Steel is tops for schools

Recent announcements by the Government confirm that the hiatus in school building in England is over and more, much needed first class buildings will be built to support the UK’s educational future.

Steel construction has a track record of delivering quality buildings that research has shown help pupils and students to thrive, and plays a crucial role in delivering the next generation of first rate, cost-effective and sustainable school buildings.

Steel construction is ideally suited for education related buildings, and many have achieved BREEAM ‘Excellent’ and ‘Very Good’ ratings. The speed of steel construction is highly valued in the education sector as deadlines relating to academic term times must be met. Cost effectiveness has always been a major plus point for steel construction, but this has assumed a fresh importance in more austere times. As you will read in these pages however, designers and contractors are confident of ensuring that cost restraints do not prevent aesthetically pleasing educational environments being created.

Around 70% of schools are built with steel frames and it is hard to imagine the UK’s educational needs being met using any other material. Education is not only about schools of course, and further and higher education establishments are equally reliant on steel construction, including student accommodation and specialist research buildings, as you will read in this special publication.

Education is an important market for the steel construction sector, and with around 10% of structural steelwork used in the UK consumed by the education sector annually, every effort is made to ensure that architects and structural engineers are provided with all the advice and guidance they need to make using steel as straightforward as possible.

We hope you find this publication about the use of steel in this vitally important sector interesting and informative, and of course, educational. January 2013
SECTOR OVERVIEW
The education sector has emerged from a period of spending cuts with a more streamlined and cost-effective approach to construction.

VIEWPOINT
An architect’s, an engineer’s and a quantity surveyor’s views on the benefits of using structural steelwork in education.

THERMAL MASS
Constructing an educational building that saves money by utilising thermal mass can be easily achieved with a structural steel frame.

PROJECT REPORT
A host of criteria, including the complexity of roof overhangs, corridor cantilevers, speed of construction and cost, all meant steel was the ideal framing material for the City of Leicester College.

DESIGN
Project teams are increasingly using standardised designs as a cost-effective way of delivering educational buildings.

PROJECT REPORT
Once complete the steel framed Outwood Academy Adwick will save money by utilising its structural thermal mass to control internal temperatures.

PROJECT REPORT
A steel frame for a halls of residence in the Orkney Islands was the most flexible and adaptable solution.

PROJECT REPORT
One of the last Building Schools for the Future projects is being constructed with a bespoke steel frame using tubular box sections to achieve the desired flat soffit.

PROJECT REPORT
A primary school in Blackpool featuring a distinctive elliptical roof could only have been constructed quickly and easily with structural steelwork.

PROJECT REPORT
A modular construction method utilising thermal mass is being used on a new academy and community church in south London.
School building freed from suspension

Things are looking brighter again for the education sector after two years of spending cuts and a disruption caused by rethinking the use of private finance. Nick Barrett finds the education sector eager to respond to calls for more cost-effective design and construction.

Education building was one of the main beneficiaries of Chancellor of the Exchequer George Osborne’s Autumn Financial Statement in December, with some £1,000M released for schools. This will translate into work on site during the course of 2013, bringing a much needed boost to a currently beleaguered sector that was not long ago one of the most vibrant, and which had shown a strong preference for using steel as the construction method.

The education building sector was brought to a virtual halt in 2010 by the cancellation of Building Schools for the Future (BSF), a 20 year £55,000M investment programme for secondary schools in England that was well served by the steel construction sector, with many iconic school buildings completed and commended for providing first class facilities. Research has shown that superior quality buildings provide environments in which schoolchildren can better thrive, and the steel sector had reason to be proud of its contribution.

Against a new, more austere, economic background some of those schools have recently been criticised for incorporating what are now regarded as wasteful elements – atriums have been a particularly sore point – and the move is now towards standardised designs and lower capital costs of construction. Architects and engineers are still confident though of delivering high quality design and construction to the education sector within the new financial and design constraints.

A review of the Private Finance Initiative (PFI) also contributed to a hiatus in school and other education building, but some of the logjam has been released by the Autumn Financial Statement and the future is looking brighter for the education sector now than it has for a couple of years. Steel construction accounts for around 70% of education buildings, according to independently produced market share surveys, and there are good reasons to assume that the fresh emphasis on speedier delivery of cost-effective schools will see that share rise over time.

Although Education Secretary Michael Gove announced in May 2012 that 261 schools will be rebuilt or otherwise improved through the Priority School Building Programme, with a hiatus on use of the Private Finance Initiative it was not clear what funding model would be used. Commentators and financial analysts had fairly consistently said that some form of PFI would be needed, but this was uncertain until the Chancellor’s Autumn Statement when a new approach, PF2, was announced.

The industry awaits news of the first batch of schools to be procured under the new funding regime, in the hope that thrashing out the final details for the process does not delay projects getting started.

There is a drive under way to cut costs, by as much as 30%, or £6M per school, according to DfE statements. Prescriptive design templates were issued in October.

Schools for the 21st century

The Welsh Government is currently planning a £1,400M investment over seven years under the 21st Century Schools Capital Programme to start in 2014-15, funded equally by the Welsh Government and local authorities.

In the period until this programme starts Wales has the last of the projects being built with £415M of capital investment provided under a Transitional Funding programme, which came as welcome news against a background of a cut of 50% in capital spending by the Welsh Government.

This was boosted in October 2012 with £15 million to be invested in 2013-14, enabling ten key school projects to start earlier than originally planned. The Government says it is seeking ways to accelerate the programme further.
School building prioritised

The Priority School Building Programme (PSBP) has a £2,000M capital cost, £1,750M of which will be spent on construction and some of which will be procured as part of the new private finance scheme, PF2. The Chancellor also announced in December a £1,000M boost to pay for some 100 schools that will start on site in Autumn 2013.

Some £270M has been provided for Further Education Colleges as part of the overall programme. Skills minister Matthew Hancock said he expects to see over £1.5Bn of further education projects come to market over the next two years after the Treasury announced a funding boost in December.

He said: “With colleges trebling the amount of government money invested in capital projects we expect to see over £1.5Bn in new college construction projects get off the ground in the next two years.”

2012 to be used for 261 schools that will replace those considered to be in the worst condition under the Priority School Building Programme. The templates imply that the schools will be 15% smaller than those built under the previous Building Schools for the Future programme.

Investment of £1,000M announced by the Chancellor is for expanding existing schools and to build 100 new free schools and academies, and comes on top of the money already earmarked for school building. The new money is expected to pay for 100 schemes to be built for local education authorities, funded via the Education Funding Agency, the centralised procurement unit created as a capital schemes delivery body for the Department for Education (DfE).

Northern Ireland was able to end a two year capital spending freeze on schools last year, announcing a £173M plan to build mostly primary schools, as well as two secondary schools and a special school.

Schools in Scotland

The Scottish Government announced in June 2009 £800M of funding to support local authorities in taking forward a £1.25Bn programme for the rebuilding or refurbishment of some 55 new primary and secondary schools by 2017/18. The programme is managed by the Scottish Futures Trust.

Funding for 35 school building projects was announced in June 2010, and a further two secondary school projects were announced in December 2010.

By the start of 2012 six schools had been completed and opened, nine schools were being built, and construction of other schools started during the 2012 - 2013 financial year.
Designs for school buildings have to adhere to a particular set of requirements, more specific than many other types of structure. Flexibility, spatial planning, the control of vibrations and acoustics, thermal mass as well as speed of construction all come into play when choosing a framing material for a project’s construction.

Requirements change depending on the type of building, for instance infant, primary and secondary schools will usually have a fairly regular set of classrooms, based around a standard grid pattern. The main difference being that infant and primary schools are usually single storey structures, while secondary schools are predominantly two or three storeys high.

These establishments will also have an assembly hall/sports hall, a structure based around a much larger grid to accommodate the necessary open column free area.

In the higher educational sector the structures will also have to accommodate offices, lecture theatres and laboratories, and even multi storey halls of residence with multiple bedrooms.

“There are many considerations to take into account when designing an educational building, but speed of construction is always one of the most important,” says Stafford Critchlow, Director at Wilkinson Eyre.

Fast construction programmes are vital so that new buildings can be completed within one academic year, or even during the summer vacation in the case of extensions. This will minimise any potential disturbance to the school, college or university, especially if the new building is adjacent to or adjoined to an existing establishment, which is quite often the case.

Steel construction has achieved a strong market position for all types of educational buildings, not just for its speed of construction – helped by the fact that steel can be prefabricated into modular elements - but also for shallow floor construction which can aid vibration and acoustic performance.

The majority of teaching spaces tend to have a 3m clear headroom and exposed concrete soffits, either precast planks or exposed in situ reinforced concrete.

“A steel frame with precast planks ticks all the boxes for school construction. It’s quick and by leaving the planks exposed the project can achieve optimum thermal mass,” explains Hugh Avison, CPMG Architect.

Flexibility is also a major consideration in the design stage. Long span steel construction creates column free space and allows rooms to be configured on the
floor plan to meet the current and future educational needs. Light steel internal walls can be relocated in the future if needs change, leading to fully adaptable buildings.

“Some projects have a long gestation period and the design can change even as late as the construction stage. Steel is more flexible and lends itself to quick alterations,” adds Chris Gilbert, Architect for Pick Everard.

Atriums and long linking streets for larger educational projects are parts of a construction job that are invariably framed with steel. Both of these features rely on long open areas where steel construction is the obvious choice, but as Mr Critchlow says steel has other benefits.

“Steel is more expressive for the construction of big feature elements such as curving and undulating covered streets,” he says. (See story on Bristol Metropolitan Academy to right).

However, with budgets being tightened, school designs have had to adapt accordingly and so large central feature atriums may be a thing of the past.

That is not to say steel construction will suffer, on the contrary many contractors are using modular prefabrication as the way to save money and time, a method that fully utilises steel construction’s inherent qualities (see story on page 22).

The QS’s viewpoint

The education sector is a key sector for structural steelwork with recent Construction Market surveys commissioned by the BCSA and Tata Steel showing that steelwork frames accounted for just less than 70% of all education construction in 2011.

“From a cost consultancy perspective, steelwork can offer a number of advantages that can translate into economies being achieved in construction both for school buildings and for further and higher education buildings,” says Alastair Wolstenholme, Partner at Gardiner & Theobald.

“School buildings typically have similar space requirements (e.g. classroom and library/resource space, catering provision, indoor and external sports facilities etc) and economies can therefore be achieved through the repetition and standardisation benefits that steelwork offers. A number of standard solutions for these buildings have been developed, which are generally steel framed, that offer both reduced design and construction periods and cost savings as a consequence. The programme advantages of steel are particularly important as completion is often driven by the academic calendar and a steel frame can offer quicker erection times and reduced overall construction periods. As a consequence of this, and the fact that associated elements such as substructures can be reduced due to lighter frame weights, economies can be achieved.

“In contrast, further and higher education buildings have a far greater variation in functions and facilities (e.g. workshops, studios, laboratories and lecture theatres as well as general teaching and office space). Within these sectors, steel can provide a range of economical solutions for the required larger spans, higher loadings and varying storey heights as well as the ability to readily vary them within a single building. Furthermore, steelwork can provide future flexibility through larger column free spaces so that buildings can be used or efficiently adapted to suit different needs and functions.”

Steel is streetwise

Part of the Bristol BSF initiative, the Bristol Metropolitan Academy was designed by Wilkinson Eyre and Arup as an exemplar scheme in 2005 and opened in 2008. The project is based around a series of learning clusters all linked by an internal street. This covered area separates the teaching blocks and provides the main focus and hub within the school.

“It combines the key circulation, social and dining spaces,” explains Stafford Critchlow, Director at Wilkinson Eyre. “By using steel’s inherent lightweight construction we created a feature that promotes inclusion.

“The street is curved on plan and undulates along its top, it could only have been built with steel.”

Engineer’s viewpoint

Edward Murphy, Technical Director Mott MacDonald says: “Education buildings are an excellent application for spaces designed with high thermal mass. Thermal loads in teaching spaces are characterised by high density occupation for morning and afternoon periods. During the evenings and overnight the building is either empty or usage is low. This cyclical nature of occupancy and thus thermal load is perfect for high thermal mass applications. In our latest Sheffield Schools BSF programme we have employed high thermal mass techniques, using a steel frame, with real success in limiting summertime temperatures and maintaining better room temperature stability year round. Just a note of caution might be to make sure that acoustic reverberation time issues are also addressed, as this is a consideration for all buildings adopting thermal mass, irrespective of frame material.”
Energy costs have more than doubled in the past decade. In schools, or any other buildings, that's a lot of added outlay – and explains the growing interest in creating buildings that save money through utilising their own thermal mass to reduce energy use.

Also known as fabric energy storage, thermal mass is the ability of a building’s fabric – particularly the exposed soffit of a concrete floor slab – to soak up excess heat. This helps to keep the internal environment comfortable while reducing the need for air conditioning.

It’s a result all round – the building’s occupants are happy, the owners save money and the environment benefits because reducing air conditioning means less CO₂ is produced.

For some architects and engineers, though, it’s led to a misunderstanding that can add unnecessary construction costs to a building.

Because concrete is the material providing the thermal mass, some believe that they are limited to the use of a concrete frame as the best way forward.

Not true, says Edward Murphy, Technical Director of Mott MacDonald.

“It’s a common misconception that a building needs lots of concrete or masonry to achieve thermal mass,” he said.

“In fact, we only require a thin skin of concrete or masonry, and this can be constructed on a steel frame every bit as easily as on a concrete frame. The key is designing so that the concrete or masonry is exposed directly to the internal environment.”

Using a steel frame in conjunction with precast concrete planks on a school in Doncaster, helped the Outwood Academy Adwick achieve optimum thermal mass.

Exposing the floor soffit in most teaching areas has helped maintain the temperature in the school below 25 degrees, resulting in reduced energy.

Thermal Mass can also be achieved using a metal deck solution which was used on St John’s Square – a four-storey council building in Seaham town centre. The project’s success was down to choosing a steel frame comprising steel decking and composite concrete floor slabs which offered the best solution to incorporate natural ventilation and thermal mass to control the building temperatures.

It can also make a huge difference to the cost of a building – when Cheshire Police built their new headquarters in Blacon, choosing a steel frame and precast planks to mobilise thermal mass saved around five per cent on the cost of a concrete frame – and meant the building was finished four weeks earlier than would have otherwise been possible.

So how does thermal mass work?

In buildings such as schools and offices, which are intensively used during the day, temperatures can build up to uncomfortable levels due to solar gain and internal heat gains from the occupants, computers and other equipment. If the soffit of the floor slab is left exposed, the warm air rises and some of the heat is soaked up by the concrete.

This helps to reduce the peak temperatures during the working day and also delays the time at which that peak temperature occurs. At night, cool external air is allowed to flow over the concrete, cooling it down sufficiently so the process can start all over again the next day.

A thin skin of concrete will moderate temperatures over a 24 hour cycle of heating and cooling. The ideal thickness is 100mm, a fact that has been accepted.
During the day, heat is produced in a building from solar gain, human activity and equipment use. The warm air rises and flows across the building's exposed surfaces, where it is stored. At night, cool air is allowed to flow across the surfaces. These cool sufficiently to start absorbing heat again in the morning.

**How thermal mass works**

- Concrete building frames create better thermal mass than steel frames.
  - **Wrong**
    - Steel framed structures are just as effective, as it's the concrete floor that provides the mass.
- The thicker the concrete used in floors, the more heat it absorbs.
  - **Wrong**
    - The first 25mm of the concrete does most of the work, and 100mm is the optimum thickness.

by both the steel and concrete industries. Thicknesses beyond this cannot be mobilised to soak up excess heat. In fact, it's the first 25mm that does most of the work (see admittance chart on previous page).

So it is important that the heat-absorbing soffits remain exposed, which rules out standard suspended ceilings and dry linings.

Experts point out that to get real benefits, it's crucial to take thermal mass into consideration as part of a whole building environment strategy that also includes glazing, building orientation and servicing strategies.

Mr Murphy says: “It’s important that architects talk to building performance engineers when they start, because we can have a very beneficial effect on the carbon performance of the building without curtailing innovation in the design process.”

The steel framed One Trinity Green in South Shields won the BREEAM award for the most sustainable office building in the UK in early 2012, and thermal mass played a large part in its success.

The builders carried out thermal modelling to create a mathematical simulation of the internal environment, which showed that thermal mass could be achieved by combining the steel frame with exposed concrete floors.

The designers made a virtue of this, creating a much-praised ‘modern Victorian warehouse’ feel for the £5.1M building.

Exposed concrete is also used to excellent aesthetic effect at Birmingham Council’s new flagship building in Aston, which achieved a BREEAM Excellent rating.

The team decided creating a steel framed structure was the only way that they could achieve the tight construction programme required on the project, and using exposed concrete floors took away the need to install excessive mechanical cooling. This offered significant cost and carbon savings.

“If you can make a building passive from a design point of view, you save energy and the building will remain low-carbon for the rest of its life,” said Mr Murphy.
Steel construction has taken the lead in the building of new facilities for the City of Leicester College.

A host of criteria, including the nature, shape, complexity of roof overhangs, corridor cantilevers, drama halls, feature entrance area, speed of construction and cost all pointed to the use of steel as the ideal framing material for this prestigious Leicester Building Schools for the Future (BSF) project.

The college has around 1,400 pupils and is a business and enterprise centre as well as a mixed secondary school for ages 11 to 18.

The project is part of the BSF scheme, one of the few such programmes unaffected following the Government’s 2010 review. It is now the largest BSF programme consisting of 21 secondary schools.

New buildings are being constructed on land already owned by the college, and the completed facilities will make use of an existing council owned sports hall which is also located on the site. The overall design layout of the new build is a T-shaped structure with three skewed teaching wings protruding from the longest leg of the building.

Sustainability has been a key issue for the design team and a lot of emphasis has been placed on natural ventilation, solar shading and other environmental features.

“The steel frame solution has enabled the designers to address the demanding targets set by the council for carbon reduction, reducing U-values, improving quality of natural light and ventilation, and reducing heat loss.”

A stack effect of classrooms has been designed for the three two-storey teaching wings. This is said to have optimised the steelwork tonnage and design as well as helping to control natural ventilation.

Steve Merrin, Miller Construction Project Manager, says: “Steel was chosen for its speed of construction, and replicating the design over two floors made the erection even quicker.”

Each teaching wing contains a centrally located double height void, to be used as an independent work area. This large open space, as well as the stack effect, will draw warm air upwards and out via the clerestory roof light.
“We looked at all materials and steel was the best option,” explains Gordon Dow, URS Associate Director. “It is cheaper and faster to build with, and it also accommodates the large expanses of curtain walling and the lightweight steel roof more economically than other materials.”

Miller Construction started on site in April 2012 and is scheduled to complete the building phase of the project in October 2013. The college will then decamp from its existing location into its new building, allowing Miller to begin the demolition and phase two of the job.

Phase two also includes turning the plots where the college is currently located into playing fields and a car park, and this is due to be completed by July 2014.

Prior to steelwork erection starting on site, the sloping site required a value engineered cut and fill operation to avoid an expensive foundation solution and high landfill taxes. To achieve this, dynamic compaction was carried out on the existing made ground before raising the site to formation level by using suitable excavated materials gained from areas of cut.

No spoil has been taken offsite. Instead, it has been used to profile the site, with one part of the college having three levels and being separated from the main two-storey sector by a retaining wall.

In June 2012 steelwork erection began, with Adstone Construction using three mobile cranes to erect the entire 800t of structural steelwork in 12 weeks.

The company also installed precast lift shafts and precast stairs along with the steelwork, while also putting up easi-edge protection with all exterior beams.

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“This is another of steel’s advantages, as the edge protection stays on after the steelwork erection and means there is a safe environment for the follow on trades,” says Mr Merrin.

The 12,700m² building is structurally divided up with movement joints separating the three teaching wings from the T-shape, and also another dividing the T and the upper axis. Stability for the frame is provided by cross bracing, mostly located in partition walls and along some façades.

Although the design is fairly simple, the project’s steel frame is not short on architectural features as a series of CHS columns are arranged along the façade that leads to the main entrance.

Summing up the project Mr Leonard says: “The selection of a steel frame has provided a building that will be high performing through its lifecycle, a low maintenance, energy efficient and ultimately recyclable structure, which is always the best solution.”

The City of Leicester College
Client: The Leicester BSF Company 2
Architect: Aedas
Main contractor: Miller Construction
Structural engineer: URS
Steelwork contractor: Adstone Construction
Steel tonnage: 800t
Project value: £23.6M

All of the steelwork was erected in 12 weeks, aiding the necessary quick construction programme

Centrally located voids in each block will aid ventilation

Much of the existing school will be demolished making room for a car park

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Designers and contractors are increasingly having to deliver more cost-effective and economical school designs in response to governmental review recommendations.

The 2011 James Review made a host of proposals, one of which was standardised designs and specifications; this was seen as a way to reduce school build costs.

A number of leading contractors now have a system in place including Willmott Dixon which has pioneered the Sunesis system. Developed along with local authority controlled company Scape, the system delivers a predesigned and standardised school in quick time, and importantly at a guaranteed price.

“We actually started designing the Sunesis scheme before the James Review, we knew what was coming,” says Bob Athroll, Willmott Dixon Education Sector Manager. “We’ve based it on our experience of building 180 schools in six years. It’s a traditional build that has been predesigned.”

Sunesis is based on five different predesigned steel frames, which can be modified around a school’s requirements. Depending on the site’s footprint, the school’s budget or the number of classrooms needed, the client can change the design’s features or attributes within a set of predetermined parameters.

“It’s a bit like buying a car, you can’t change the shape of the product but you can change or add features,” adds Mr Athroll.

There are said to be a number of advantages with the Sunesis method, many of them associated with steelwork’s speed of delivery and its lightweight attributes. With steel design, a quick and cost-effective programme is assured, while a steel frame usually means shallower foundations are required, which again saves the client time and money.

By choosing a predesigned Sunesis school, a client is importantly reducing procurement times and the associated fees for legal issues, feasibility studies as well as the time spent at design meetings, says Willmott Dixon.

The architect and structural engineer for one of the five Sunesis models is Atkins. It has worked on the Keynes primary school model, which offers four steel framed variants. The first completed project recently opened in Rugby (see box).

Philip Watson, Head of Education at Atkins says: “The Keynes model is based on a 24m span portal frame, which allows lots of future flexibility within the structure.

“Using steel is always best the option...
The UK’s first school to be built using the Sunesis scheme has opened in Rugby. The new structure, erected by steelwork contractor Traditional Structures, is a single storey portal frame that requires a concrete slab of only 135mm and no internal structural columns.

The 1950s built Oakfield Primary School needed to expand as many classes were already using additional temporary accommodation. The original plan was to extend the school at a cost of around £2M. However, with Sunesis, the school now benefits from a brand new building for £2.2M, excluding site preparation costs.

John Harmon, Assets Strategy Manager at Warwickshire County Council said: “With the original budget, we were looking at extending and altering the current building, but analysis showed it wouldn’t be suitable for conversion into a 21st century school premises – a refurbishment option would have meant a poor learning space and the running costs would have been high.

"Rather than try a ‘make do and mend’, for a little bit more we got something much better – a modern flexible teaching and learning space, which minimises its impact on the environment both now and in the future. And we got it quickly too which saved money.”

Peter Owen, managing director for Willmott Dixon in the Midlands said: "Councils across the country are facing similar challenges; constrained finances and a boom in pupil numbers. Post the Government’s James Review of school buildings, Sunesis provides a new generation of affordable designs giving real value and quality for councils that need to improve learning space."

Next Generation school

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Steel proves academic credentials

Work is nearing completion on the Outwood Academy Adwick, a £16m school rebuild project on the outskirts of Doncaster. The Academy, which is scheduled for completion this spring, will feature improved teaching spaces; a dance and drama studio; a new sports hall; and a personalised learning centre - a space for individual care. With 10,651m² of floorspace, the school will cater for 1,350 students from ages 11 to 18.

Wates Construction is delivering the project and was appointed through a Future Schools Agreement designed to speed up the procurement of new education buildings. Commenting on the project, Peter Davies, Mayor of Doncaster, says: “The new school is going to provide the staff and young people with a superb learning environment and it will be a tremendous asset for the local community.

“Outwood is the second of four Doncaster secondary schools benefiting from a rebuild and it follows our successful lobbying of government to invest in our school buildings.”

Using a steel frame in conjunction with precast concrete planks has also helped the project achieve optimum thermal mass. “The floor soffit is exposed in most teaching areas and this will help the school's temperature to not exceed 25 degrees,” explains Hugh Avison, CPMG Project Architect.

“At night the building will cool down via passive cooling through the exposed soffits and this will mean less energy consumption.”

As with most educational projects these days, cost and economics have played central roles in the design and construction of this project. Wates has built a number of schools in recent times, all of which have been constructed with steel. From this past experience, as well as advice from other project team members, steel was chosen as the most economical framing solution.

“Steel is quick to erect, robust and consequently ideal for building schools,” says Paul Hudson, Wates Construction Project Manager.

Structural steelwork was also deemed the most appropriate framing material for this project to reduce the risk of disruption to the construction programme from bad weather. Whilst construction programme is important on all projects, it is particularly significant for the education sector where the academic calendar dictates absolute deadlines. The decision was the right one as little or no time has been lost because of inclement conditions, which is highly important on all projects not least education jobs which have to meet deadlines that correspond with academic terms.

The new Outwood Academy is being constructed on former playing fields. Once the school has decamped to its new premises the existing buildings will be demolished and that site turned into new outdoor sports areas.

The new Academy building is a predominantly three-storey E-shaped structure with all lift and stair cores located in the main vertical interlinking part of the structure.

Thermal mass, economy and speed of construction were crucial criteria when it came to choosing structural steelwork as the framing material for a new academy in South Yorkshire. Martin Cooper reports.
Each of the three teaching wings differs slightly as they accommodate different sized classrooms, although the steelwork grid is largely based around a 7.2m × 7.2m pattern. One of the wings is two storeys high, but wider at the ground floor level as it accommodates a canteen and kitchen.

The majority of the upper second level of the Academy – which will mostly accommodate sixth form students – is more open plan than the rest of the school.

“It’s an economic structure, one that flexibly incorporates classroom sizes tightly controlled by the school prior to the construction details being finalised,” says Gez Pegram, Alan Wood & Partners Director. “We were then able to slot the framing around these areas, which was relatively straightforward to do with steel.”

Stability for the building is provided by steel cross bracing and this is located in and near lift and stair cores in order not to clash with windows; gable ends have also been used for bracing. The locations allowed the frame to be erected over five phases, with minimal additional temporary bracing needed.

“The steel frame has a fairly regular grid which suited the use of steelwork. There are also a couple of open plan double height spaces within the Academy and the long span design also lends itself to steel,” adds Mr Avison.

“Flexibility is also important and not putting bracing in partition walls means it can be removed in the future, thereby creating larger classrooms if needed.”

The open areas consist of a double height ground floor with a library and a drama theatre on the first floor. The drama theatre features a sliding partition, allowing the area to be subdivided into two smaller rooms.

Adjacent to the main school building, Atlas Ward Structures has also erected a sports hall, which features a 33m × 18m five court arena. A series of long span cellular beams spans the courts. These were chosen for economy, as a light steel member was sufficient to support the relatively lightweight roof.

Erecting structural steelwork on a greenfield site is usually a quick process, and this was the case at Outwood Academy Adwick. As the new buildings are being constructed on former playing fields, steelwork erection was able to begin within a month of the construction programme starting, once groundworks had been completed and a stone sub-base installed.

“Using two mobile cranes, one of which was also used to place the precast planks, we erected the entire E-shaped main building and the sports hall in less than three months,” explains Richard Woodhead, Atlas Ward Structures Project Manager.

As the structural design consists of a braced building, temporary bracing was installed alongside the initial steelwork. It had to remain in place until a number of braced bays were self supporting, and once this was achieved the process was repeated for adjacent bays.

The structural design is fairly simple with some vertical repetition as classrooms are the same size. This all adds up to an economical steelwork programme and one which was cost efficient and speedy.

Steel programme makes good time

Thermal mass is the ability of a building’s internal fabric to absorb excess heat, store it and either expel it or use it at a later time.

Did you know ...

- A steel frame can achieve thermal mass just as effectively as a concrete frame, as it’s the concrete floor that provides the mass.
- It is only the first 75-100mm of exposed soffit that absorbs excess heat on a diurnal cycle. Exceeding this thickness has no value in mobilising thermal mass and will simply increase to the weight of the superstructure.
- The first 25mm of concrete does most of the work, with 100mm being the optimum thickness.
Future flexibility

Steel construction proved to be the most cost-effective and economical option for new halls of residence at Kirkwall Grammar School on the Orkney Islands.

Construction projects on outlying islands, where weather conditions can be extremely changeable, are just the sort of jobs where steel construction's inherent advantages come to the fore.

Structural steelwork is prefabricated and can be delivered to site in manageable loads, whatever the distance is from fabrication facility to the project.

Steel is also quick to erect and this is always an advantage on a project where windy conditions can arise and potentially disrupt the construction programme at any time.

These benefits, and more, have all played a significant role in the construction of the Papdale Halls of Residence at Kirkwall Grammar School on the Orkney Islands.

As part of a multi million pound schools investment programme for the islands main contractor, Morrison Construction is also delivering an adjacent new grammar school, a swimming pool and squash courts, and a primary school in Stromness.

The Papdale Halls of Residence will replace existing halls located nearby. They are an essential element for the new Kirkwall Grammar School as pupils from across the entire Orkney Islands study here.

"Pupils from the outlying and northern islands of Orkney cannot travel to and from school in one day," explains Alan Moar, Orkney Islands Council Project Director.

“They will generally arrive on a Monday morning and stay at the halls until Friday.”

In conjunction with the adjacent school build programme, Papdale is scheduled for completion in May. Morrison has been on the overall site since mid 2011, but work on the halls only started in March 2012.

Early works included levelling the sloping plot and then installing foundations in preparation for the steelwork erection to begin in March.

Steelwork contractor BHC, who has also erected the 1,200t steel frame for the grammar school, completed the halls in just three weeks.

“The speed of steel construction was one of the main reasons for choosing the material,” says Ronnie Bruce, Morrison Construction Project Director. “We looked at all options and even if we’d have had to stop erecting steel for a period due to windy conditions, it was still the best and most cost efficient framing option.”

Working on a location such as the
The design of the Papdale Halls of Residence consists of two adjacent blocks that both splay outwards from a common linking entrance area.

To avoid adjacent bedroom windows directly facing each other, and to give occupants privacy, the inner elevations feature angled bay windows. The angled bays face away from the adjacent block and allow views to the front of the halls, towards the school’s playing fields.

Steel was the only material for this tricky design criteria,” says Alastair Kinghorn, Keppie Project Architect. “To form these bays in any other material would have been costly and labour intensive.”

All of the bay windows, straight units for the outer façades as well as the angled units, were prefabricated by BHC and brought to site as complete pieces. This speeded up construction as they were simply and quickly lifted and bolted into place.

Orkney Islands means all materials have to be transported from the mainland, with the steelwork arriving by ship from Aberdeen.

“Steel is more adaptable than other materials as it can be shipped to site in small loads,” comments Alastair Kinghorn, Keppie Project Architect.

BHC had to limit the steel deliveries to 25t truckloads, which were taken by road from its South Lanarkshire fabrication facility to the port at Aberdeen. Once shipped to Kirkwall, the steel loads were held in a compound until required on site.

The Papdale Halls comprise two three-storey blocks linked by a ground level passageway and entrance. Together they provide 70 en-suite bedrooms, mostly singles with a few twins and four disability rooms.

Each floor is accessed via lift or stairs, with bedrooms all on the upper two floors, while the ground levels accommodate kitchens, laundry, dining rooms, TV lounge and staff quarters. The layout of each block is the same, with a central corridor separating two outer rows of bedrooms.

The two blocks are of similar size and are constructed as steel braced frames supporting metal decking for the slabs. Bracing is located in gable ends and in the lift cores and stairwells.

Steel beams and columns are based around a fairly regular grid pattern of 3.75m × 3.75m, with alternate bays larger in one direction at 3.75m × 6.75m.

“It’s a lightweight frame and for economic reasons the design has allowed the omission of alternate columns,” explains Mr Kinghorn.

Summing up, Mr Moar adds: “By using steel we also given ourselves the flexibility to extend the halls if necessary. An extension could simply be bolted on to the existing frame.”

All in the detail

The design of the Papdale Halls of Residence consists of two adjacent blocks that both splay outwards from a common linking entrance area.

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In the frame

The use of structural steelwork has played a crucial and significant role in the construction of a flagship academy in Bradford.

A number of factors come into play when deciding on a material for a project’s structural frame. Quality of construction, future flexibility and cost are always major considerations, but on a school project in Bradford another criteria was deemed equally as important.

For Dixons Allerton Academy the project team wanted a frame that was quick to erect and, importantly, formed a flat soffit. The thinking behind this decision is that it helps with the installation of services and partition walls, making the construction programme quicker.

This was particularly important at this academy as it will be mechanically ventilated, so consequently there is a fair amount of associated ducting to be installed.

“A flat soffit with no down-stand beams certainly means the follow on trades can complete their work more quickly and efficiently once the steel frame has been erected,” explains Jonathan Pye, BDP Project Director.

BDP designed a Slimflor steel frame using tubular steel box sections, with each beam having plates welded to the underside to support concrete floor planks, so ensuring the desired flat soffit.

Speed of construction is of utmost importance on all projects and this job was no different. The new school is scheduled to open in time for the 2013 autumn term, so a quick steel erection programme (completed by Elland Steel Structures in just 17 weeks) was a bonus to all concerned.

Main contractor Wates Construction was keen on utilising a steel framed design as it has successfully constructed a number of school projects in recent times (see Outwood Academy in this issue), all of which have employed structural steelwork.

However, this project is slightly different as it is one of the last Building Schools for the Future (BSF) schemes. "Because of this it has a bespoke steel framed design, and externally we’ve gone for – at the client’s request – a robust brickwork cladding,” says Mark Powell, Wates Construction Project Manager.

Specialising in health and science, the new Dixons Allerton Academy in Bradford will accommodate 1,886 students from ages three right through to 19. This will break down to 26 nursery places; 420 primary and preschool places, and 1,440 secondary places.

To accommodate such an array of age groups, the school’s design incorporates classrooms on a standard grid, but some feature moveable partitions – which is easier to do with a steel frame - allowing two classes to be combined into one larger room as required.

"Future flexibility is one of the main design criteria for modern schools,” says Mr Pye. “None of the partition walls are load bearing and so they could be removed, allowing the
classrooms to be reconfigured."

The new building consists of a long curved three-storey secondary school element, with a two-storey primary school attached to its northern elevation. The primary and secondary schools are linked on two levels and share a common entrance.

The secondary part of the school houses a sports hall at one end, and here, because of the sloping topography, the building is stepped. The ground floor ends at a retaining wall beyond which sits the sports hall, which is linked directly into the rest of the school’s first floor level.

Stability for the steel frame is derived from bracing which is positioned at various locations around the structure, mostly inside internal walls.

The elongated secondary school building includes two large atriums, both featuring skylights which will allow natural daylight to penetrate the inner structure.

Classrooms are arranged predominantly into three rows, with two adjacent corridors either side of a central spine row of classes. The passageways follow the curving shape of the building and separate the inner classrooms from the two perimeter rows of classes.

Because of the long span steel design, the inner or spine row of classes could be removed in the future, as there are no column lines in their partition walls.

“The design has accommodated IT classes in the spine, as these don’t necessarily need direct daylight,” explains Paul Owen, BDP Architect Associate.

The exceptions to the three classroomed row configuration are the atrium locations, where only the perimeter rows continue either side of the void, and the sports hall where only one row of classes continues along the northern elevation.

Because the main curving secondary school building is so long, it has structurally been split into three manageable segments by two movement joints. The primary school, although attached, is in fact a stand-alone structure and is separated from the rest of the school by another movement joint.

The primary school is arranged in a square shape around an inner courtyard. This area has an internal and external element, and will be used as a recreational area overlooked by the classrooms.

An additional external play area has been accommodated along the front portion of the primary school’s upper level.

When the Dixon’s Allerton Academy is completed in August, the existing school buildings will be demolished to make way for new sports pitches, which will also be available for community use.

By providing a multi-disciplinary service coupled with a Building Information Modelling (BIM) workflow, BDP says it was able to play to its strengths on the Dixon’s Allerton project. At an early stage, the structural team at BDP Manchester took ownership of the architect’s design model (BDP Sheffield), which improved communication, and reduced re-draw time.

As each profession developed the model, clash detection became an integral part of the design process in order to produce coordinated and accurate information in the handover to the various steelwork contractors.

All construction documentation was produced directly from the data-rich 3D model; from the architect’s planning submission drawings, through schedules and quantities, to detailed design.

“By referencing live information, it became quickly apparent when a call across the Pennines was needed to tidy up a detail, five minutes later... issued resolved,” says Mr Pye.

But the use of BIM not only improved communication and co-ordination within the design team, it also offered additional outputs visually, through 4D construction sequencing.
Government figures show almost 800,000 more children aged 11 or under will be eligible for state education by 2020. This means that approximately 3,200 new primary schools will be needed by the end of the decade as the pupil population soars to a 50 year high.

Local authorities up and down the country are already gearing up for the highest level in the primary population since the early 1970s with a raft of construction plans.

An example of this trend is the new £5M Baron Road Primary School being built in Blackpool. Scheduled to open this coming September, it will ultimately have a capacity for 420 pupils, enabling the seaside town to prepare for a rising population as well as giving parents more choice when choosing a school.

The project’s client is Blackpool Local Education Partnership (LEP) which is a Public Private Partnership between contractor Eric Wright, Blackpool Council and Northgate Managed Services.

The LEP has delivered a number of education projects in the area using structural steelwork. The decision to use structural steelwork was primarily a contractor driven decision, based on past experience and the need to complete the job quickly and efficiently.

“Speed of delivery and cost were the main reasons for deciding on a steel frame,” says Stephen Linforth, IBI Nightingale Project Architect. “Once the decision was taken we designed the structure around the LEP’s blueprint which included a curved building with a sloping roof.”

The structure’s distinctive roof has a design driven by the proximity of the coast, while its slope is a sympathetic nod towards the adjacent residential properties.

Construction is taking place on a brownfield site close to the town’s football stadium. Due to the presence of peat, the building has adopted piled foundations and a suspended ground floor slab.

On plan the school building structure is elliptically shaped with a highly architectural design that incorporates 7m long cantilevers at either end. The building is essentially two-storey with a pitched roof that slopes in one direction.

Because of the roof’s geometry one elevation is lower and consequently the upper level on this eastern side of the building accommodates plant rooms and...
“Steel was the obvious choice because of the project’s shape,” adds Ian Entwistle, Booth King Project Engineer. “To achieve the curved façades the steelwork is all faceted which is fairly straightforward, using any other material would have been more complicated.”

Speed of construction using steel is always a vital component of any construction programme, and this project is no exception. Once the steel frame was erected the follow-on trades were able to begin their work and the job was able to quickly take shape and get watertight.

Steelwork contractor Billington Structures erected the entire steel package in four weeks, a contract that also included installing three precast stair units.

In the absence of any cores, stability during steel erection required particular attention. “We had to brace the steelwork temporarily, and these props stayed in position until we had the entire frame up,” says Jon Batty, Billington Structures Project Manager.

Once the composite floors were constructed the diaphragm action of the frame stabilised the structure along with strategically positioned permanent vertical bracing.

Taking into account the elliptical shape of the structure one of the main challenges associated with steelwork concerned the irregular grid pattern.

Each of the columns had to be set at a different angle to achieve the shape, while all of the steel connections – designed by Billington Structures – are unique, because of this complex geometry (see box).

Steelwork arrived on site on a just-in-time basis in erectable loads of approximately 25t each. The advantage of this was that the steel did not require storage on site.

In the absence of any large spans, the biggest being 8m in the school’s centrally positioned double height atrium, there are no exceptionally large steel elements, which meant the erection sequence was completed using just one 25t mobile crane.

The largest steel members are four 12.5m long beams, each weighing 3.3t each, which are positioned in pairs at either end of the school building. These beams, supported on two columns to the rear, create the feature cantilevering canopies.
Steel on the side of the angels

An academy in south London is reaping the benefits of the construction team’s new approach. Martin Cooper reports.

Since the James Review was published in 2011 the process of constructing educational facilities has radically altered. Using bespoke architecture, quite often incorporating a feature atrium, is out, and standardisation is very much in.

A number of leading contractors have decided that in order to achieve the Government’s 30% savings target a standardised building approach is needed. Savings can be made with this approach to construction and figures of between 25% and 60% have been mooted. Steelwork is the ideal material for this method, as it is rapid to construct and is erected to tight tolerances, which accommodates a modular or prefabricated approach to other aspects of the building.

For St Michael’s and All Angels Church of England Academy in south London, main contractor Balfour Beatty has adapted its standardised school building system to ensure the project is delivered on time and cost effectively. This approach ensures the minimum amount of disruption to surrounding occupants, such as the existing school, and reduces the amount of on site work which can have a potential health and safety benefit.

Known as BBi600, Balfour Beatty’s school system is based on a standard format that can be repeated again and again. The contractor has used the system successfully on a number of schools already and has now slightly adapted it for this scheme, which is different as it consists of two schools and a church all on one site.

“We are prefabricating as much material offsite as possible,” explains Bob Jenkins, Balfour Beatty Project Manager. “The steelwork is included, it was fabricated early in the programme and was then ready to go up on time, and this will ultimately help us to close the envelope quickly and get watertight.”

The steel frame has been erected rapidly and was configured to facilitate fast installation of the cladding system. Steelwork contractor Bourne Steel delivered the steel to site with pre-engineered channels attached and these will accept brackets from which the cladding contractor simply hangs the insulated exterior panels.

“By using steel the frame has gone up quicker than it would have with concrete. The design is very efficient and by using metal decking and composite beams we’ve used less tonnage than previous projects based on our construction principles, thereby saving money,” says Simon Stocks, ATOM JLC Project Engineer.

The soffit of the metal decking will be left exposed in the classrooms to assist in the cooling of the school. “Utilising the slab to achieve optimum thermal mass is an important part of the project’s design strategy,” adds Mr Stocks.

The use of metal decking instead of
Because of the proximity of roads much of the intumescent fire protection has been done offsite.

precast concrete planks is increasing as designers recognise that they can deliver the required thermal mass from standard composite construction. This cost-effective method can either utilise a standard galvanized finish or a Colorcoat® option which has a pre-finished painted sofit.

Once the steel frame is up the services are then quickly slotted into place. Many of the project’s services are modular, with all risers arriving on site complete and ready to be installed within the steel frame immediately.

The project is divided into four main sectors, the main St Michael’s and All Angels Church of England Academy (SMAA) building, an adjacent three-storey block for Highshore special needs school, a sports hall and a church (see box) which will be linked to the SMAA structure.

SMAA is 100m long by approximately 36m wide and consists of a three-storey element sandwiched between a couple of two-storey segments. Breaking up the structure are two open courtyards and a centrally located movement joint.

Steelwork has been based around a regular 7.8m grid, not just for SMAA but also for the smaller three-storey Highshore building, and both these structures rely on concrete cores for their stability.

Bourne supplied cast in plates for the core-to-beam connections, making sure the steelwork could begin quickly and efficiently.

A steel framed sports hall, measuring 34m x 20m will be one of the last areas to be completed. Long clear spans are essential for this type of structure and a series of 3t beams will be erected to form the sports hall.

“We are working around a ‘live’ school and the project’s footprint is very tight. Using steel and prefabricating offsite will allow us to complete on time without causing undue noise and disturbance to the students,” explains Mr Jenkins.

Aman Kasturia, Balfour Beatty Design Manager, further explains: “With so many elements being manufactured offsite by different suppliers, a higher level of coordination between the interfaces is required, and to facilitate this the design team and key suppliers such as Bourne Steel have utilised Building Information Modelling (BIM) heavily throughout the project.”

With the close proximity of the functioning school in mind and the fact that the site is also bounded on two sides by roads, all of the perimeter intumescent fire protection for the steelwork is applied offsite.

“This is a safety procedure,” says Kevin Springett, Bourne Steel Project Manager. “We’ll then bring the 10t structure to site and erect it in one day.”

The steel framed spire will be 17m high and will be clad in white brickwork to match the exterior façades of the church.

At present the St Michael’s and All Angels Church of England Academy is operating at 50% of its intended capacity, having vacated half of its premises last year. Some of the school was then demolished to make room for the new build.

Construction work is to be completed this summer, and the academy is then due to open in September when the remaining old buildings will be demolished to be replaced with new sports fields.

Community church

The project includes a new St Michael’s Church, to be used not only by the academy but also by the local community. The church will be connected to the academy’s SMAA building, but structurally it is an independent structure.

Erected as a steel braced frame, the church is 19m long x 9m wide with a sloping roof which is 9m at its highest point. The decision to build this element of the project with steel was down to cost effectiveness. Time is of the essence and as this part of the project was the last to be erected, a quick programme was essential and steel was the obvious choice as it could be completed in a couple of weeks.

Standing adjacent to the church, a feature spire will also be erected by Bourne Steel.

“We will be fabricating and assembling the entire spire offsite to save time,” says Kevin Springett, Bourne Steel Project Manager. “We’ll then bring the 10t structure to site and erect it in one day.”

The steel framed spire will be 17m high and will be clad in white brickwork to match the exterior façades of the church.

Preparation of the site

All work to be carried out in compliance with the requirements of all relevant Statutory Authorities and Regulations. All work to be carried out in a way that all requirements under the Health and Safety at Work Act and the Building Regulations are met.

This drawing to be read in conjunction with all relevant specifications & design objectives reports. This drawing to be read in conjunction with all relevant drawings and any matter where the requirements are in doubt. Please confirm with the Engineer on SMHS_CIV_28_CDM_300.