MOTT MACDONALD

Project
Priority Schools Building Programme

Location
Kent and Surrey (phase one) and south west England (phase two), UK

Client
Education Funding Agency

Expertise
Research, development, engineering design and procurement

New school standards

Ninety new schools in five years? It's a tall order using conventional construction, but a standardised, prefabricated solution developed by Mott MacDonald and architect Bryden Wood promises to deliver, making life better for children and their teachers across the UK.

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>
> **Andrew Williamson**
> Mott MacDonald project director

90

primary schools will be built using modular design and construction

‘Battling the bulge’ and ‘Overcrowded and crumbling’. Headline writers have a knack for summing up a situation, in this case the challenges affecting UK schools right now. A soaring birthrate is swelling the number of primary school children – there are expected to be 4.68M in the system, 10% more than now, by 2026. Meanwhile, a third of 1000 headteachers surveyed in 2015 reported that their school buildings were not fit for purpose.

The government’s Education Funding Agency (EFA) is working to turn things around under its £4.4bn Priority Schools Building Programme (PSBP).

There’s a lot to do and fast, yet government budgets remain tight. The EFA had a pretty clear idea of how to tackle this conundrum when launching the PSBP, which has set out to use standardisation allied with design for manufacture and assembly (DfMA).

Efficiencies would be gained by developing design solutions that could be replicated in different locations many times over. Offsite manufacture of prefabricated components and modules could be used to save materials, reduce build times and improve quality. And with most construction work done in factories, time spent on site would be slashed, allowing much of the work needed for school upgrades and expansions to be carried out during school holidays, minimising disruption to the children’s studies.

Pyrford Primary School in Surrey, UK, is one of the six pathfinder projects procured using Portakabin’s tried and tested Yorkon system.

Portakabin (both images)

Pret à Porta

Mott MacDonald was brought on board by the EFA in 2015 during the first phase of the PSBP, to research the modular construction market and lead procurement of a construction contractor. Phase one is delivering six DfMA primary schools in Kent and Surrey.

Ask the average citizen to name a company that produces readymade buildings, and the chances are that they'll say 'Portakabin'. It was Portakabin that we appointed to construct the schools, using its Yorkon system, tried and tested on dozens of previous schools, and hospitals, offices and warehouses besides. Yorkon is described as a 'design and build' solution. It employs a standardised 'off the shelf' kit of parts, but allows a high degree of variation in the way they are combined, offering the client a bespoke end product.

Portakabin reckons that Yorkon buildings are about 50% faster to erect than a conventional building of the same size. We wanted to know: How much more efficiency could we achieve if we came up with a brand-new module range, designed specifically for schools?

3

months' construction time for a new school, compared to 10 for a conventional build

The EFA retained Mott MacDonald for the next phase of the PSBP, which will involve the reconstruction or upgrading of 277 schools. About a third of those projects, spread across the south west of England, have been earmarked for DfMA. We're the EFA's technical advisor, managing design, through procurement, to construction. We have teamed with London-based architects Bryden Wood.

Not only were we tasked to develop a solution offering real economies of scale, it needs to work equally well for a wide range of school sizes – from the smallest taking in only one class per year, to the largest taking in three. Our modular design would need to make a functional, comfortable and replicable school that met stringent EFA rules for natural light, thermal comfort and ventilation. A 2.7m ceiling height and depth (corridor to wall) of 7.2m were specified.

Portakabin

14

days to erect a weathertight building envelope

Building blocks

Transportation set the basic dimensions of the new modules: measuring 13.6m long and 3.5m wide, they can fit on the back of a lorry.

Then came the process of configuring the modules to provide all the functions needed in a school. Internal walls can be fitted during manufacture to divide modules into smaller rooms; or several 'empty' modules can be combined to create large assembly or dining spaces. Modules are pre-fitted with mechanical parts, electrics and plumbing where needed.

Rooms serviced by water, wastewater and air are clustered to keep pipe and duct runs short and simple. It helps keep capital costs down and minimises disruption to the school during maintenance.

Modules were digitally mapped onto several real-life locations to show how they tessellate to form a whole school. They are designed for use in single and multi-storey arrangements. A linear plan offers the most spatially efficient layout. But almost unlimited permutations are possible.

Some clever thinking has been required to arrange the anatomy of a school in such a way that it can be 'cut apart' into modules.

"We needed a standardised, replicable layout that could be constructed from the same pieces, used in different ways, to meet the diverse needs and site constraints of many different schools," says Andrew Williamson, Mott MacDonald's project director. "It's like creating a jigsaw: we needed to know what the final picture would look like in order to create the pieces and put them back together."

Many types of room, including plant rooms, are split between modules for transit, then bolted together on site.

Anatomy of a school

Bryden Wood director Jami Crosser-Brown visited and surveyed four 'typical' schools to see how different types of school use space. Her study identified 32 different room sizes, ranging from 1m^2 to 180m^2, and six types: staff and administration, basic teaching, learning resources, storage, assembly/dining halls and 'service-heavy' – plant, kitchen, toilet and server rooms. But she also found that "there were rooms that are common to all school types, and that many rooms with different uses are basically the same size – for example, an office is the same size as a group room." The average primary classroom is 55m^2.

"We don't need a design that can accommodate 32 different room sizes," Jami says. "If you look at the basic space requirements, there are more commonalities than differences. A room's purpose is created by what you put in it."

Room sizes have been standardised to create a modular system that is regular and flexible, enabling modules to be "switched in and out."

Module at a glance

Modules have steel frames that support floor, internal/external wall and ceiling/roof panels. External walls have an insulated foam outer layer facing the elements, and a plasterboard inner layer. Internal walls are coated with plasterboard on both sides, offering up to 55dB sound resistance, and 90 minutes of fire resistance.

Windows, gutters and doors are factory-fitted, as are the joints needed to connect modules together. All internal fittings and fixtures come ready-fitted too – staircases, plant rooms, toilets, kitchens, laboratories.

External panels are coated with a sprayed waterproof membrane to provide weather protection, and can then be finished with an architectural cladding.

Site-based activities are limited to foundations, drainage and utility connections. On delivery, modules are craned into place and joined with bolted connections.

When the going gets hot

Taking the linear school layout, we modelled solar gain and natural lighting. Potential for overheating was modelled using TAS software, using temperature data for a scorching, worst-case-scenario summer. The EFA's indicative design brief suggested mechanical ventilation. We found we could largely avoid that by opening windows.

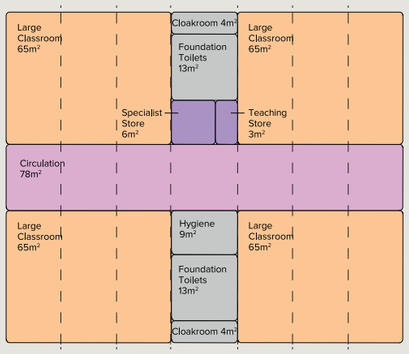
Natural lighting throughout the year was studied from all points of the compass. The initial glazing configuration, accounting for about 35% of the façade area, was optimised by raising the height of the windows. "Making them higher ensures that incident light reaches across the 7.2m room depth," says principal simulation engineer Yudish Dabee. The EFA demands that 80% of teaching and learning spaces are naturally lit. The design passed comfortably, with 90% daylight.

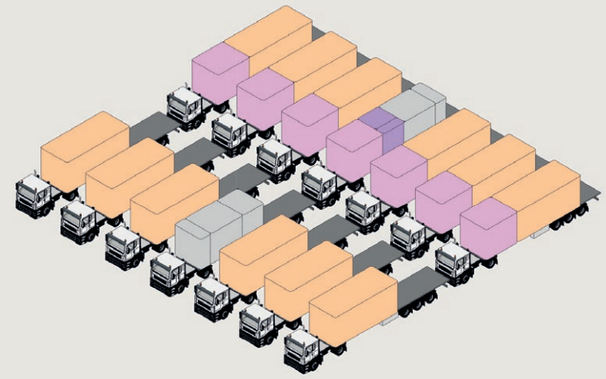
Drag and drop design

The full array of modules has been created using BIM and each is saved in a digital 'catalogue' as a BIM 'object'. BIM objects are tagged with useful metadata – dimensions, weights, materials, power ratings, manufacturers' details, servicing and replacement instructions, for instance. Objects therefore 'know' what they are and in the case of complex assemblages like a school kitchen module, what they contain.

It means that designing and specifying for new schools can be massively accelerated. Primary school designers can use BIM to create a school that will be correctly configured, fully costed, and compliant with the EFA's requirements for natural light, thermal comfort and ventilation.

In principle, BIM designs can be used for automation of the fabrication and assembly processes, with digital information enabling just-in-time delivery of the components required for each module to the factory. BIM models are Level 2 compliant, providing data for the schools' operations and maintenance crews.





Future-fit

We estimate that fabrication and construction time will be comparable to that for one of the schools made by Portakabin – about half the time of a traditional school build. Excluding time taken to complete groundworks and enabling, the modular school could be constructed in three months, compared to 10 for a conventional building. The weatherproof school envelope itself can be built in just 14 days.

'Modernise or die' is the title of a provocative report on the UK construction labour market, written for the government by consultant Mark Farmer and published in October 2016. Farmer's report argues that increased use of digital technology and offsite production should form a major part of a rescue programme for the industry. PSBP is breathing new life into the schools sector.

Mott MacDonald and Bryden Wood have now been awarded the next stage of the EFA's modular schools project, which focuses on secondary schools.

"The digital model enables a more proactive approach to O&M by providing details of when equipment is scheduled for inspection."

Andrew Williamson
Mott MacDonald project director

Opening opportunities with connected thinking.

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