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MTX continues to transform the perception of modular construction

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Sloping site proves bonus, not barrier

Speed of construction, with significantly less disruption to on-site activity, and continuity of a wide range of orthopaedic surgery, coupled with excellent prior experience of the modular build specialist's expertise at the site, led the project team for a suite of four new orthopaedic operating theatres at the Leicester General Hospital to again select Stockport-based MTX Contracts for the job. As *HEJ* editor Jonathan Baillie reports, last November's completion of the £6.5 million theatre complex means the University Hospitals of Leicester NHS Trust will no longer, in the face of growing demand, need to send some 600 patients annually to private hospitals in the area for their operation.

Built on a sloping site at the heart of the Leicester General Hospital campus in Evington, about three miles east of Leicester city centre, the new operating theatre complex saw its first patients late last November. It was subsequently officially opened by former England rugby union captain and Leicester Tiger Martin Corry on 17 December.

The four new theatres, each of which is equipped with MAT laminar flow canopies to minimise infection risk during surgery, were designed by architects Nightingale Associates after consultation with surgeons, anaesthetists, nursing, and other theatre personnel. Subsequently, a number of changes to the original layout, functionality, and services, which were suggested by members of the multidisciplinary project team as the construction work progressed, were successfully incorporated by MTX.

The new theatres link seamlessly to the existing hospital at first floor level; connection is via two new bridges, and via a corridor into a dirty utility area serving general theatres. MTX also built and incorporated into the new modular building a patient reception area and holding bay, a six-bed recovery area with a separate isolation/anaesthetic block room, staff change rooms, a large rest area, offices, and three large stores. Also part of its £4.2 m contract were the construction of a new modular-built pre-operative orthopaedic assessment unit close to an existing orthopaedic theatre which remains in use, and refurbishment of existing facilities in the same location.

Groundworks in progress. The site of the new orthopaedic block is close to a key hospital service road and several clinical buildings. On first excavating, MTX discovered a fair amount of water and electrical services needed re-routing. Right: One of the 35 modules being lifted into place.

Unexpected benefits

While potentially a challenge, the new theatre block's sloping site enabled MTX to offer the Trust features it had not actually anticipated; it was able to use the space at basement level to incorporate some 300 m^2 of new offices and seminar rooms, which are used both by clerical and administrative staff, and by clinicians. During the design phase, MTX devised a plan to "drop into place" additional modules to support the new extension. This provided the space for the additional facilities "at a minimal cost", making good use of otherwise "dead space". Meanwhile the new theatre reception area, sizeable storage rooms, and staff changing accommodation, were created by MTX's refurbishment of the hospital's former Sterile Services Department.

Andrew Brown, a consultant orthopaedic surgeon at the hospital,

The rooftop plant room incorporates an air-handling unit for each orthopaedic theatre and for the recovery area.

The finished orthopaedic theatre building; the new theatres link seamlessly to the existing hospital at first floor level.

and the clinical lead for the Trust's musculoskeletal clinical business unit, who was a key member of the project team, explained that the additional storage facilities are proving particularly useful, since, as he put it, "orthopaedic surgery is highly dependent not only on medical equipment such as the image intensifiers used during surgery to X-ray parts of the patient's body, but equally on prostheses – typically artificial joints such as hips and knees, all of which take up considerable storage space".

"The reason why the new theatres were needed," he explained, "was that, with an ageing population, and an increase in the range of orthopaedic procedures we can offer, we have seen a steady rise in demand for procedures ranging from knee and hip replacements to complex spinal surgery in the past 3-5 years." This, he explained, had put increasing pressure on the hospital's' four existing orthopaedic theatres, three of which are at least 30 years old, and had not been refurbished throughout their lifetime. Insufficient capacity in these existing theatres had, in fact, seen the Trust forced to contract out around 600 orthopaedic procedures each year to other local private hospitals, clearly not a desirable long-term practical or financial solution.

The surgeon explained: "With the completion of the four new theatres, we have been able to close the three older ones, while keeping the newer MTX-built facility, which was competed in 2005, operational."

Project director appointed

Andrew Brown explained that planning in earnest for the four new theatres began in May 2009, at which stage the project team took on as project director an expert independent consultant, Ian Currie. Following the tender process, the full business case was approved by the Trust's Board in August that year. MTX subsequently started groundworks on the site, which is close to a key hospital service road and several clinical buildings, in February 2010.

"Careful co-ordination of the work, and an excellent relationship between MTX, its sub-contractors, and the Trust project team, as well as with clinicians and other hospital staff, saw the project progress very smoothly," explained Andrew Brown. "There was minimal disruption to day-to-day activities on what is a very busy, 680-bed acute hospital campus."

The 35 pre-fabricated modules that form the new theatre complex were craned into position just after Easter last year, with the partitions, first fix trunking, and other containment components, pre-installed off-site. Andrew Brown said: "On first excavating, MTX discovered that a fair amount of water and electrical services needed re-routing, and, of course, the company was working close to existing buildings and a well-used service road. It nevertheless managed the building programme extremely efficiently, and all involved were excited and delighted to be able to start moving equipment and staff over to the new complex during November."

The University Hospitals of Leicester NHS Trust, the consultant surgeon explained, employs around 35 orthopaedic surgeons city-wide, with elective procedures currently undertaken both at the Leicester General Hospital and at Glenfield Hospital, and orthopaedic trauma and children's orthopaedics carried out at the Leicester Royal Infirmary. Overall the Trust provides orthopaedic surgery for an estimated 4,000 inpatients, and sees some 2,500 day case patients, every year. For greater efficiency, it is in the process of looking at consolidating all elective surgery at the Leicester General site, a strategy that could well see the three older theatres currently out of service redeveloped.

Mounting pressure

Andrew Brown said: "The pressure on our orthopaedic surgical facilities had been mounting, and one of the priorities here was that the new theatre complex should be built quickly, to maintain continuity. During the planning process, as part of

The M&E plant room, one of four plant facilities serving the new building.

the wider project team, I, anaesthetic consultant Jeanette Gross, and divisional head of nursing Elaine Ryan, visited a number of orthopaedic theatre facilities at other hospitals (including the four-storey orthopaedic and surgical facility built by MTX at Stepping Hill Hospital in Stockport – *HEJ* – April 2009). At one stage we were keen to specify a barn theatre-type building. However latterly the decision was taken not to opt for such a facility, but instead for a more conventionally configured theatre block, but one where, sharing some of the feel and characteristics of a barn theatre, the four theatres are built adjacent to each other in a horizontal line, with windows in between. This means surgeons can see what is happening in adjoining theatres, while each pair of the four shares sluice and scrub facilities. This helps reinforce a feeling of teamwork, and means surgeons and other theatre staff enjoy good communication.

"The contract for the new theatre block was put out to a traditional tender, with the competing contractors offering a mixture of modular, and more traditionally built, solutions," he continues. "MTX was selected not only because we had excellent experience with the company when it built our earlier orthopaedic theatre, but equally because we knew that, using its modular system, it could not only construct the new theatre suite for us quickly and efficiently, but also complete it to a high standard, and without compromise. I am pleased to say that our faith has been vindicated; we have an excellent new facility with which the surgeons are very pleased, and which patients comment on as being light, bright, and airy."

Concrete floor

The new theatres incorporate a concrete flooring system which complies with British Standard BS 6742 on resistance to vibration in buildings, delivering a response factor of less than 1. Cast *in situ* concrete slabs were used within a metal floor deck within theatre areas, meeting the floor response requirements in HTM 03-01.

Andrew Brown noted that a stable, solid floor is a major asset during orthopaedic surgery, not only because of the demanding and sometimes delicate nature of the procedures being undertaken, but equally because some of the equipment used, such as the image intensifiers, which have to be wheeled in during surgery, can be extremely heavy. He said: "Some modular build systems tend to provide a somewhat bouncy floor surface, which is not ideal in an orthopaedic environment."

Also incorporated are laminar flow canopies, the fixings for which were installed off site, with the canopies

The light and airy "pre-op" reception area.

themselves incorporated on site. Andrew Brown said: "I know none of my surgical colleagues would be happy these days to undertake many orthopaedic procedures, and especially joint replacements, without laminar air flow in use. (in fact within the new theatres the air changes some 300 times/hour, ensuring that clean air is always circulating).

"Research has shown that laminar air canopies help to minimise infection during orthopaedic procedures, to the extent that infection rates during operations like knee replacements are only around 1%. One reason why clean air is so important is that, with many of the prostheses made of synthetic materials, should infection set in during surgery, even repeated antibiotics will not always eradicate it, since components such as plastic knee joints have no blood supply, and there is thus no way for the drugs to reach them."

Given that image intensifiers are regularly used during operations, the four new theatres also incorporate lead-lined walls and doors, as well as electrical sockets and other key fittings. Lighting, from Trumpf, is mainly LED surgical theatre lighting, which Andrew Brown emphasised has excellent colour contrast and clarity and does not suffer the "excessive brightness" of the white light afforded by some LED systems.

Future training role

He added: "The Trust's Information Management and Technology Department has also installed PACS screens, which allow us to consult patient scans and X-rays whenever we need to. In addition, one of the Trumpf lighting pendants incorporates a camera system, enabling us to capture surgery on video and subsequently use it for training purposes. This is a facility we intend to make increasing use of in the future."

The theatres and other new facilities' automatic sliding doors maximise accessibility and, Andrew Brown explained, minimise damage to beds and other equipment being wheeled in and out, while the design optimises patient flow so patients effectively enter the anaesthetic room through one door, have their operation, and are subsequently returned to the recovery area through another, via a circular route.

Increasing evidence, of course, suggests that a hospital environment with ample natural light not only benefits patients, but also enhances the staff working environment. Andrew Brown said: "The windows between the theatres give a view from one to another, while at the end of the block there are further windows into corridors, which in turn have windows at each end. This makes the operating environment much lighter.

The six-bed recovery area.

The theatres enjoy ample natural light, while surgeons and other staff can see what is happening in adjoining theatres via large internal windows.

Light, spacious feel

"There was very little natural light at all in our older orthopaedic theatres. Quite a number of our patients only require a local anaesthetic, so are awake during the operation, and the light and spacious theatre environment is also a welcome feature for them."

Other features of the new theatre suite (in addition to those already described) include non-touch IP sanitary wear, wipe-clean internal walls, Rada Sense "no-touch" washroom controls, and a Starkstrom touchscreen surgeon's control panel in each.

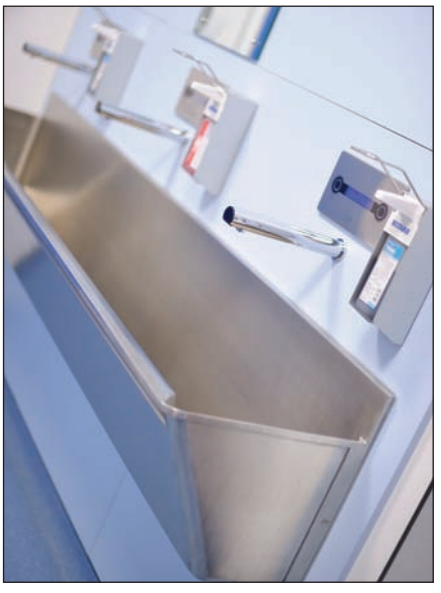
Andrew Brown feels MTX managed the project "extremely efficiently"; disruption was minimal, and he says he and his team are "delighted" with the new facilities. Much of the required medical and operating equipment was moved to the new building from the older theatres, although some new machinery, and surgical instruments, were purchased specially. The surgeon added: "Clearly minimising the time we were out of action was a priority, and I am delighted to report that, having closed three of the four existing theatres on a Thursday, we were able to move everything over and re-commence surgery in the new theatres the following Wednesday."

Re-routing services

Co-ordinating the project at MTX was the company's contracts manager, David Peacock, who said: "This was a complex and demanding, but ultimately very satisfying, project. Among the challenges we faced were the tight site constraints; the proximity of other buildings – including acute wards, the hospital's maternity unit, and ITU; the site location at the hospital's heart; and the need to route a number of key services, as well as to get a large crane in to manoeuvre the modules into place, and to move a mobile MRI scanner located close to where the new building is located. All these activities had to be undertaken with minimal impact on day-to-day activities, and, as the Trust was particularly keen to start bringing back in-house orthopaedic operations recently contracted out by mid-November last year, to very strict timelines.

"At the same time as commencing the groundworks for the modular operating theatres, we started similar work for the new pre-operative orthopaedic assessment unit." Also constructed off site in modular form, this is located close to the main hospital "street", close to the existing orthopaedic theatre which MTX built in 2005, and which the Trust is keeping in use. After completing the "pre-op" unit, MTX refurbished the adjoining existing pre-operative assessment facilities, and formed the two – old and new – into one.

"Building all the modules for the theatres and the assessment unit off site, a process which only took about four weeks from steel fabrication to finished units, considerably simplified the project and speeded completion," David Peacock explained. With careful planning it took just four days to crane all 35 modules into place."



Rada Sense "no-touch" washroom controls feature within the "scrub" area.

Craning challenges

Although MTX was able to get the 500-tonne crane required for the lifting operation to the site via one of the hospital's service roads, this particular road is used not only by ambulances and for deliveries, but also as the emergency access route for fire engines. Careful co-ordination between the Trust's project team, MTX as main contractor, other hospital departments, and the local police, was thus essential to ensure a smooth delivery process. David Peacock said: "The modules had to be craned in in a defined order, and we were delighted that we were able to get them into position with a tolerance of just 10 mm."

Mark Starling, assistant director of facilities at the University Hospitals of Leicester NHS Trust, who, with capital works manager, Keith Hibberd, oversaw the project from an estates and facilities standpoint, said: "We were fortunate not only to develop a very close working relationship with MTX, with whom we had good previous experience, but equally to benefit from the services and expertise of an external project director appointed by Elaine Ryan, at the time operations manager for musculoskeletal activity (she is now divisional head of nursing for clinical support)." Mark Starling went on to explain that the independent project director, Ian Currie, not only helped draw up the outline business case working from the indicative designs from scheme architect Nightingale Associates, but was then involved throughout, leading regular progress meetings and keeping an expert eye on how the scheme was proceeding.

He said: "Before helping us draw up the outline business case, and subsequently the full business case based on tenders, Ian Currie also analysed, in detail, the orthopaedics department's surgical throughput, types of operation, and the number we were having to contract out, and thence identified the type and size of new theatre facility we would need. His input and expertise cannot be overstated; the work he did was critical, both to the

project getting off the ground, and to its subsequent smooth completion. We simply do not have the resource in-house to devote any one member of the team to a full-time project director role."

Generator replaced

Keith Hibberd of the Trust, and MTX's David Peacock, went on to explain that, aside from the tight, sloping location, the project team, and MTX and its sub-contractors, also encountered, and had to re-route, electrical cabling, gas, and local water mains. Keith Hibberd elaborated: "There is a small electrical sub-station close to the new operating theatre block, from which a number of electrical cables run underground and serve adjacent facilities, including the maternity unit, ITU, and acute wards. Not only, working with MTX, did we have to replace one of the three generators inside it with a more powerful one due to the substantial extra power required for the new theatre, but we also had to re-route a number of cables, while maintaining continuous supply to existing buildings."

David Peacock added: "We also re-routed a local water main to run into the undercroft of the new theatre block, from where incoming water, and thence steam, runs through plate heat exchangers, culminating in hot water for use in the new theatre building."

To serve the new building MTX constructed four separate plant rooms – the rooftop plant room incorporates an air handling unit for each orthopaedic theatre and for the recovery area, the theatre-level plant room medical gases, and on the lower ground floor are plant rooms housing electrical controls and wet plant. In addition to connecting up all the required pipework, cabling, and conventional gas supplies to the existing services, and the re-routing of cabling, water, and gas supplies, MTX also moved a large mobile MRI unit from the site of the new theatres to a new location – a concrete base built specially for it close to the hospital's' radiology unit.

Also present at the meeting at the Leicester General Hospital's estates offices, where I discussed the project in some detail with some of the key individuals involved, was Gabrielle Rhys, theatre sister in the new orthopaedic facility, who was full of praise for the high standard of build achieved by MTX.

A user's view

She said: "From a user perspective the new theatre building provides a more spacious, airy, and much lighter working environment than our older theatres, coupled to which the design, with windows between each theatre, and shared sluice and scrub facilities, enhances communication, and engenders a greater feeling of teamwork.

Inside one of the new theatres; the Starkstrom surgeon's panel, Trumpf lighting, and MAT laminar flow canopy, are clearly visible.

"The main theatre corridor is very wide, and there is plenty of space between the anaesthetic room, the scrub area, and the theatre, all features we did not previously enjoy. Patient flow is also efficient: patients enter the main corridor from the reception area through automatic swing doors, progress into the anaesthetic room via sliding doors, which, from an infection control viewpoint, provide fewer touch points, and, following their procedure, are then wheeled to the recovery area through automatic swing doors opening the other way. We can now operate orthopaedically on many more patients as day cases, and a sizeable number are able to walk straight into our reception, have perhaps a 15-20 minute wait, and then go straight through for their operation."

One of the other features that the new facility has provided to improve efficiency and throughput is a dedicated anaesthetic block room, as Gabrielle Rhys explains: "Previously patients requiring just a local anaesthetic had to be anaesthetised in the main anaesthesia facility, but, with the new block room, the 'block' can now be administered in a separate dedicated space. This considerably speeds patient flow, and helps surgeons get through their lists more efficiently."

More space and better storage

Other features singled out for praise by the theatre sister include the dedicated mobile equipment space adjacent to the theatres, and the sizeable prosthesis store. She says: "In our previous orthopaedic theatres, where storage space was severely limited, it could take time to find the required prosthetic component, whereas now all the items are efficiently housed on shelving, and we can find what we require quickly."

While these key functional benefits are clearly appreciated by staff, from a design standpoint, the use of a simple blue and white colour scheme (also incorporated to fulfil DDA requirements) throughout the interior makes for a clean, crisp working environment which is also proving popular. Gabrielle Rhys said: "We also now have a spacious new rest room with its own kitchen, which is great, as many of the clinicians and nursing staff prefer to be able to eat their lunch within the facility. This improves efficiency too, since if staff do go out at lunchtime it means changing into ordinary clothes and then back into theatre 'blues'. Finally, the standard of finish throughout is first-class, with the vinyl flooring and simply painted walls simplifying keeping the theatres and associated facilities clean."

Each theatre incorporates an MAT-supplied laminar flow canopy, with the dedicated laminar flow "field" below clearly delineated not by the customary red lines, but instead by the blue shaded flooring used, for instance, around nurse stations and close to walls in corridors around the rest of the new building.

Accommodating changes

Mark Starling says of the project's smooth completion: "MTX did a fantastic job in taking into account the varied suggestions of the clinicians, estates, nursing, and other personnel involved as the project progressed, and then turning these into reality. Despite the complex site challenges, the new block was delivered in good time, enabling us to meet our deadlines in terms of bringing operations back in-house.

"Ian Currie, meanwhile, constantly challenged the team and the contractor in a way that ensured that the finished facility is not only functionally highly efficient, but equally a building we can all be proud of."

MTX Contracts Ltd, Fairacres House, Fairacres Road, High Lane, Stockport SK6 8JQ
www.mtxhealth.com • Tel: 01663 764845 • Email: info@mtxcontracts.co.uk