Titan in its tomb

The country's second largest ever concrete pour was needed to create a building for Cambridge's materials scientists in which vibration could be kept to a minimum. Mark Smulian reports

It must have been a remarkable sight when 120 lorries drove up to a site on the western edge of Cambridge and over 24 hours deposited enough concrete to constitute the second largest pour of the material seen in the UK after London's Shard.

The concrete was needed for an unusual purpose too, not just for a normal building base but one that would – as far as possible – eliminate vibration from the structure that would stand on it. Using concrete on such a vast scale for the new building for the University of Cambridge's Department of Materials Science and Metallurgy was a challenge.

Project architect Rebecca Mortimore, senior associate and science and education projects director at architectural practice NBBJ, says: "We pushed what orthodox construction can do to the limits here."

Requirements for vibration and the accommodation of large and complex equipment were imposed by the department, which wanted an environment in its new £48 million home where its electron microscopes could be protected from interference – including also from sound and thermal currents – that disturbs their readings.

In addition to some 500 staff and students, the building would be home to what is known jokingly as 'The Tomb', home to Titan, more formally the FEI Titan 3 Electron Microscope. This device allows scientists to analyse structures less than one-half the size of a carbon atom and more than a million times smaller than the width of a human hair.

It would also house a variety of other machines, including

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The main entrance from the road

The library is lit by the narrow atrium (above) and the brick pattern reflects shapes familiar to metallurgists (opposite)

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smaller scanning electron microscopes, and the scientists wanted a building in which they could advance knowledge by pushing these devices' performance further then ever.

Their work is frontiers of knowledge stuff and projects include the study of 'nanowire' proteins that cause conditions including Alzheimer's and Parkinson's diseases. Researchers are also investigating lighting devices that could work for 60 years and how to purify water using ultraviolet lights to kill bacteria and viruses.

All this made for a demanding design brief for Mortimore. True, she has a greenfield site little encumbered with neighbouring buildings to work with, but how could she produce the building the department wanted?

So complex were the demands that design alone took some two and a half years, and construction another two years. The solution was a 1,000 sq m building for the electron microscopes, which appears from both the outside and inside to be part of the whole, but is in fact separate from the main 10,700 sq m materials science building. These structures are joined by a thin movement joint so that "inside you cannot tell when you move from one to the other", Mortimore says.

Electron microscopy sits on a concrete base two metres deep, while the main building needs only a one-metre depth base.

"A high water table in the area means the electron microscopy suite could not be completely underground and that would also have been expensive," Mortimore explains.

So sensitive are the electron microscopes to vibration that a road outside had to have its pavers removed and given a smooth surface because passing buses disturbed the machines, even though they ran some 35 metres from the building.

Indeed, the microscopes can detect vibrations from the M11 motorway, which is not even visible from the site.

"Vibrations go round the Earth and you cannot do anything about them, so the vibration and sound and thermal problems cannot be eliminated but you can design the building to mitigate them out of the critical range of each instrument," Mortimore says.

Both buildings are constructed from structural concrete with brick cladding over the laboratory areas and curtain walling where offices and a refreshment area are located. The site slopes four metres from north to south. Laboratories are on the north and east sides and occupy the whole of the lower ground floor, for vibration stability.

Office mezzanine floors are to the south and west. Both parts of the building are accessed via open staircases and separated by a narrow atrium, which gives light over the

'Water provides an attractive visual feature but the lake is an integral part of the site's drainage and was dug as part of the project'

library. Staff offices have external balconies that form horizontal bands across the facades, reflecting the mezzanine floors inside.

Offices are organised into clusters with mixes of flexible open-plan and cellular space per floor and staircase landings widened to accommodate collaboration hubs. Furniture is modular to allow for reconfiguration, and accessible risers and oversized ceiling voids facilitate modification.

Outside the office areas, bespoke gold-anodised aluminium uprights enclose access walkways for maintenance staff and provide privacy and sunshade for occupants.

Although the subject groups in the department collaborate closely, each needed its own teaching and research area since they use different equipment and methods and so no two laboratories could be designed the same way.

"All the laboratory suites are different to match the needs of academic groups," Mortimore says.

Disciplines include basic metallurgy biochemistry and electrochemistry, microscopy, nano-science, coating and ceramics technology. Their equipment's bespoke spaces include, for example, a process laboratory that contains all the largest equipment, and a testing laboratory for rigs and crushers.


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A 'sputter' laboratory (pictured above), in which layers of materials only an atom thick are laid on each other, contains what looks to the layman like an intimidating array of devices inspired by science fiction, with an extraordinarily complex mesh of mechanical and electrical servicing overhead.

General and teaching laboratories – without the need for heavy equipment – are on intermediate floors and hazardous and high-pressure laboratories are on the top floor.

The double height entrance foyer of the main building connects the road entrance through to another at the rear where a cycle path – important in such a bike-friendly city – runs alongside a small stream that flows from a lake. Water provides an attractive visual feature but the lake is an integral part of the site's drainage and was dug as part of the project.


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Complex M&E equipment in the sputter laboratory (within text) and an artificial lake sits at the rear of the building (main)

BUILDING PROJECTS

Scientists are encouraged to share ideas in the Tea Room (above) and the front of the building show brick and curtain wall areas (above right)

A secure service yard at the rear accommodates bulk gas storage, maintenance workshops and delivery areas.

In the electron microscopy laboratories chilled beams are used to cool rooms to "control thermal turbulence from machines which could disrupt images," Mortimore says.

All noisy support equipment is in an ante-room and so cannot disrupt the machines (or indeed be heard by the human ear) in their adjacent room.

At its most extreme, Titan's 'Tomb' is a 7-metre cube fully screened by low carbon steel in four layers to keep out noise and vibration. Outside it equipment whirrs, inside there is dead silence.

The vibration problem limited the use of sustainability features. A large photovoltaic array occupies the roof of the main building, supplying three per cent of the power equipment, the electron microscopy suite has a green roof and rainwater harvesting is employed, along with natural ventilation for non-laboratory areas.

The mixed-mode ventilation system incorporates natural venting to non-laboratory areas using the light well as a solar stack, and mechanical assistance with heat recovery is used during peak conditions.

Exposed thermal mass provides passive cooling and operable hoppers allow overnight purging.

'We could not use any sustainability measures that would interfere with the equipment, such as ground source heat pumps'

Project architect Rebecca Mortimore

While the building enjoys BREEAM Very Good status, "we could not use any sustainability measures that would interfere with the equipment, such as ground source heat pumps," Mortimore says.

Brick was used for robustness and visual effect on the exterior of the laboratories. At first sight, the outside of both buildings appears to comprise flat brick, but look a little closer and some bricks are raised or recessed by 15mm to make patterns that are most clearly visible when the sun creates a shadow.

These patterns might mean little to most people, but to metallurgists they are the shapes made by the grains in metals when examined under microscopes, the first stage of study for most of them. The idea for the patterns came from academic staff, who were able to rapidly sketch what they wanted.

In the coming years the building will have neighbours since it forms part of the West Cambridge campus, to which the university is relocating over 20 years a number of mainly scientific departments whose older accommodation has become inappropriate. A campus master plan shows how the buildings should work together.

From the outside the materials science building is an attractive addition to the university. Deep inside, machines are at work helping staff to expand the store of human knowledge.

Client: University of Cambridge Estates Development

Architect and interior designer: NBBJ

Main contractor: Willmott Dixon

Structural engineer: Ramboll UK

Services consultant: Hoare Lea

Services sub-contractor: Mitie

Landscape architect: Robert Myers Associates

Project manager: Davis Langdon

CDM coordinator: Gardiner & Theobold

Cost consultant: Turner & Townsend

Vibration consultant: Colin Gordon

Planning authority: Cambridge City Council