City tower gets on top of neighbours

A lightweight structural solution was critical for London’s new 18-storey Aldgate Tower being built on an occupied existing three-storey basement

Aldgate in London’s financial zone, Aldgate Tower is being built on phase two of the plot. However, few construction projects in central London are straightforward and the challenge for Aldgate Tower was that RBS would continue to use the lower two levels of basement (B2 and B1) beneath phase two while Aldgate Tower was being built above.

Emergency logistics

A further logistical challenge on the current build are the three emergency exits from RBS’s basement levels which emerge at B1 level under Aldgate Tower and a service road for RBS at ground level (see box). “The building footprint had originally been designed for a nine-storey reinforced concrete-framed building,” says Brookfield Multiplex Multiplex project manager George Amy.

A steel frame with a central braced steel core to accommodate lifts, stairs and washrooms was designed to keep the building’s height low. This was essential, since the basement was supported by an existing three-storey reinforced concrete basement constructed in the early 1980s. It is made up of a perimeter diaphragm wall, raft slab at basement three (B1) level and large diameter pipes outside of the basement footprint.

The basement was originally designed to support two separate buildings. Until now, only half the plot had been developed.

"Arup redesigned the building with a steel core and frame (with composite floors) and managed to double the height of the building. Construction of Aldgate Tower on phase one of the site began in January 2013. A steel-framed transfer structure was the first to be erected to provide the base for the new building’s steel core and to transfer load to existiing concrete substructure (see box)."

This operation first required the existing ground floor slab directly below the core to be cut out to accommodate the steel core - a 9 m by 30 m rectangular frame made up of two 47-tonne and two 30-tonne, 1.5 m-deep steel plate girders. These members were fabricated in Severfield-Watson’s Bolton workshop.

"Arup designed the building with a steel core and frame and doubled its height" GEORGE AMY, BROOKFIELD MULTIPLEX

Overnight installation was developed as a more cost-effective alternative to building a crash deck over the road and installing the trusses during the day, he adds. Steel columns on the perimeter of the building sit on top of the existing concrete substructure layout where possible. Where other design features (such as the column-free ground-floor reception area or service road) interrupt this rhythm, columns are cranked, or offset via transfer beams. To maintain constant floor-to-ceiling heights, beams are made up of thicker plate sections (up to 100 mm thick), such as over the double-height reception area.

"Services run through openings in the beams creating a very efficient slim structure," Mr Amy says.

PREFABRICATION OFFERS QUALITY BENEFITS

With so much of the building’s external steelwork being prefabricated on site, it made sense to optimise prefabrication on the project, where possible. Vertical services risers are prefabricated so they can be slotted into a tower core, says Brookfield Multiplex project manager George Amy.

"The trusses sit on a plant-mezzanine level between ground and first floor and had to be erected overnight to prevent disruption to RBS. These substantial trusses support significant plant loads on the mezzanine level, including 2 m-deep water tanks that Arup associate director Ben Tricklebank says are equivalent of five floors of imposed office loading. Overnight installation was completed by December.

"Steel has allowed us to build a very efficient building. The pieces arrive in kit-form, ready to go up and with a consistent high quality," Arup said."

The steel frame and core tower have been built on an existing three-storey basement floor.

“Arup’s prefabrication approach for the alternative core plan to gain more floor space creates a very efficient building,” says Arup associate director Ben Tricklebank.

Each of the steel decking and lightweight concrete office floors are broadly similar and the entire steel frame was erected using two tower cranes in just six months. Inconspicuous coiling for fire protection is applied only to primary beams, with secondary beams requiring no treatment. Severfield-Watson also installed all the shop drawings on the project. Aldgate Tower’s first tenants are expected to move in from Q4 2014 and the building will be completed by December.

ALTERNATIVE PLANS

In 2007, extra basement columns and floorplates were installed on site when ready to receive a new steel-framed structure, but by 2013 developer Aldgate Tower Developments expressed a preference for an alternative core plan to gain more floor space.

This meant many of the existing basement columns would no longer line up with the new superstructure core columns. “Including a 1500 mm-deep transfer structure (acting also as the steel core base) allowed us to offset the column arrangements for the building’s extra floor area,” explains Arup associate director Ben Tricklebank.

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From BP depot to Bayside campus

A 26 ha former BP depot on the coast is being completely transformed into a new science and innovation campus for Swansea University

**PROJECT REPORT**

**RUBY KITCHING**

Sea views and sand dunes don’t usually go hand in hand with lecture theatres and laboratories, but students at Swansea University’s new Bay Campus will be able to experience these contrasting features from September next year.

In fact, when Richard Powell, construction project manager for developer St Modwen, describes the site, he could be reading from a brochure: “The beautiful promenade, really make this a wonderful location”.

This is a world away from when the site was owned by BP and was used to store oil and pump it to a refinery about 4 km away at Coed Darcy St Modwen purchased the site in 2007 and, from 2013, headed up the colossal clean-up job prior to construction commencing in 2013.

The 46 ha Bay Campus development is located along the A465 Fabian Way, a strategic route into Swansea city centre from the east. Seven new steel-framed mixed-use buildings make up the first phase of the Bay campus development.

Steelwork contractor Caunton Engineering and main contractor Vinci Construction finished erecting five of these buildings in December 2013. Work is now focused on cladding and fit-out.

The buildings under construction are the Great Hall, Manufacturing Facility, Library and Institute of Materials.

Two other three-storey steel buildings known as the Innovation Hub and Energy Safety Research Institute have been built by the university’s framework contractor Leadbitter.

“The academic spaces have a multitude of different functions and spatial requirements, so a steel frame offered the flexibility we needed for the design – efficiently and cost effectively,” Mr Powell says.

**Weather resilient**

Located on the coast and subject to seawater spray and high winds, steel also offered what he describes as a robust frame to withstand the weather and one which could accommodate different façade details. With just a two-and-a-half-year construction programme, speed of construction was also essential.

Since many of the academic buildings will also house laboratories, having an open steel frame which could be divided in many ways to suit future needs was also attractive for the university, he explains. “A lot of time was spent making each design work for current and future intended use – these buildings will be here for the next 100 years at least.”

The buildings sit on either pad foundations or piles, depending on ground conditions and building loads. One of the most prominent buildings will be the 26 m-tall braced-steel, two-storey Great Hall. At ground floor, this building will accommodate lecture theatres, while an assembly hall will occupy the first floor. The steel frame will be clad with recomposed stone.

Cladding panels weigh about 10 tonnes each and are hung from 10 m-wide portal frames. The roof, which will house many different businesses, “is another prominent building on this being within Wales. “The bridges bring the two parts of the building together but controlling differential movement across the building, which could potentially damage the tensile roof, was a challenge,” Mr Shimwell adds.

Throughout the steel programme, Caunton Engineering has had one erection gang working sequentially around the site, a plan that has worked well with Vinci’s overall works.

“This was one of the reasons we contracted a steelwork company that could do a design-and-build job,” explains Vinci Construction Project Director Jerry Williams.

“They’ve been able to do one structure straight after another seamlessly and without any design or erection hold-ups.”

**CONTROLLING LATERAL DEFLECTION**

“Controlling lateral deflection in this building was particularly challenging given the potential for high winds from the sea.”

**Added complexity**

“In addition to this, the building’s column-free spaces and height combine to present a complex design,” explains Caunton Engineering senior structural engineer Matthew Shimwell.

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The benefits of thermal mass

More and more buildings are being designed to use thermal mass as part of their cooling strategy to reduce energy bills and lower emissions.

**THERMAL MASS AND TEMPERATURE**

The concept of thermal mass involves using the fabric of a building to absorb, store and release heat energy so that the energy usually required to cool a building is reduced. For many buildings, this can mean that they will never need air conditioning systems, or their reliance on artificial cooling will be minimal. Either way, the result is lower carbon emissions and a cost saving for the building owner. This concept is generally well understood by the industry, but there are still some common misunderstandings over how to maximise the potential of thermal mass.

“Historically, it has been assumed that you need a heavy building to take advantage of thermal mass, but the fact is that any framing material can utilise thermal mass,” says British Constructional Steelwork Association sustainability manager John Dowling.

This means the advantages of thermal mass can be just as effective in steel-framed buildings as in concrete ones, with steel structures also benefiting from speedy construction methods, lightweight and smaller foundations.

Most commonly, thermal mass is utilised in the exposed concrete soffits of floor slabs in non-domestic buildings, as seen in the office floors of the Redcar Leisure and Community Heart building in Teesside case study.

Increasingly, however, schools, universities, commercial developments and health centres are also benefiting from thermal mass (see boxes). To highlight the use of thermal mass in lightweight construction, steel manufacturer Tata Steel and the BCSA have published a guide called Steel construction – Thermal mass which can be downloaded for free from steelconstruction.info.

This 20-page guide includes 10 case studies and gives details of how different structural solutions and building types have made effective use of thermal mass. It explains, for example, that it is most effectively used by building types which are used by day and are vacant at night. This allows the fabric of the building to absorb heat during working hours, helping to maintain a comfortable temperature for occupants.

The temperature in the building peaks much later in the day (see graph), when the building is likely to be either lightly occupied or unoccupied.

At night, when external air temperatures drop, natural ventilation is used to purge the stored heat energy from the building fabric so the process can be repeated the following day. In some situations, mechanical ventilation and water cooling may also be used to extract this heat from the building fabric.

“For designers, it is important to understand that designing for thermal mass doesn’t mean it will completely dictate the structural solution – any framing material can utilise thermal mass,” Mr Dowling says.

The guide also states that only 75 to 100 mm of concrete is required in the build-up of a typical floor for the whole building to benefit from thermal mass – a fact commonly agreed with the concrete and steel advisory bodies as well as the Chartered Institution of Building Services Engineers and research body Building Research Establishment.

The guide says: “Based on a 24-hour cycle of heating and cooling, heat energy can only penetrate up to around 100 mm into the exposed building element and… that designing thicker floors specifically to utilise thermal mass offers little benefit.”

The floor slab of standard steel-framed buildings typically contains at least 100 mm thickness of concrete, so steel-framed buildings are able to benefit from thermal mass as well as concrete-framed ones.

An economic, structural frame which could contribute to an Excellent BREEAM rating as well as accommodate future layout changes were the main reasons for using steel in Winchester University’s St Alphege Learning and Teaching Building.

As with all academic buildings, a tight programme – commission to completion in just 18 months – also meant that using a steel frame with non-load-bearing blockwork walls ensured the two-storey building could be delivered on time. Using block work walls will allow the university to move partitions in the future, while including exposed 12 m-span precast planks for all floors and the roof has enabled the building to use its thermal mass as part of its cooling strategy.

The exposed concrete is able to absorb and store heat generated in the day from students and computers, keeping the internal temperature at a more comfortable level. Rather than using passive overnight cooling to purge this heat, as at Outwood Academy, St Alphege used integral water pipes as part of the building’s cooling and heating strategy. Main contractor Geoffrey Osborne, Design Engineer Architects, structural engineer Heyne Tillett Steel and steelwork contractor Snashall Steel Fabrications completed the building in 2013.

**OUTWOOD ACADEMY, ADWICK**

This secondary school on the outskirts of Doncaster was designed as a steel-framed structure by CFMG Architects and structural engineer Alan Wood & Partners. Built by Wates Construction, the brief required a robust frame for the school’s students along with high energy efficiency and speedy construction methods, which would be quick to erect.

The ‘E’-shaped building is made up of two three-storey atriums constructed using a braced steel frame and precast concrete floor slabs with exposed soffits in most teaching areas. The thermal mass of the precast slabs enables the whole building’s cooling strategy to keep temperatures below 25 deg C during the day. Passive cooling at night also allows the building to cool down. A steel frame was ideal for accommodating regular classroom layouts, double-height areas and long-spanning halls.

Steelwork contractor Alfred Holland erected the steel structure in just three months and the whole building was completed in 52 weeks.

**HOUGHTON-LE-SPRING PRIMARY CARE CENTRE**

This 7,000 sq ft new-build primary care centre is a combination of health and social care facilities linked to an existing sports and leisure facility. Co-op Group Health & Learning and Teaching Building.

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**ST. ALPHEGE LEARNING AND TEACHING BUILDING, WINCHESTER UNIVERSITY**

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Choosing a steel-structured frame for a new civic building in Redcar has meant that many more facilities can be accommodated.

**Project Report**

RUBY KITCHING

Redcar town centre is undergoing a £25m regeneration which will include a new 22,000 sq ft civic building called the Redcar Leisure and Community Heart.

The development, which features a leisure centre, car park and business centre, is nearing completion. For structural engineer Buro Happold, the challenge has been to design an efficient structural frame which can accommodate all these uses.

The building is 120 m long and has had to be split into structurally separate blocks to reduce the effects of thermal expansion across the building and to aid a simpler lateral bracing system.

A braced steel frame was deemed the only viable structural solution for the project due to the variety of occupancy across the development. As such, to span the 20 m-wide pool hall while supporting ductwork, long-spanning Fabsec cellular beams are used. For the sports hall, 35 m-spanning Fabsec cellular beams supporting ductwork, long the 20 m-wide pool hall while

The circular openings were designed to allow the area to be divided into smaller halls, including for use as a number of dance studios, which has meant that a separate dance studio did not have to be built.

"The circular openings were designed to allow the area to be divided into smaller halls, including for use as a number of dance studios, which has meant that a separate dance studio did not have to be built," Mr Riches explains. "The diagonal members were sufficiently large to accommodate the forces anticipated, but they were considerably smaller than the top and bottom chords of the truss, which meant there was the possibility of these 'punching' through the wall of theSBs members forming the top and bottom chords of the truss."

"Elsewhere in the building, the curved corners of the debating chamber have been framed using steel beams and columns, while the more regular layout for the adjacent business centre office block uses Slimedge beams and precast planks. "The use of precast planks to the upper floors was proposed primarily to allow the use of exposed concrete as thermal mass to aid the cooling of the office units," Mr Riches says.

"From a purely structural perspective, the use of Slimedge beams allowed us to achieve a relatively slim floor construction."

Much of the steel for the project has been sourced from Tata Steel’s Teesside Beam Mill at Lackenby, to the delight of Redcar cabinet member for economic development Mark Hannon.

"It’s fantastic to see Teesside steel being delivered in a project that is integral to the regeneration of the borough," he says. "I am really enjoying watching this ambitious development take shape."
The new sports hall at City University’s Goswell Road site will feature trusses spanning 28.5 m while supporting a heavily loaded ‘green roof’.