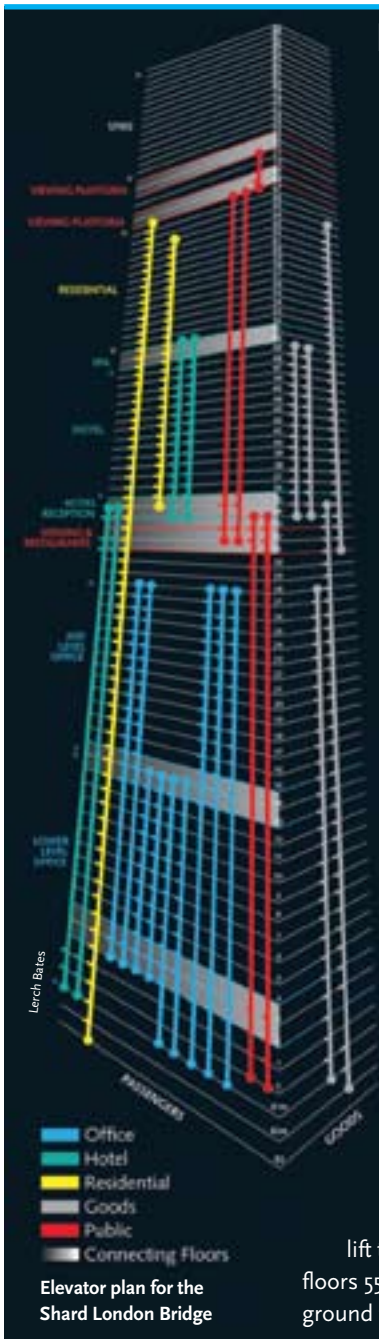
away from it. 'We don't want a hot water engineer coming into the lift machine room – it's a safety issue,' says Manning. 'It took a lot of design co-ordination to get there.'

To make best use of space, toilet blocks are frequently sited in the lift lobby on each floor, where there is often room to spare because many of the lobbies conceal lifts that pass through without stopping. The engineer will try to arrange the toilet blocks one directly above the next

from floor to floor, to make the most efficient arrangement of pipework. However, higher up the building, there is less space in the lift lobbies, as more of the lifts are stopping, so the toilets have to be moved to other parts of the floor and the pipework starts to zig-zag.

'You really don't want to do that,' notes James Thonger of Arup. He adds: 'We start with the lifts, then the toilet and ventilation strategy, then you usually have to go back and tweak your lift strategy, then someone usually says "Your net to gross ratio is terrible, you have to do better."'

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Elevator plan for the Shard London Bridge