MARCH 2006 VOL14 NO3

NSC

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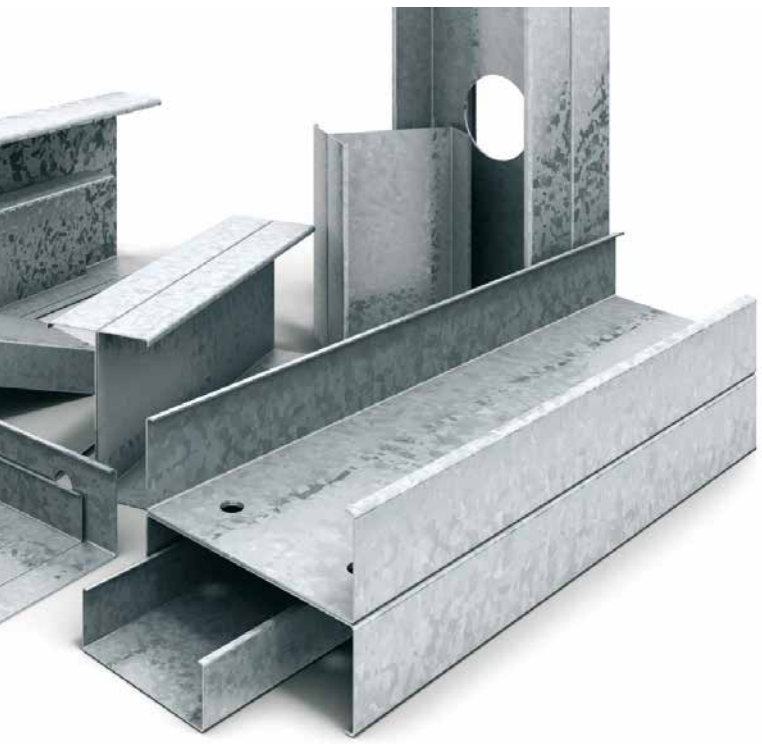

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The greening of sheds

Nick Barrett - Editor

Steel sector delegates at the major two-day sheds event in Newport last month (see News) heard much to please as well as much to challenge. The event was aimed mainly at developers and funders but it was also a success for the service providers. The Steel Construction Institute managed to get a copy of their new guidance for the sheds supply chain into the hands of all the 850 delegates.

We have commented frequently in NSC that sheds are getting bigger and more complex, but there were still a few surprises at Newport. Gazeley for example wants recreational facilities on the roofs of some of their 500,000m^2 developments. These sheds would incorporate the maximum of flexibility, with walls – even external walls – only being installed as and when required.

Our definition of what constitutes a shed may have to change. Property developer Brixton, for example, is looking at designs for sheds of up to six storeys. Others will be focussing on a new generation of smaller, edge-of-town, distribution schemes.

An underlying theme of all these plans is sustainability. Carbon neutral sheds are a target of developers, funders and the ultimate inhabitants of sheds that will challenge the whole supply chain. Steel already has a cogent sustainability case and signatories to the BCSA sustainability charter may find themselves increasingly at a significant advantage as clients and planning authorities scrutinise the 'green' credentials of each development.

Spanish eyes are on spalling concrete

The Spanish authorities have produced their report on the causes of the fire that destroyed the Windsor building in Madrid a year ago, which has been examined and reported on in this issue of NSC (p26). The report provides an excellent case study in why in forensic engineering it is dangerous to rush to conclusions before assembling and carefully reviewing all of the facts.

Although it is essentially a concrete building, much was made by sections of the UK concrete sector while the building was still smouldering of the fact that steel mullions were involved in the collapse. It is clear now that the collapse of mullions that were unprotected was not the only factor involved in the failure of the floors that collapsed.

As Dr Roger Pope points out in his NSC article, the remaining structure was condemned by the Spanish report, which has wide implications for reinstatement of fire damaged concrete structures. At the sort of temperatures seen at Madrid differential expansion caused failure of the concrete-reinforcement bond. The material ceases to be reinforced concrete and has to be condemned, and completely replaced. Everywhere the fire spread the concrete had to be condemned. So even parts of the structure that are still standing may be damaged beyond repair.

Contrast this with the limited need for replacement after fires in fire protected steel structures. Also contrast the extensive knowledge about steel in fires gained from in depth research. If the Spanish report doesn't prompt the concrete industry into investing in research into the behaviour of concrete in fire then one wonders what will it take? Not enough is known about spalling of concrete and there seems to be little urgency to find out.

Wolseley expands in Leamington

Atlas Ward Structures is erecting 1,700t of structural steelwork for a new distribution centre in Leamington Spa for construction products and materials distributor Wolseley UK.

The new building will provide 35,000 m² of floor space and it is situated adjacent to Wolseley's Headquarters at Spa Park. Lead by main contractor FKI Logistex and subcontractor Bowmer & Kirkland, the development comprises two buildings, 61m apart, that are connected by a link bridge. This ensured optimal use of the site while allowing vehicle access between the buildings. Each building is constructed with triple spans of 30m and is 15m high to eaves.

A small difference in total height between the two buildings meant that the fully enclosed link bridge had to be designed and constructed to a slight gradient. The 9m wide bridge has a clear centre span of 32m, is 6m off of the ground and links up with mezzanine floors in both of the buildings. It is designed to enable pallet trucks to move easily between the two buildings.

The building should be fully operational by the end of 2006 and will employ more than 150.

Spanish condemn Madrid fire concrete

Spanish authorities have produced their report on the Windsor Building fire in Madrid a year ago, condemning the surviving elements of the concrete structure as beyond repair. The report scotches earlier suggestions that failure of unprotected perimeter steel mullion columns was the sole cause of the building's collapse (see article on p26).

During the fire the top ten storeys at one end collapsed and much of the perimeter above the 17th storey collapsed later. The building was constructed using a concrete core, internal concrete columns, RC waffle slab floors and steel perimeter mullion columns. The mullions had originally been left unprotected and were being gradually protected during a refurbishment programme when the fire struck.

None of the fire protected mullions failed and the Spanish report says that it is likely that the upper storeys would not have collapsed had fire protection been in place. BCSA Technical Consultant Dr Roger Pope said: "The report concludes, unsurprisingly, that if you do not protect light steel members they will fail in a prolonged fire. Most levels below the 17th were protected, but on the 9th level which was unprotected the mullions buckled but did not collapse as the loads were taken by alternative load paths, which is a classic robustness provision."

Dr Pope says that alternative load paths above floor 17 failed to prevent collapse because there was no effective fire compartmentation, and because of failure of two portalised internal 1200x500 concrete columns at the northern end of the building which collapsed. "The report concludes that the failure of these columns resulted from debris loading and progressive load shedding. But did it? My analysis suggests that the heat from the fire which started at the northern end reduced the capacity of the columns critically, so they were unable to withstand the load from weakened mullions together with whole frame expansion effects."

The report also says that everywhere the fire spread the concrete was then condemned, because differential expansion causes failure of the bond between reinforcement and concrete in fires in excess of 500°C. In the Madrid fire this temperature was reached to a depth of 100mm over more than half the floors and columns.

Dr Pope said:"This means that reinstatement would be impractical because so much of the structure, having been exposed to this severity of fire for so long, would be condemnded."

Heathrow tower under control

An 87m pre-fabricated steel control tower at Heathrow Airport has been completed ahead of schedule after the structure was jacked up within a live airport environment.

Under the £50M project, the 1,000t cabin of the control tower was pre-fabricated by Bolton-based Watson Steel some three kilometres away from the tower's location next to Terminal 3. The completed 27m high cabin was then rested onto a 200t lifting yoke, place onto three trailers and rolled two miles along the runway in a painstaking night-time operation.

Temporary strand jacks from three lifting towers were then attached to the cabin which was hydraulically lifted. As the cabin rose, eight sections of the slender triangular shaped steel mast were slotted in underneath.

Once the structure was erected, the next challenge was to install six steel macaloid cables that would be tensioned from the top of the tower to keep the slender structure stable in high winds.

A curved piece of steel was fitted onto the corners of the three storey base building for each of the six steel cables to rest on while they were tensioned up.

Peter Czwartos, Project Manager at Mace, said the key to success was detailed planning among an integrated team including contractor Mace, structural engineer Arup and steelwork contractor Watson Steel.

"There were a number of technical challenges that would be difficult enough in their own right without such challenging site conditions," he said. "But to do it in such a confined space in a live airport environment was a major logistical challenge. Everything had to be 100 per cent planned. There was no scope to improvise."

Market warms to sustainable sheds

Sheds became the focus of attention of a wide range of property developers and funders at a two-day Sheds conference and exhibition.

The Steel Construction Institute Supersheds Group launched a new guide – Single Storey Buildings: Best Practice Guidance for Developers, Owners, Designers and Constructors – at the event near Newport.

Major clients like Gazeley and ProLogis attended the event where some of them unveiled their hopes for a new generation of sheds that put sustainability higher on the agenda than ever before. Gazeley for example showed outlines of plans for schemes of up to almost 500,000m^2 that could accommodate recreational facilities for use by local communities on their roofs.

These "open air" schemes would only have walls added when they are let.

Property developer Brixton unveiled plans for two and six storey industrial sheds, at Heathrow and London's Park Royal respectively. Others spoke about plans for a new generation of small, edge of town distribution schemes.

Research released at the conference revealed that occupiers of sheds wanted changes in the way they were treated. For example, they want developers to understand their operational requirements better and to be more flexible in design specification. Overall however occupiers are happy with their buildings.

SCI's Senior Construction Technology Manager Graham Raven said: "The event was a great success and we were able to get the new guide into the hands of over 800 delegates. Sustainability was uppermost in everybody's minds, and carbon neutral sheds are a target, which fits in well with the steel sector's own plans for sustainable buildings."

Brixton's model of a two storey shed it has planned for Heathrow

Record high undergraduates awards entries

Entries for both Corus' 2006 Undergraduate Architect Awards (UGAA) and Corus' 2006 Undergraduate Design Awards (UGDA) are running at very high levels.

More than 200 teams have registered to enter final designs for the 2006 UGAA, which challenges them to find a creative solution using steel that illustrates how architecture can communicate global environmental issues to individual communities. The UGAA provides a creative vehicle for undergraduates to learn about the use of steel in sustainable developments.

The UGDA aims to give structural engineering students an opportunity to display their design skills in an innovative and effective way. The awards will be made in two categories, Bridge design and Structural design.

The 2006 bridge design brief is to design a cost-effective and elegant structure to carry a single carriageway over a deep gorge while the structural design brief is to design a high level access building for a theme park roller coaster.

In both cases the competitors are expected to demonstrate sound engineering and structural design skills to produce elegant structural solutions. In addition they are expected to demonstrate individuality and an ability to communicate their ideas in a written report with calculations and drawings.

Corus Construction & Industrial General Manager Alan Todd said: "The increase in numbers reflects not only the growing interest in steel design, but also the desire of the undergraduates to test their classroom knowledge against complex real problems and generate credible overall solutions."

New floor design software excites

Oasys has released a new version of their Compos composite floor design software. The new version allows designers to "excite" a floor for vibration checks and also "dampen" the excitement using the Resotec damping system from Richard Lees Steel Decking.

Compos is said to be the only software that can analyse the effects of using the Resotec Damping System. Resotec sits between the steel beam and metal decking to dampen movement between them. The system is the result of long term research into floor vibration, combined with intensive, high level development work by Richard Lees Steel Decking in partnership with consulting engineer Arup.

Other Compos benefits include being able to calculate the response factor of footfall induced vibration checks. Tapering plate girders is another benefit, and variable slab widths and thicknesses can be allowed for. Standard features of Compos include analysis and design of composite steel beams, including automatic beam and stud selection. Web penetrations and notches, whether with or without stiffeners are also easily dealt with.

The software allows analysis and design to BS5950 ultimate and serviceability limit states such as vibration frequency, deflection, beam weight and depth. Beams can be linked together so that secondary beams load primaries.

AROUND THE PRESS

Contract Journal
15 February 2006
Suddenly it seems the steel industry is sexy… When prices rose, Todd says many contractors revisited the steel vs concrete debate. "Luckily for us, most people found steel was still the thing to use."

The Times
3 February 2006
High-rise concrete blocks are a good example of properties that many lenders avoid. Properties made of concrete have suffered structural problems in the past and they can require expensive maintenance.

Property Week
17 February 2006
Tall and green is future shed vision. He (Gazeley Procurement Director Jonathan Frenton-Jones) showed images of schemes up to 5M ft² (464,511 m²) that could double up for community use by allowing development of recreational facilities on their roofs. These open air schemes would also only have walls added when they are let, reducing the use of construction material.

New Civil Engineer
2 February 2006
From the letters page on claims that solar gain caused the problems at the Castlepoint concrete car park in Bournemouth. I know that I live in the Dorset Riviera, but am I really supposed to believe that the fabulous differential of 16° on either side of a properly designed and constructed precast concrete member will cause spalling and failure.... Come on NCE, give us information, not fairy stories.

New Civil Engineer
2 February 2006
Regarding the Burj Dubai which is set to be the world's tallest building: The structure's reinforced concrete frame and core will be superseded by a steel structure for the final 50 storeys. This will be jacked up from the core of the building and is adjustable, so the height can be extended should developer Emaar so decide to go higher.

One stop shop for Fire Engineering

A new one-stop-shop website has been launched to support the development of the fast growing discipline of structural fire engineering. The website – www.structuralfiresafety.org – has been developed at the University of Manchester with support from a Department of Trade and Industry "Partners in Innovation" initiative, and from industrial partners from across the construction industry, including steel organisations.

Manchester University's Professor Colin Bailey, who has played a leading role in developing the website, said: "The website has been created to reduce the current burden on UK industry in the procurement of efficient and economical construction projects which apply the latest technology associated with structural fire engineering.

"Structural fire engineering is progressing at a significant pace, bringing together the traditional disciplines of structural engineering and fire engineering. New design methods are continually being developed based on theoretical and experimental research. Designers and clients are starting to become aware of the benefits of using

structural fire engineering, which generally leads to the construction of more economical, robust and innovative buildings."

The web site provides free practical and impartial advice on all aspects of structural fire engineering allowing the full benefits of previous research and developments to be utilised in practice. The information on the site includes sections on how to design, quick solutions for the non-expert, case studies, material behaviour, references and test data.

New Heathrow terminal waits to take off

Another massive steel-framed building project at Heathrow Airport is in view after BAA appointed a team to work up plans for a new terminal building to replace Terminal 2.

An integrated team including Foster & Partners and consulting engineer Arup will now work up detailed plans for a terminal building which will be bigger than Terminal 5 and capable of handling 30m passengers a year. The building will sit on the site of the demolished Terminal 2 and the adjacent Queen Elizabeth office block, and also take up space to the east of the existing buildings.

The team will provide early stage construction advice to BAA ahead of a planning application expected in 2007. It is hoped the £1,500M project will gain planning permission in 2008, avoiding the lengthy public inquiry that delayed planning consent for Terminal 5 because the building will replace existing facilities. The project is expected to start on site in 2009 and complete in time for the 2012 London Olympics.

BAA said that there was a unique opportunity to do the project before Terminal 5 got up to full capacity. This would allow aircraft using Terminal 2 to transfer to Terminal 5 while the new facility is built.

"The significant increase in capacity created by Terminal 5 gives us a once in a lifetime opportunity to look at the rest of Heathrow and think creatively about how we can use our current very limited space better," said Mick Temple, Managing Director, BAA Heathrow.

Mike Forster, Business Strategy Director at BAA added: "These companies will help us to understand the key elements of the project in the weeks and months ahead. It is important to stress that they have been appointed for early design and development work only."

Heathrow's Terminal 5 building is around three quarters complete and on schedule for its completion date of April 2008, said BAA.

The £4,200M project on a 260ha site between Heathrow's two runways will include the largest single span structure in the UK at 396m long and 39m high.

The completed steel frame is connected by 22 steel box section rafters. The structure uses 80,000t of structural steel which has all been pre-fabricated off site by BAA framework supplier Watson Steel.

The T5 project also includes two satellite buildings, 4,200 seat multi storey car park, 600 bed hotel and 60 aircraft stands.

Steel demand at high levels

Steel customers should prepare for another possible rise in the price of mill sections of £20 to £30 per tonne around May warns the BCSA, following rises of £20 per tonne in October 2005 and in February this year.

But these sections price increases are thought unlikely to push the price of fabricated steelwork beyond the 5% increase already projected by BCSA for 2006.

BCSA Director General Dr Derek Tordoff says the situation beyond June is harder to predict, but any further increases are not expected to be at levels higher than those for May.

Dr Tordoff said: "All construction products are currently facing raw material and energy price increases and, although steel is not the worst affected material, these pressures, combined with higher steel demand levels, lower stocks and higher prices in other regions of the world, are resulting in the steel mills indicating that the conditions are right for them to introduce higher market prices for structural sections."

It is understood from the sections supply chain that stockholders/distributors, which have seen their margins squeezed in recent months, are likely to recover the price increases and more at the earliest opportunity.

Plates products prices are thought to have reached their base line and some price recovery will emerge in the spring.

Steel construction demand is currently at very high levels, with order books extending into the autumn and beyond. BCSA says new project enquiries reported by members are good and, with steel continuing to win market share, the forward workload projections for 2007 are excellent.

Barnshaws completes Dubai beams and tubes

Barnshaws Steel Bending has successfully completed curving sections for the steel structure of the new Concourse 2 at Dubai International Airport. The work is part of a $2,500M expansion plan for the airport that started in 2002 and is due to be completed later this year.

Barnshaws work included curving large European beams and hollow sections to multiple radii along the same length of section. Some of the HEB 500's and 200 x 100 RHS sections had up to 6 radii along their length, the tightest being a HEB 500 curved on the x-x axis to 4.5m radius. All of the sections were cold bent, to remove the need to heat treat them after bending.

"Cleveland Bridge & Engineering (Middle East) Limited chose Barnshaws as there were no other companies in Europe capable of cold bending the large amount of steel," said Barnshaws Associate Director Greg North. Corus Group (Middle East) is also working on a section of the airport construction and also contracted Barnshaws to carry out the steel bending.

Barnshaws curved a total of 200 beams for the project and completed the work in 10 weeks using five different machines, including the worlds largest bending machine, that is capable of cold bending tubes up to 1524mm x 60mm thick.

When the expansion is completed the airport will be able to cater for nearly 60M passengers – more than double the current number – and will be able to handle the new Airbus A380 Super Jumbo.

Five storey storage for export cars

A new car storage facility at The Port of Southampton has been completed by Bourne Steel.

Constructed on behalf of Associated British Ports, the car storage building provides 2,293 spaces for cars awaiting export. The five storey flat deck building is equivalent to an additional seven and a half acres of storage capacity, with each suspended deck being 93m x 75m in size.

The £3.5M building has been designed to be extremely durable because of its proximity to the sea. A tensioned wire crash barrier was used throughout the car park and the columns were painted orange to lift the buildings appearance.

This economic form of multi storey car storage has saved a considerable amount of space and was built over an existing open surface storage area. The facility is now fully operational and is expected to store over 100,000 cars a year.

NEWS IN BRIEF

Severfield-Rowen Plc and Murray Metals Group, one of the UK's largest structural steel and specialist metal suppliers, have launched a new joint venture company, **Steel UK Ltd**. Steel UK has been created to enable its founders, who will have a combined structural steel requirement of approximately 300,000 metric tonnes per annum, to conduct their structural steel purchasing activities, creating one of the largest buyers of steel in Europe.

A new consultation that aims to provide the Government with a framework to guide future progress in the construction industry has been launched by the Rt. Hon Alun Michael, Minister of State for Industry and the Regions. The draft **Strategy for Sustainable Construction Report 2006** consultation will include a Stakeholder event on 7 March and it is hoped that the review will be completed by the early Summer of 2006.

The **Institution of Structural Engineers** is proposing to make health and safety training from graduation onwards a condition of membership. Health and Safety would have to form part of Initial Professional Development for graduates applying for membership. The move is in response to changes in the Construction (Design and Management) Regulations.

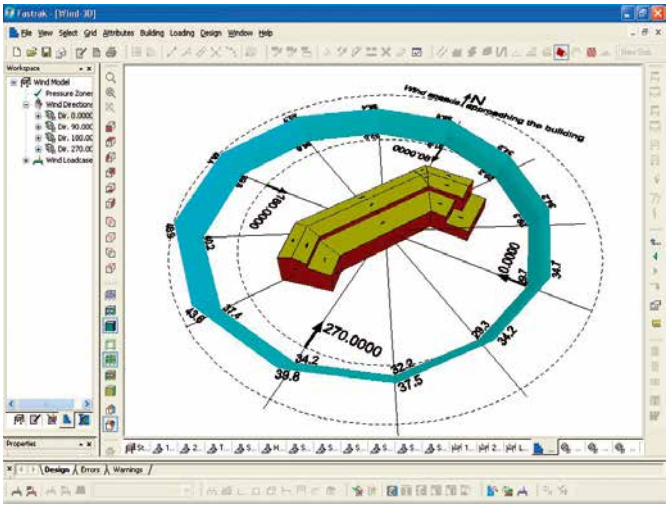
Watch out for the **Financial Times** on March 8 which will publish a special "Steel Construction" report.

The latest DTi figures show orders for private new commercial construction in the fourth quarter of 2005 30% higher compared to the previous quarter, and 31% up on the same quarter a year earlier. Private industrial orders in the fourth quarter rose by 44% compared to the previous quarter, and by 27% compared to the same quarter a year earlier.

CSC upgrades software

CSC is releasing new versions of its software products during the first half of 2006. The first available is the TEDDS® calculation pad software – Version 9. The new version contains many new library calculations from snow loading to enhanced retaining wall analysis and design. Additional calculations for steel as well as other materials are included and many improvements have been made to the mathematical functions. CSC provides regular updates to ensure continual improvement of all their different software products, and compliance with the latest design standards and guides.

CSC has also launched a new Fastrak Wind Load Modeller. The new auto wind loading is in accordance with BS 6399 and has been developed for the Fastrak Building Designer. It calculates the wind loading for a structure using BREVe software using 3D models. The system can give significant time savings and can apply the wind load to automatically created zones for any shaped structure.



Warrington regeneration underway

A new steel framed bus interchange is forming a central part of a major development and regeneration of Warrington Town Centre. The A A Group erected the structural steel, for main contractor Kier North West, in three phases due to site restrictions.

Work began in July 2005 when the old bus station was demolished, with a temporary station situated right in front of the site. "The temporary bus station, along with being in the centre of the town and next to the shopping centre, makes the site very restricted" said The A A Group's Managing Director Kevin O'Keeffe.

The first phase of steelwork involved the erection of 37t of steel to construct a public tunnel from the Golden Square shopping centre to the temporary bus station. The following phases saw the erection of the main structural frame containing a total of 148t of steel.

Construction of Warrington Interchange is expected to be completed by July this year.

Combisafe launches new safety system

Combisafe has launched a new edge protection system that is said to be "stronger, adjustable, lighter, easier to install" and designed specifically for steel frame construction.

Steel Mesh Barrier Mark II replaces Combisafe's existing SMB, and is designed to be fitted to steelwork at ground level, it is then lifted into place with a crane, which speeds up erection times. Combisafe's Director of Operations Barney Green said: "The edge protection has several new safety features and offers time and cost savings to steelwork contractors."

New features include a closed toeboard to ensure debris is contained and an attachment system that allows for vertical and horizontal adjustment. The 'Adjuster' enables the worker to raise or lower the barrier using one hand and without dismantling the whole system, which allows for elements such as glass facades to be installed safely with the barrier in place.

A custom holder is bolted on to the barrier post, with the mesh barrier attached by a hook, allowing the barrier to be attached at any height so work can be carried out underneath it. The SMB MkII system also has reinforced flat-bar edges to prevent damage during transport.

Diary

23 – 27 April 2006 **Interbuild 2006**
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www.interbuild.com

22 June **Structural Steel Design Awards Luncheon**
Winners of the 2006 awards sponsored by Corus, the BCSA and the SCI, will be announced.
Contact Gillian.Mitchell@steelconstruction.org

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Pacific Structural Steel Conference
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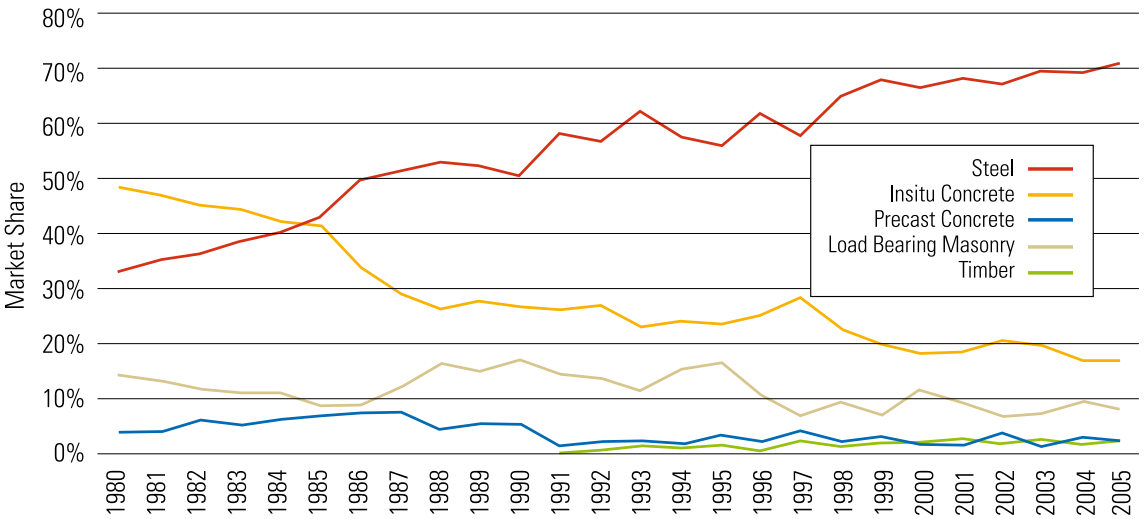
For details visit www.pssc2007.com

30 July – 1 August 2007
International Conference on Steel and Composite Structures
First call for papers. University of Manchester.
For details email mcc.reg@manchester.ac.uk

Surveys show 25 years of steel's success

The headline news from the 2005 Market Shares Survey is that steel's share of the multi storey non-residential buildings market for frames has reached 70% for the first time. But there is much else in the survey to bring cheer to steelwork contractors, Nick Barrett finds.



Total Market Share, Great Britain 1980-2005

This is the 25th in a series of market surveys undertaken by independent market research company Construction Markets, during which time steel's market share for multi storey frames has risen from 33% to its current position of preference among designers and clients. It is worth stressing that although the survey is commissioned by Corus, it is produced independently by Construction Markets, well known for a range of other market research projects for clients across the construction sector.

The original study 25 years ago was to provide market share data for the total market, subdivided by offices and 'other buildings', broken down also by number of storeys. Not much has changed there. The research also establishes the market shares of insitu and precast concrete, load bearing masonry and timber. Construction Markets investigates two broad building sectors, offices and 'other buildings', the latter category comprising retail, leisure, industrial, education, health, other public and other private. Obviously there have been marked changes over time in the relative importance of the components of the other buildings category that reflect the UK's changing economy and hence demand for buildings.

Regarding the overall market, the survey found that in 2005 the market rose 7.4% to 13.26M square metres of floor area built. The offices market increased to 3.85M square metres of space, a 2.9% rise. Other buildings showed more marked growth, of 9.4% to 9.36M square metres.

Steel's share of the overall market reached 70% for the first time, up from 69.2%. Pre cast concrete fell again to a 2.2% share, from 2.8% in 2004, while insitu concrete managed a marginal increase to a 16.9% share.

It is clear that steel is preferred as a framing material by the overwhelming majority of clients

In the offices sector steel increased market share to 71.9% with insitu concrete showing a marginal fall to 20.7% and pre cast up to 2.5%.

A significant rise was seen in the other buildings category, where steel's market share rose to 70.4% – in a rising market – from 68.2% in 2004. Market share there has been captured from precast concrete and load bearing masonry.

Another notable change over time that we can see from the survey concerns the market share in the different heights. It used to be that steel had a very strong share of the low rise market, and this fell off appreciably the higher the building got. This tradition has changed substantially. Steel now has over 85% of the market for three storey office buildings and 74% for six storeys and over.

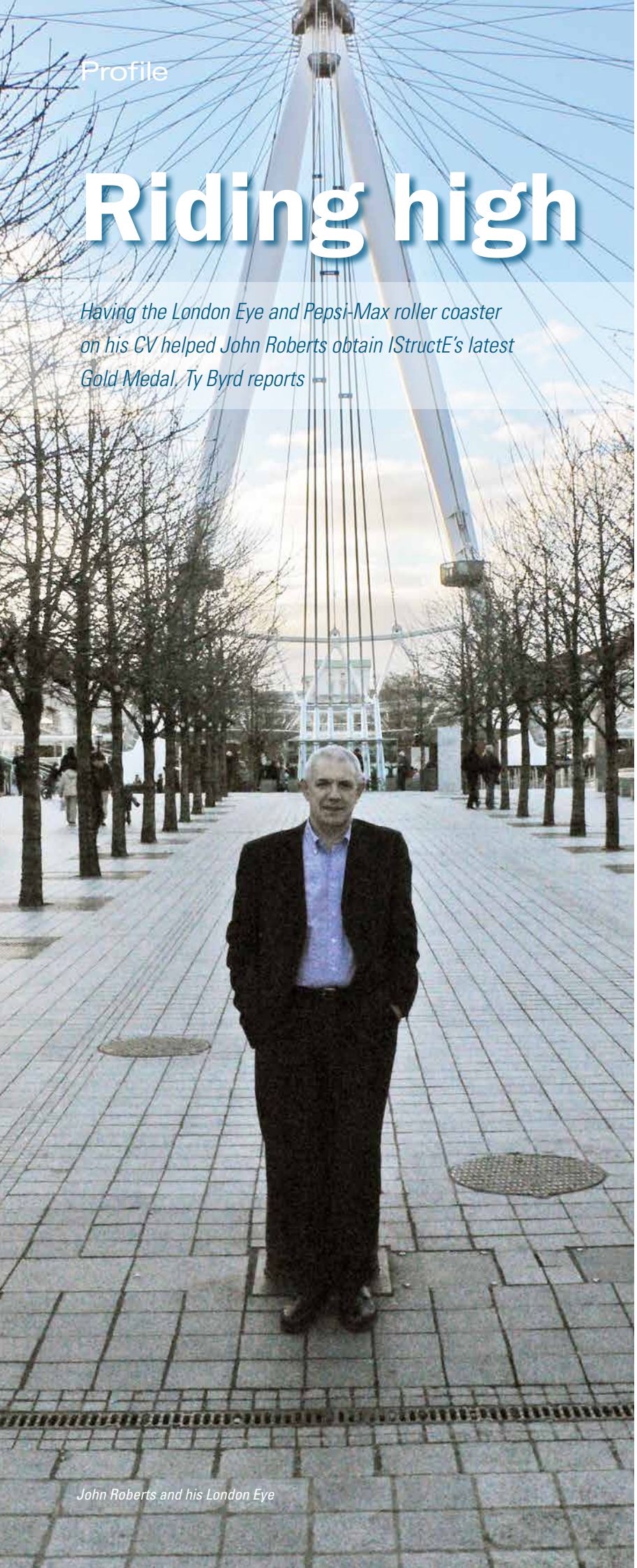
In the other buildings category steel enjoys a near 72% market share at two storeys and over 75% for six storeys and over.

Reasons for this success? The survey does not cover that, but it is clear that steel is preferred as a framing material by the overwhelming majority of clients. Corus General Manager Alan Todd said: "The survey proves that the traditional benefits of steel as a framing material, like speed, flexibility and cost predictability, are well recognised in the market.

"It is crucial though that we keep up our industry wide technical and market development efforts to ensure we can retain and build on the success of the past 25 years. Increasingly this will mean dealing with new factors such as the wider sustainability benefits of steel, making sure those messages are properly delivered to the market."

Riding high

Having the London Eye and Pepsi-Max roller coaster on his CV helped John Roberts obtain IStructE's latest Gold Medal, Ty Byrd reports



John Roberts and his London Eye

Award of the Institution of Structural Engineer's Gold Medal is never for nothing: the medal is high prestige and the latest recipient – Dr John Roberts – got it for helping raise public awareness of big structural projects. This he has done not least as a television pundit on engineering matters given credibility with the public by his involvement in two high profile steel structures. Both of these are the biggest of their kind: the 135m London Eye observation wheel and the Pepsi-Max Big One, Blackpool Pleasure Beach's world beating roller coaster. Roberts and his former firm Allott & Lomax – now Jacobs Babtie – enjoy a kind of cult status as Britain's leading experts on passenger carrying rides. "We do other things as well," he says, "but it is the big rides that get the attention."

"We do other things as well but it's the big rides that get the attention."

Roberts is, in fact, one of Britain's leading structural engineers, having been President of IStructE in 1999-2000. He served as director responsible for structural engineering at Allott & Lomax from 1985; and since 2000 he has been head of Jacob Babtie's building structures division. His name is attached to many major structural steelwork projects. All that said, he has a soft spot for theme parks in general and rides engineering in particular, carried out by his specialist team in Manchester.

Alton Towers, Chessington World of Adventures, Tusenfryd Park in Oslo and the London Dungeon have all got structures in whose existence the consultant has played or continues to play a part. Robert's firm carried out the engineering design of the Pepsi Max and was appointed consulting engineer on the London Eye to verify the adequacy of the structure and oversee its safety, a responsibility it continues to exercise today. There are other rides at home and overseas (either operational or planned) with which the firm is involved. The engineering is highly specialised and the fact there are not many specialists is a matter of some delight.

"We had to learn it all from scratch," Roberts says, "having been introduced to the discipline by chance." One of his engineering colleagues, a water and drainage man, met a director of Blackpool Pleasure Beach while on holiday abroad. He learned the leisure company was looking for an independent engineer to carry out safety checks on its rides. John Roberts subsequently met the Pleasure Beach owner and put forward a proposal, freely admitting his firm had no specific knowlege of roller coasters, but claiming lots of knowledge of structural engineering per se. "We were appointed consultant, given a crash course in how rides work and told to get on with it. That was in 1985 and we've worked for them ever since. It's been great."

Rides are so interesting, especially in their maintenance he says. "They are not static buildings but operating machines withstanding enormous dynamic forces. Maintaining them, you find out how structures perform, you really find out about fatigue." The leisure and theme park world is

similarly fascinating, involving strong and colourful clients. One such was John Broom who owned Alton Towers in the 1980s. "He rang to say he had bought the mono rail trains from Expo 86 in Vancouver and that they were on their way by container. This was February 1988. 'I want the monorail up and running in 16 weeks,' he said. I said: 'In that case, we'd better get our fingers out'."

The track was 3.5km of steel box girder in a loop, supported by steel columns on 88 foundations. There were two stations. The lot was to be competitively tendered. "And we did it on schedule with Fairfield Mabey performing well as the fabricator." One item not carried out in the time was temperature analysis. "We warned that this would have to be done later, and subsequently retrofitted additional foundation tie down bolts to counter the effects of winter cold." Mr Broom did not moan about the late bill for this, it seems. He probably believed that, overall, he had a bargain. Captain Kirk of the Starship Enterprise opened the ride to much publicity, and was paid more for his efforts than the consulting engineer was for its. "I learned from this," Roberts says.

"'I want the monorail up and running in 16 weeks,' he said. I said: 'In that case we'd better get our fingers out'."

One thing that pleases him about the development of passenger carrying rides as a specialism is it has given continuing relevance to some abstruse research he conducted 35 years ago for his PhD. He looked into impact overload of steel structures which, "against all the odds", has proved very useful in the years that followed. His three year PhD was carried out at Sheffield University, from which he had graduated with a first class honours degree in civil engineering. "I think I was a late developer, academically," he says now. "Certainly, that's what my parents used to say."

Perhaps they just wanted to keep his feet on the ground. John Roberts was a product of England's first purpose built comprehensive school, in the Bristol constituency of Tony Benn. He had passed the 11+ but his mother did not favour the grammar school. He obtained three good A levels and sat the Oxford Entrance Exam before finding out that his chosen subject was not an option at Oxford.

"As a sixth former, I spent two summers labouring on construction sites, the second one working all God's hours soil testing for the M5. I earned enough money to buy a Mini Cooper S and thought, crikey, if I can earn this much as a labourer, how much more will I earn as a civil engineer?" He plumped for Sheffield, a good steel town, in search of a good education and real wealth. "I actually won the British Iron & Steel prize when I graduated which involved lots of dosh. Well, £30 seemed like lots in the late 1960s." He married his girl friend Angie in 1969, she just having finished teacher training college and willing to be sole wage earner for the next three years. "One of us had to bring in money during my PhD," he says.

"If I can earn this much as a labourer, how much more will I earn as a civil engineer?"

It's much more fun designing rides, says John Roberts

John Roberts worked for contractor Sir Alfred McAlpine between 1972 and 1974 ("I didn't tell them about my PhD in case they wouldn't employ me"), then consultant Bertram Done & Partners for seven years before joining Allott & Lomax in 1981; spending all his working life based in Manchester. He has been project director on the likes of the SAS Radisson Hotel at Manchester Airport, Victoria Buildings on Salford Quays and the Battersea Power Station redevelopment – as well as lots of theme park schemes. He holds the chair of visiting Professor in Principles of Engineering Design at the University of Manchester; and sits on the Councils of both the Steel Construction Institute and the British Constructional Steelwork Association.

Enthusiasm bubbles out of him, seemingly about everything he does. Being part of the Jacobs family pleases him greatly – "now I can pretend I'm an American" – because this means it is easier to work in the States and Jacobs Babtie can draw on immense profes-sional resources in the US. His enthusiasm for Europe, in particular Eurocodes, is less easy to discern. Perhaps the fact that he has proposed to colleagues a moratorium with regard to Eurocodes activity at the moment gives a clue to his thinking. "It's much more fun designing rides," he says.

Enfield's Palace on target with steel

A 530 space, five storey steel car park will be the centrepiece of the redevelopment of Enfield's town centre.

The days of dreary car parks being tucked out of sight at the rear of developments are passing as architects and clients realize the benefits of using them as eyecatching signature buildings. Jon Masters reports on an innovative car park taking shape as a centrepiece of a London borough's redevelopment.

FACT FILE
Palace Exchange, Enfield
Main client: *ING Real Estate Development*
Project value: *£30M*
Architect: *Reid Architecture*
Structural engineer: *Gifford*
Main contractor: *Costain*
Steelwork contractor: *Bourne Steel*
Steel tonnage: *2,500t*

An innovative four storey steel car park structure is a key element of the PalaceXchange shopping centre in the London Borough of Enfield's town centre. The structure will be highly visible as the signature building of the development, but a successful construction programme is essential to deliver the scheme in time for Christmas trading at the end of 2006.

PalaceXchange, a project by ING Real Estate Development, consists of three main steel framed buildings and provides an extension to Enfield's existing town centre retail facilities. An enclosed walkway across a new pedestrian precinct will connect two shopping malls and the most southerly of these will be joined by a slender steel footbridge across Cecil Road to the third building – the 530 space steel car park integrated with a glass fronted civic building. The civic facility will occupy one end of this structure, and include a new library, offices and other public facilities for LBE, over three storeys to the car park's five.

A successful construction programme is essential to deliver the scheme in time for Christmas trading at the end of 2006

According to Technical Director James Miller of structural engineer Gifford, selection of steelwork for the main frames was an important and early decision led primarily by what was wanted from the car park.

"The architect wanted essentially flat soffits within the car park and there was a desire to fit in as many floors as possible, so we needed efficient use of the building height," says Mr Miller. "Design alternatives were considered, but not selected because with steelwork we could achieve a floor to floor storey height of 2.75m, which is a tight figure made possible by a very efficient structure and asymetric beams from Corus."

Bourne Steel is the steelwork contractor on the PalaceXchange development, fabricating and erecting around 2,500t of steel for Costain which is carrying out the main £30M design and build contract for developer ING. Gifford carried out the outline design in 2002 as development consultant for ING and is now working as Costain's designer.

"The job was tendered twice, first as a two-stage, then a single design and build contract. At each point, contractors looked at concrete as well with various speed and cost comparions on the economics of the different solutions," Mr Miller says.

"We could not have done the same buildings in reinforced concrete in the time available."

"The design of all three buildings stayed as steel frame with composite floor construction due to the time constraints. The planning consent gave a narrow window of 112 weeks for construction, including extensive enabling works to get the development open by October this year."

Costain's Project Manager David Woodhouse said: "Steel frame is quicker and it also allows more flexibility on changes to design during construction. Time was the critical factor though. We could not have done the same buildings in reinforced concrete in the time available."

Car park ramps were delivered as 18m long pre fabricated pieces

The job has essentially been a logistics exercise for Bourne, working with main contractor Costain. The five storey, steel framed car park is on the critical path and has been built up in full height sections with reinforced concrete filled Circular Hollow Section (CHS) columns. All of the steelwork is being delivered to a busy urban area to a schedule carefully managed by Costain and Bourne. But the CHS columns require particular attention. After fabrication, shot blasting and painting at Bourne's yard in Poole in Dorset, they travel north in 18m lengths for filling by Tarmac in Derbyshire, before being transported back down to Enfield at the correct time.

"The logistics of the project are very important."

"The logistics of the project are very important," says Bourne Steel Divisional Manager Nick Flexen-Cook. "The CHS columns have to be fabricated early for preparation, concrete-filling, shot-blasting and painting before getting to site, plus there are concrete stair and floor units to go in at the same time. Planning is being carried out in close cooperation with Costain because we have occupied the site at the same time and we have got to work around each other."

Requirements for the car park and a tight construction programme resulted in selection of steel

Erection of the steelwork is now nearing completion and the PalaceXchange is currently on schedule for its October opening. The retail accommodation is of two and three storey structures with storeys varying between 2m and 6m in height. The steel frame of the northernmost building weighs 310t and consists of 2260 pieces of steel and 7415m^2 of composite metal deck flooring erected in 10 construction phases. The southern building has a smaller floor area of 5130m^2 and consists of fewer pieces – 1378 – but is a heavier structure at 434t.

"The steel frames are a fairly simple design, with columns typically 254 UC 89 in the North frame and floor beams up to 610 x 229 UB 113. It's fairly light stuff, but coordination of the fabrication, delivery and erection has been critical to the overall construction programme," Mr Flexen-Cook says.

Bourne is due to complete its work at the end of March this year and now just has steelwork of the car park and civic building to finish off. The erection of the car park started in October last year. Bourne has operated on two work fronts in tandem, working out from the building's four cores with two crawler cranes. Columns have been built on a large 12m grid, with 300mm deep hollow-core pre cast planks spanning between the asymetric beams.

The car park steelwork weighs 1482t and consists of 1703 pieces including the eight ramps between floors. The ramps were delivered to site as 13 pre fabricated, 18m long pieces. Each consists of steel lattice trusses forming the structural depth and the ramps' barriers either side of pre cast concrete roadways. All of the structure is above the roadway, so no downstand interferes with headroom below. And an onerous 150kN restraint specification has been met with the steelwork barriers.

"The car park is the dominant feature," says Gifford's James Miller. "It is possible to build ugly car parks, but the PalaceXchange structure will have a slender appearance, alongside the glass fronted civic facility which will wrap around one corner of the building. Cladding has been chosen carefully and will be Cedar from sustainable sources."

Sums add up for eco friendly school buildings

Da Vinci's main structure is designed as a two storey braced frame

Long term maintenance and sustainability were among the key criteria resulting in the selection of steel for two schools that are part of a Derby Private Finance Initiative project. Nick Barrett reports.

FACT FILE
Da Vinci Community College & Merrill College
Main client: *Derby City Council*
Architect: *Race Cottam Associates, Bond Bryan Partnership*
Structural engineer: *Pick Everard*
Main contractor: *Norwest Holst*
Steelwork contractor: *Caunton Engineering*
Steel tonnage: *710t*

Private Finance Initiative school operators and associated facilities management companies have 25 years of operational liabilities to look forward to when they commission new buildings. Initial cost considerations are never out of the calculation either, so it was no surprise that the design team opted for steel solutions for the first of two schools being built for Derby City Council under a five-school PFI concession.

"There was no specific requirement for future flexibility or expansion, the steel frame solution nevertheless maximises any future layout options," says Ian Tipton, of structural engineer Pick Everard.

Derby City Council's brief was to provide a building for Merrill College which made maximum use of natural light, was energy efficient and reflected high profile sports, dance and the arts, as well as the differing cultural and ethnic backgrounds of the students who would use the building.

"The council also wanted the design team to produce a building representing a caring, friendly environment, reflecting a contented life at work and leisure for Da Vinci,"said Mr Tipton. "The college also needed to be eco-friendly and had to be designed to meet Building Bulletin 95 'Schools for the future'.

The central rotunda has a high level circular roof

The main driver of the choice of steel for Da Vinci Community College and Merrill College was a tight programme to meet project delivery dates required by main contractor Norwest Holst. The two schools have similar design concepts, both comprising two storey steel frames with composite floor decking and cold rolled purlin, sheeted roofs.

Da Vinci is a secondary school, a fairly typical design for today using 260t of steel. Architect was Race Cottam Associates. Merrill is the biggest of the five being built under this PFI scheme, using 450t of steel. Architect was Bond Bryan Partnership. Bigger schools are coming through PFI now demanding up to 600t, with most in the 200t to 600t range, but Merrill was big for the time when planning started.

The council wanted a building representing a caring friendly environment

Schools can be noisy places so demand careful attention to design to meet acoustic performance. "An overall 175mm concrete floor deck was sufficient to meet both the structural and acoustic criteria," says Mr Tipton, "with services concealed within a suspended ceiling zone."

Basic structural grids of 6.4m and 7.2m were adopted for the main classroom areas, with bay widths adjusted to suit open areas and halls. Ribbon windows on the elevations are a common feature of the schools, with secondary steelwork providing both opening trimming and restraint to adjacent masonry cladding. Braced bays provide lateral frame stability.

Caunton Engineering's Technical Manager Robert Weeden said the main structure at Da Vinci is

The rotunda has two storeys.

It is an economical design solution

Nine metre classrooms with clear spans are on either side of a central corridor

designed as a two storey braced frame, comprising three main wings off of a central rotunda area. The central rotunda has a high level circular roof, formed in 30 degree facets. Block C wing contains a single storey double height Sports Hall. Nine metre classrooms with clear spans are on either side of a central corridor.

"We were brought in early on in the design process so we were able to make a significant input to the design process," Mr Weeden says. "It has a central entrance area, a two storey full height rotunda. There are three wings going off at 120 degree angles. Two of the wings comprise two storeys of classrooms and the other has a sports hall at the end.

"Sustainability was a big issue so we were happy to describe the benefits of steel to the client."

"It is an economical design solution, using some curved floor and roof beams. The roof is low pitched with aluminium standing seam cladding.

"There wasn't too much emphasis on fast tracking the work. Since it was a PFI job we were involved with it for almost a year. We were working on a goodwill basis for about six months while all the financial and other details of the overall PFI deal were concluded."

Merrill College was built at the same time and run as one contract by Caunton to a layout and shape described as traditional. Again it is a two storey structure with a low pitched roof and a sports hall in one wing. There is a feature tower through the library, and the structure required two movement joints. Spans are similar to those at Da Vinci.

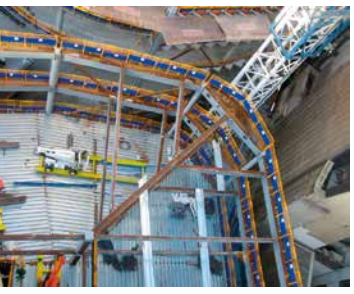
Natural ventilation was specified to meet environment objectives. 'Sustainability was a big issue so we were happy to describe the sustainability benefits of steel to the client," says Mr Weeden. "It is a growing issue which we found the local councillors to be very interested in."

The rotunda has a high level circular roof formed in 30 degree facets

Steel the best insurance for new London landmark

The new Foster & Partners designed high rise development rising on the old Lloyd's of London site will provide a striking City landmark. Margo Cole reports that choosing steel was the best policy.

The structural model was developed jointly by the structural engineer and steelwork contractor



Below: Steelwork is erected two storeys at a time with the prefabricated decking following immediately behind
Bottom: Each Fabsec beam is specifically designed for its position in the building

It is 25 years since construction began on Richard Rogers' iconic Lloyds building in London's financial heart, but only now is a new building going up on the site of the original Lloyds headquarters that it replaced. The new building – known as The Willis Building – has been designed by Rogers' former colleague Norman Foster.

It's a sleek, sophisticated high rise design, but far from simple to build.

The new development at 51 Lime Street consists of two buildings linked at ground floor level and with a common two-storey basement. The smaller building is a curved, 10-storey structure, while the larger is an "arrowhead"-shaped building that steps down in three terraces from 29 storeys to 16. It's a sleek, sophisticated high rise design that makes the most of the oddly shaped infill site but, like most of Foster's designs, it is far from simple to build.

"It's an awkward-shaped building on top of an awkward-shaped hole," is how Project Director Nick Moore of Construction Manager Mace describes the development. Every elevation is curved, making the floor plates very complex, so the choice of construction method was critical – especially as the 701,062 sq ft (65,000 sq m) development must be built to shell and core in just 18 months.

The entire space has been pre-let to the Willis insurance group, but the project began as a speculative development by British Land, which appointed Stanhope as Development Manager. Stanhope – an expert in delivering complex buildings, with a reputation for fairness and farsightedness in construction procurement - opted for a Construction Management route, with Mace as Construction Manager.

Construction Management, where the contractor manages the project for a fee while the work is carried out by trade contractors employed directly by the client, is designed to eliminate any potential for contractual conflicts between main and subcontractors, and enable all parties to be open and honest about their costs.

At the Willis Building Construction Management has been combined with close cooperation between the key trade contractors, who were brought on board at a very early stage. For the main superstructure, Mace got the main players together as soon as it was appointed.

Stanhope Technical Director Peter Rogers asked for a comparison to be made between post tensioned concrete and steel, so concrete contractor Laing O'Rourke, steel specialist William Hare and the scheme's structural engineer whitbybird were brought in to compare the costs and engineering merits of the two.

"Time wise, concrete was faster and not so crane dependent," says Mr Moore. "Concrete was also initially cheaper, because you don't have to fire protect it. But it was much, much heavier, which would have added too much cost and time onto the piling and substructure."

Mr Moore had some reservations about lining and leveling which were resolved by incorporating a jump-form concrete core. "The advantage of the core is that we can fix into it with cast in place plates, which gives us a bit of flexibility," explains William Hare Director Nick Day. "To us that's the best solution."

A prefabricated decking solution was selected – something that had been used before but not on the scale of the Willis Building with its complicated floor plates. Using prefabricated decking, with large sheets designed to fit exactly, means there is no on site cutting. The result is a quieter, faster decking process.

According to Mr Day, decking contractor Richard Lees Steel Decking was initially unsure if the prefabrication would work on a building of this complexity, but it proved to be the right decision. Richard Lees Steel Decking Managing Director Nick Grimsey said: "We faced the logistical challenge of getting the correct prefabricated deck bundles to the right location on site, at the right time. By working closely with our deck manufacturers Corus Construction and Engineering Products, we established an efficient and effective logistical process to overcome this.'

At the Willis Building Construction Management has been combined with close co-operation between the key trade contractors

Using prefabricated decking with large sheets cut to fit exactly means there is no on-site cutting

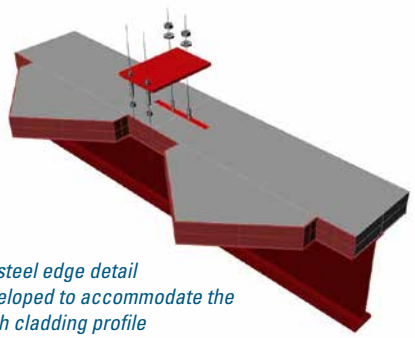
Fire protection also receives an innovative solution. Both the tower and the lower building are entirely glass-clad, with the façade columns exposed. Here, Foster's design was for circular columns but, rather than going for an intumescent paint finish, whitbybird and William Hare developed what they call the "Lancashire Column". This is a standard column section with plates welded between the webs and then placed inside a larger circular hollow section with the void filled with concrete. William Hare fabricated these structural columns and delivered them in two storey height lengths to site.

Mr Moore is delighted that they don't have to be fire protected at a later stage. "That's one trade on site that I don't have to worry about," he says. "One trade whose materials I don't have to lift up with each floor - which is great on high rise."

Since being appointed in June last year, William Hare and whitbybird have worked extremely closely, with William Hare designers taking up residence in the engineer's offices to build a "virtual model" of the steel frame using Tekla Structures. "We built some of the models and they built some, and we passed them back and forwards," explains whitbybird associate director Peter Chipchase. "There was an element

Above: The new building is at the heart of London's financial district

FACT FILE
The Willis Building
Main client: *The British Land Company*
Architect: *Foster & Partners*
Structural engineer: *whitbybird*
Development Manager: *Stanhope*
Construction Manager: *Mace*
Steelwork contractor: *William Hare*
Value: *£117 million*
Steel tonnage: *5,500t*



Right: A steel edge detail was developed to accommodate the saw tooth cladding profile

Below: Circular columns were delivered to site pre-filled with concrete

of trust and a lot of checking, but it was the only way to hit the tight programme. It seems to have worked out pretty well."

The 3D model contains absolutely every piece of detail about the frame, down to the connections, the intumescent paint, and when each piece is going to be made, creating a genuine virtual model of exactly what is built.

The buildings' primary steelwork consists of 11,700 individual pieces of steel, weighing a total of 5,500t. Although the columns are made of standard sections, the majority of the beams in the two superstructures are bespoke "Fabsec" beams, made by William Hare from welded plate, rather than rolled. The Fabsec beams can be bespoke designed, with each piece of plate the optimum size and with holes cut out for the service penetrations.

Although the beams are slightly more expensive per tonne than standard sections, the overall weight of steel is much lower because each beam is working as efficiently as possible. "We have also played around with each beam size to get the intumescent paint down to a single pass, because it's such an expensive item," says Mr Chipchase. "It means some of the beams may be slightly bigger, but that's much cheaper than running the beams through another pass of paint."

The 3D model contains absolutely every piece of detail about the frame

The building has also been subjected to analysis of how it would behave in different fire conditions. This analysis resulted in the fire rating being reduced from 90 minutes to 60 minutes in some places.

Sustainability issues are high on the agenda. "Part of the way into the cladding design - which we had assumed would be straightforward – we were told that the client wanted the building to get a "Very Good" BREEAM rating," recalls Mr Moore. "Fosters did a solar study, and came up with an intermittent saw tooth design for the cladding around the curved facades of the north and south elevations. It left us wondering how we were going to deal with the slab edge."

Again, the solution was steel. whitbybird and William Hare designed and fabricated a saw tooth edge detail for each section of the façade, which acts as the stop end for the deck and will allow the glazed cladding to be fixed in exactly the right location. On plan, every saw tooth section is different, as they are all angled to suit the movement of the sun and provide the correct levels of solar shading.

"Without this detail, we would have had to set them all out individually," says Mr Chipchase. "There are 40 points for each bay, and 15 bays around the perimeter on each floor."

William Hare has been involved in the job since June 2004, although steel erection did not start until last September. Main steel had reached the fifth floor above ground on both the tower and the lower building by February, although more than one third of the total weight of steel has gone in – thanks to the heavy steel frame in the two basement levels. The record set by the erection team is 52 pieces placed and fixed in a single day. Erection is due to finish in June this year.

Lessons from Madrid

The Windsor Building being refurbished

Dr Roger Pope analyses the Spanish report into the causes of the Windsor building fire in Madrid. Unprotected steel mullions were not the sole cause of the collapse, he suggests

The Windsor Building engulfed in fire

On 12 February 2005, fire broke out in the 30 storey Windsor Building in Madrid. This building was constructed using a concrete core, internal concrete columns, RC waffle slab floors and steel perimeter mullion columns. The mullions had originally been left unprotected although the dangers of this had been recognised and a refurbishment programme was in progress, in part with the objective of rectifying this issue. The fire took place, however, before this could be completed.

During the fire the top 10 storeys at one end of the building collapsed and much of the building's perimeter above the 17th storey later collapsed also. This 17th storey was a strong floor. Most of the core remained intact.

A view has previously been expressed that the collapses were caused by failure of perimeter steel mullion columns which were directly exposed to fire and this has been contrasted unfavourably with the perception that the concrete structure performed extraordinarily well.

Now that a report has been published by the Spanish authorities[1] it is possible to see that the situation is not as simple as the view expressed above. This article reviews some the information contained in this report and develops one important hypothesis.

First it must be made absolutely clear that the steel mullion columns should have had applied fire protection. Reference to BS 5950-8[2] or the Eurocodes would confirm this as they were relatively light load bearing multi-storey columns with high section factors (A/V between 100 and 200 m^{-1}).

It must be made absolutely clear that the steel mullion columns should have had applied fire protection.

In the course of refurbishment, fire protection had already been applied to these mullion columns on all levels below the 17th with the exception of the 9th. None of the fire protected mullions failed and the Spanish report concludes that, although it cannot be stated with absolute certainty, the collapse of the upper storeys would not have occurred had this fire protection already been in place throughout.

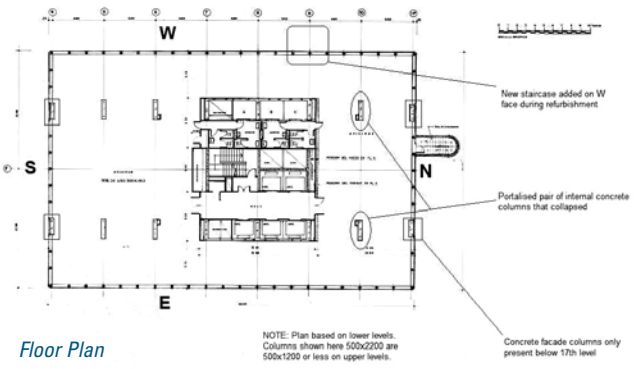
Buckling of 9th floor mullions

That is the end of the report's specific conclusions about the contribution of the steel mullions to the collapse. If you do not protect light steel members they will fail in a prolonged fire. Hardly rocket science!

However, it is interesting to see what happened on the 9th level. The picture shows that the unprotected steel mullions buckled as they were restrained against thermal expansion. But collapse did not ensue. Why? The answer is that the loads were taken by multiple alternative load paths – a classic robustness provision. Mullions above from level 10 to 17 and below from level 8 down were able to distribute and share the loads as the 9th level mullions failed. The fact that there were 60 mullions per floor level added to the number of alternative load paths available.

A portalised pair of 1200 x 500 concrete columns did collapse

Why was it that although these alternative load paths existed above the 17th level they did not apparently prevent the collapses? There are two answers to this – firstly because there was no effective fire compartmentation of the building; secondly because of the failure of two internal concrete columns. Yes, a portalised pair of 1200 x 500 concrete columns did collapse.



Floor Plan

The fire started on the 21st floor level. As shown in the picture taken from the east after the fire, the serviced storey between 16th and 17th levels arrested all the progressive collapse that occurred to the upper superstructure. Such "strong floors" in multi-storey buildings are another classic robustness provision.

The fire eventually raged over nearly every floor from the 5th upwards. It spread both up and down the building as there was no effective fire stopping between floor levels which were meant to act as compartment boundaries. This seems to be due to the fact that the fire stops had been re-


Collapse arrested by strong floor


Four hours after ignition

moved during the refurbishment process. Yet many levels of the building were still in daily use – luckily the fire occurred at night! As should be well known, the need for proper fire protection measures starts during construction and does not cease during refurbishment. Lack of effective compartmentation is a classic weakness in fire.

Had each floor provided effective fire compartmentation then even unprotected mullions on floors above and below would have retained their capacity to redistribute loads as occurred around the 9th level. Compartmentation is, in effect, providing fire protection to all parts of the structure outside that where the fire originates, and, as insurers will say, compartmentation is a key to limiting the scale of damage from a fire.

However, the lack of compartmentation meant that the fire raged over several floors at once. Below the 17th level the fire protected mullions could still provide alternative load paths. Above that level, weakening of the unprotected mullions over more than one adjacent level simultaneously meant that the alternative load paths were far more widely distributed and placed much more demand on the concrete floor slabs to redistribute the loads. Once a slab failed on one level in one area, the added tensions above and collapsing debris loads below led to progressive failure of several storeys until arrested by the strong floor. This is what happened at the southern end of the building.

The lack of compartmentation meant that the fire raged over several floors at once

The simple conclusion expressed in the report is that the failure of the portalised concrete columns resulted from the debris loading and progressive load shedding described above. But did it? It should be noted that the columns that failed were at the northern end of the building and the similar pair of columns at the southern end were robust enough not to collapse when the surrounding floor plates suffered progressive collapse. Furthermore, load shedding reduces the load on upper columns and does not increase it on lower columns other than by debris impact effects.

The difference may be due to the fact that the fire started at the northern end and had been raging seriously for about 1¾ hours when the collapse occurred. The next clue is what happened at level 8. The picture shows a column with extensive spalling, buckling of the exposed reinforcement and fracture of the containment stirrups. Restrained thermal expansion can explain these observed effects from heating of the column. This column was 2200 x 500 with 52 no 32mm dia rebars and loss of the capacity of the end seven bars would not be critical.

Above the 17th level the columns were a maximum of 1200 x 500 with far fewer rebars concentrated close to each 500 wide end face. It is not difficult to see that restrained thermal expansion from extended exposure to heat could reduce the capacity of such a column very significantly. It appears to be a reasonable hypothesis to say that at the northern end this could be enough to reduce the capacity critically such that, even


Effect of heat on 8th level columns

East façade as northern end collapses

allowing for safety factors and material over-strength, the weakened concrete columns were no longer strong enough to withstand the load shed onto them from the weakened mullions together with any whole frame expansion effects.

The final clue supporting this conclusion is in this picture of the east façade as the northern end collapses. Whilst much of the façade glazing has gone, the steel mullion columns are intact. It seems that a "soft storey" is the reason why collapse is taking place at the right hand (northern) end, with intact floors above dropping as an integral assembly. If so, it was only load shedding at the floor where the concrete columns failed that mattered together with loss of column capacity from prolonged exposure to the fire at that level. Had the steel mullions been properly fire protected, the multiple load paths they provided would almost certainly have helped redistribute the loads shed by internal concrete columns weakened by the fire.

Finally, the assessment in the report condemned the remaining structure in a way that has wide implications for re-instatement of concrete structures in comparison with fire-damaged steelwork[3]. The report states that concrete exposed to fires in excess of 500°C will heat up such that temperatures within a surface layer will exceed 200°C. When this happens differential expansion eventually causes failure of the bond between concrete and reinforcement. It goes on to show that in the Madrid fire this critical temperature was reached to a depth of 100mm over more than half the floors and columns, and concludes that the risk of damage to reinforcement-concrete bonds due to the intense heat was inadmissibly high throughout the structure, with the exception of a few individual members on the 5th storey.

Everywhere the fire spread the concrete was then condemned

In other words, independent of whether the steel mullions were fire protected or not, everywhere the fire spread the concrete was then condemned. Thus, whilst the steel and concrete materials regain nearly all their strength on cooling, the two components are no longer able to act as reinforced concrete. Widespread exposure to fire such as that experienced by the concrete elements of the Windsor Building would thus mean that so much of the structure would be condemned that re-instatement would be impractical.

So what are the major lessons from Madrid?

1. **Don't jump to conclusions. Get the facts and carefully review them.**
2. **Effective compartmentation is the primary fire design consideration.**
3. **Structural robustness mitigates the extent of damage in the contingency that the compartmentation fails.**
4. **Even parts of the structure that are still standing may be damaged beyond repair.**

References

1 INTEMAC Report NIT 2-05, December 2005 "Fire in the Windsor building, Madrid. Survey of the fire resistance and residual bearing capacity of the structure after the fire"

2 BS 5950-8: 2003 Structural use of steelwork in building – Code of practice for fire resistant design

3 SCI Publication P-113, June 1991 "Investigation of Broadgate Phase 8 fire"

The bowl shaped stadium starts to take shape

New stadium underpins soccer strategy

A field near Milton Keynes is being transformed into a centre for sport, retail and leisure, with the MK Dons football team the star attraction. Virtually non stop value engineering has ensured an economical design, Margo Cole reports

In the 1989 film "Field of Dreams", ghostly voices advised Kevin Costner: "If you build it they will come". It is not known if Pete Winkelman, chairman of Milton Keynes Football Club, has been hearing voices, but he is certainly following their advice.

The charismatic entrepreneur, who defied critics by relocating Wimbledon Football Club from South London to Milton Keynes, has put together an ambitious development plan that includes a 30,000-seat stadium for the club, despite its current position at the bottom of League One and average attendances of just under 5,000. Construction of the stadium has been under way for just over a year, and it could be complete in time for the start of the 2006/7 season.

Also included in the plans are an 80-bed hotel, a 5,000-seat arena that is set to be the home of the MK Lions basketball team and – looking further ahead – a Chelsea Village-style ring of duplex apartments around the stadium.

Also included in the plans are an 80-bed hotel, a 5,000 seat basketball arena and a ring of duplex apartments around the stadium

The first phase has been funded by deals that developer Inter MK (chief executive Mr Winkleman) secured with the local authority, development agencies and large retailers. After getting the land from Milton Keynes Council, Inter MK sold parcels off to ASDA and IKEA to pay the £42M cost of the new stadium.

With that money in the bank the challenge was to build the best stadium possible for the budget. MK Dons might not be riding high in the football league, but Mr Winkelman believes fervently the team will ultimately grace the highest division, and residents will turn out in large numbers to watch matches.

Music mogul Mr Winkelman is very much a "hands on" client, according to Mark Vinnicombe, Project Manager for Rowecord Engineering, which is building the main steel frame and roof of the stadium. He says: "He's a nice guy, and he definitely likes to get involved in everything. He comes to all the design team meetings."

Rowecord finds itself almost in the role of main contractor for the superstructure. Although subcontracted to Buckingham Group Contracting, which has a fixed price contract to build the stadium, Rowecord's responsibilities include fixing precast concrete units on top tier and both supplying and fixing the metal decking for floors in the building that rings the bowl.

Main contractor Buckingham impressed Mr Winkleman when it converted the National Hockey Stadium into a temporary home for the Football Club. He brought the company in on the stadium project - by far its largest to date - when larger contractors could not agree to meet the budget. Buckingham managed to shave some of the costs off, and the design team made changes to make it affordable.

Rowecord's first involvement was at the start of 2005, by which time the design had been finalised. However this does not mean there haven't been changes. "When we first got involved the scheme was just the stadium, with plans later for an arena," says Mr Vinnicombe. "Since then an 80-bed, four-star hotel has been added, and also provision for the duplex apartments."

The hotel - which makes use of the frame on the West Stand - adds an extra 1,200t of steel to Rowecord's original estimate, and a great deal more cost to the project as a whole. As a result, savings have had to be made elsewhere, which meant Rowecord was involved in value engineering from the word go.

The decision to add the hotel also has programme implications. "We've had to wait for information on the West Stand, as it has been redesigned to accommodate the hotel," explains Mr

This page, clockwise from top left: Steel raking beams support the top level of seating and half of the lower level; Every bay has been temporarily braced; All the erection is being done using mobile cranes and cherry pickers; The cantilever sections are erected from the base of the stadium's bowl

Vinnicombe. "The steel has been beefed up in that area."

So, despite the West stand being on the critical path, Rowecord had to start with the North and East Stands then move onto the more complex West and South.

The stadium, designed by HOK Sport, has two tiers of seating all the way round, with a concourse running the full circumference between the two. Unusually, the concourse is at ground level, with the pitch sunk in a 4m deep bowl and much of the lower tier of seating sitting directly on the banked sides of the bowl.

As a result, the steel structure supporting the roof is much lower than in traditional two tier stadia, and both tiers can be accessed directly from the concourse without the need for either stair towers or special access for the disabled.

The entire North and East Stands and half of the South have the lower tier of seating constructed from in situ concrete placed on the banked sides of the bowl, and in all stands the upper tier consists of precast concrete units supported by 1,020mm deep steel raking beams fixed to the main structural frame. For the West and half of the South Stands, however, the lower tier of seating is also supported by raking beams rather than on the earth bank to accommodate the future arena and the hotel.

Rowecord's basic frame consists of two columns with the floor steel spanning the 7.2m between them, a 9m long triangular backspan section at roof level, and the first section of the cantilever roof and a raking beam. In all, there are 50 of these frames around the outside of the bowl, placed on a 7.2m grid.

For the columns and the floor beams, Rowecord has stuck with standard universal beam and column rolled sections. But - as part of the value engineering that has been a constant element of the project - the fabricator introduced the cheaper alternative of using welded plate girders for the 28m long raking beams.

Plate girders have also been used for the tips of the 31.8m long cantilever roof trusses. These cantilevers are erected in three sections. The first - at the back of the stand - go up as part of the initial frame construction, working from within the floor plate of the building. Then, the 14.2m long mid section and 10.2m tip are erected from the pitch level. The upper and lower chords of the cantilever trusses are made from 250 x 250 square hollow sections, while the infill steel is 114mm diameter circular hollow sections.

There is no tower crane on site, and all the steelwork has been erected using mobile cranes, with the erectors working from cherry pickers. "We haven't had anyone out on the steelwork yet," says Mr Vinnicombe. "We've planned the whole project not just around the fabrication and delivery to site, but also around the construction. Any big project like this has got to be construction-led."

Rowecord must ensure the frame is stable throughout the construction process. Structural engineer SKM's design is based on the roof acting as a diaphragm, so it is not stable until the entire structure is complete. To compensate, Rowecord is installing full height temporary cross-bracing in every bay. On the West Stand, the lower tier of raking beams also provide permanent bracing, so they have to be in place before the front section of the cantilever roof truss can be erected.

Rowecord started work on site in mid-August 2005 and will finish in April 2006, putting the scheme on schedule for completion in time for the start of the 2006/7 football season. It remains to be seen if Mr Winkelman's dream will be realised, and the fans will then come.

FACT FILE
Milton Keynes Dons Stadium
Main client: *Inter MK*
Architect: *HOK Sport*
Structural engineer: *SKM*
Main contractor: *Buckingham Group Contracting*
Steelwork contractor: *Rowecord Engineering*
Project value: *£42M*
Steel tonnage: *4,300t*

‘But not long after there arose against it a tempestuous wind, called Euroclydon.’

Drafts of the UK National Annexes to the Eurocode suggest a convergence with the current British Standard. There will however be significant changes concerning determination of wind loads, which the Steel Construction Institute’s David Brown highlights.

This article offers a preliminary overview of EN1991-1-4, which covers wind actions. For UK designers, having only relatively recently managed the change to BS 6399-2, the quotation from the Acts of the Apostles may seem particularly appropriate as we open the Eurocode. However, the main conclusion of this article is that the draft UK National Annex appears to move the Eurocode fairly close to the British Standard – meaning that the process will be familiar, even if the nomenclature has changed. EN1991-1-4 is already published, and its National Annex is expected to be published for public comment this year.

The process will be familiar, even if the nomenclature has changed

Wind loads will be (even more) important

Under the Eurocode regime, wind loads will be a more important part of the design load combinations than previous practice. This is not the responsibility of EN1991-1-4, which simply defines the wind loads, but arises from EN1990, which describes load combinations and their factors. Table 1 shows a limited comparison between combinations to the British Standards and Eurocode, (including some assumptions about the factors likely to be in the National Annex for EN1990.)

Table 1: Comparison of probable load combination factors between British and European Standards

	Dead	Imposed	Wind
British Standards	1.4	1.6	—
	1.2	1.2	1.2
Eurocodes	1.35	1.5	0.75
	1.35	1.05	1.5

When designing to the Eurocodes, wind loads will appear in most load combinations, and may have a significant impact on ‘lightweight’ designs, such as portal frames. For other structures, such as offices, the effect will be modest, and only make an impact on the bracing and stability systems.

Key Changes

This article does not attempt to explain *why* things have changed, but only to point out what significant changes designers might expect in the process of determining the wind loads. This can only be an introduction, as the National Annex is not yet available for public comment. Designers will have to work with the published documents as they become available rather than the information in this introduction!

There is no equivalent to the ‘directional method’ found in BS 6399-2. The Eurocode approach is similar to the ‘Standard method’ but will allow an equivalent to the ‘hybrid method’ where the pressure is calculated by considering different directional factors, terrain categories and distances from the sea around the site.

Basic wind velocity

The map has modest differences, as it is based on a 10-minute mean wind speed. BS 6399-2 was based on an hourly mean, and CP3 on 3-second gusts. For users, this has no impact on the process.

Terrain Categories

Although there are five categories in the Eurocode, the National Annex reduces this to the three familiar to UK designers – sea, country and town. Designers may regret the opportunities denied for the intermediate categories, but may rejoice that the UK position will be simple and familiar.

Altitude factor

The Eurocode introduces a reduction factor into the calculation of the altitude factor, of the form $(10/z)^{0.3}$ where z can be the height of the structure (it seems). This applies where $z > 10$m. A structure of 40m height will produce a reduction factor of 0.66, which will appeal to UK designers.

Mean wind velocity

The size of the National Annex is due in some degree to the very extensive guidance to calculate the mean wind velocity. Graphs are provided for sites in country and town terrain that will shortcut the approach taken in the Eurocode. Again, the idea will be familiar to UK designers, who are now used to discriminating between sites, allowing for the distance from the sea and allowing for the distance

Terrain category	Z_o m	Z_{min} m
0 Sea or coastal area exposed to the open sea	0.003	1
I Lakes or flat and horizontal area with negligible vegetation and without obstacles	0.01	1
II Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0.05	2
III Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest).	0.3	5
IV Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15m	1.0	10
NOTE: The terrain categories are illustrated in A.1.		

Table 2: Eurocode terrain categories – simplified in the draft National Annex to sea, country and town terrain.

into the town. Software applications will probably need the graphs in the National Annex in numerical form – an interesting challenge!

Size effect and dynamic factors

The UK National Annex takes the opportunity to split the Eurocode's so-called structural factor into its two constituent factors – the size effect factor and the dynamic factor. Although the presentation of these is different, at least the principle will be recognised by UK designers. The National Annex introduces familiar building types when considering building dynamics – just as there are in BS 6399-2.

One interesting observation is that the structural factor (the combination of size effect and dynamic factors) is limited to external forces, and is not applied to internal forces. UK designers are used to calculating a size effect factor for the internal pressure. This will affect nett pressures, since the internal pressure (be it positive or negative) will be at its 'full' value and not reduced by a size effect factor. Long span roofs will be the most affected by the apparent change in net pressures compared to BS 6399-2.

Long span roofs will be the most afftected by the apparent changes in net pressures

Pressure coefficients

The coefficients will look familiar. 'Division by parts' is as prohibited as it is in BS 6399-2. Positive (downward) pressures will still be a feature for the design of roofs, as they are in BS 6399. The National Annex introduces a set of 'overall force' coefficients, missing from the Eurocode.

The Eurocode proposes coefficients that vary between loaded areas of 1m² and 10m², with interpolation between. This would have probably led to early retirement en mass within the design community, had the National Annex not brought some sanity. The National Annex applies the single "10m² coefficient" for at anything larger than 1m², which will save the day for structural designers. There may be interesting (and onerous) implications for the designers of small items (<1m²) and the fixings for such items.

Internal pressure

A sense of déjà vu is created here! After becoming used to an internal pressure coefficient of -0.3, the Eurocode requires designers to calculate the actual coefficient, based on the openings on the faces and roof. However, the Eurocode does offer the following: *"Where it is not possible, or not considered justified to estimate (the opening ratio) then c_{pi} should be taken as the more onerous of +0.2 and -0.3"*. This will sound awfully familiar to CP3 users. Casual observation suggests that realistic calculations do lead to an internal pressure coefficient of around -0.3, so a headlong rush towards +0.2 should be resisted.

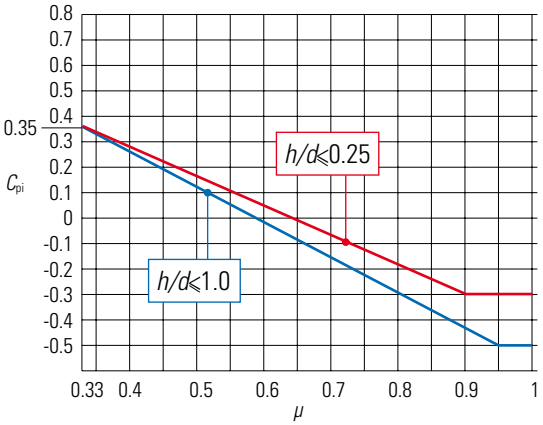


Figure 1 – Calculation of C_{pi} in accordance with the Eurocode

$$\mu = \frac{\sum \text{area of openings where } C_{pe} \text{ is negative or -0.0}}{\sum \text{area of openings}}$$

Conclusions

Firstly – when will it all happen? The general expectation is 2007 onwards. The draft National Annex for EN1991-1-4 is expected for public comment soon, so publishing early in 2007 seems reasonable. The other essential parts of the Eurocodes necessary for design should be in place (each with their all-important National Annex), to this sort of timetable.

The draft National Annex to EN 1991-1-4 will be welcomed by many, as it makes the process of calculating wind loads familiar to BS 6399-2 users. Designers will recognise the process, despite the different presentation and nomenclature. As calibration exercises and the first few designs are complete, no doubt wrinkles will be discovered. These may be simply due to the heightened impact of wind in the basic combinations, as well as features of EN 1994-1-4 itself.

New and Revised Codes and Standards

(from BSI Updates January 2006)

BRITISH STANDARDS

BS 5400:-
Steel, concrete and composite bridges
BS 5400-5:2005
Code of practice for design of composite bridges
Supersedes BS 5400-5:1979

BS EN PUBLICATIONS

The following are British Standard implementations of the English language versions of European Standards (ENs). BSI has an obligation to publish all ENs and to withdraw any conflicting British Standards or parts of British Standard. This has led to a series of standards, BS ENs using the EN number.

Note: The date referenced in the identifier is the date of the European standard.

BS EN 14399:-
High-strength structural bolting assemblies for preloading

BS EN 14399-6:2005
Plain chamfered washers
Supersedes Parts 1 & 2 of BS 4395 which remain current

AMENDMENTS TO BRITISH STANDARDS

BS 8100:-
Lattice towers and masts
BS 8100-4:1995
Code of practice for loading of guyed masts
Corrigendum 1 AMD 15979

BRITISH STANDARDS WITHDRAWN

BS 4449:1997
Specification for carbon steel bars for the reinforcement of concrete

BS 4482:1985
Specification for cold reduced steel wire for the reinforcement of concrete

BS 4483:1998
Steel fabric for the reinforcement of concrete

DRAFT BRITISH STANDARDS FOR PUBLIC COMMENT

05/30141510 DC
BS 5950-5 AMD 1 Structural use of steelwork in building. Part 5. Code of practice for design of cold formed thin gauge sections.

05/30142353 DC
EN 10343 Steels for quenching and tempering for construction purposes. Technical delivery conditions

CEN EUROPEAN STANDARDS

EN 1998:-
Eurocode 8: Design of structures for earthquake resistance
EN 1998-2:2005
Bridges

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Disproportionate Collapse the Revised Building Regs	1 February 06	Southampton
Practical Structural Building Design	7/8 February 06	Manchester
Preparation for Eurocode 3	21 February 06	London
Frame Stability	28 February 06	Leeds
Practical Structural Building Design	15/16 March 06	Swindon
Composite Design	22 March 06	Bristol
BS 5950-1:2000 Understanding the Essential Principles	29/30 March 06	Manchester

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Corrosion Protection Course Seminar	2 March 06	Dublin

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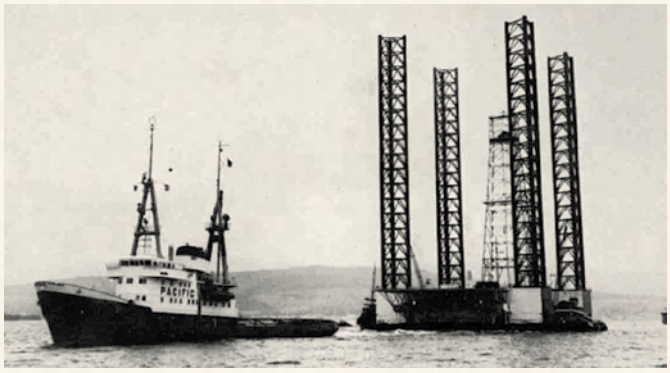
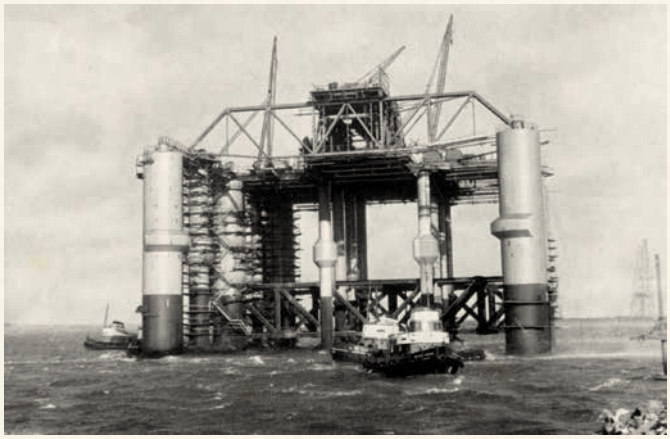
BUILDING WITH STEEL

Structural steelwork and the North Sea operations





Left: Tower Bridge compared with a Gas Council-Amoko drilling platform. Top: Drilling platform 'Neptune 1' being prepared for launching. Middle: 'North Star', the first UK built self elevating drilling barge. Above: 'Ocean Prince', a 6,100 ton semi-submersible rig built in Middlesborough.

The search which is being carried out at present in the North Sea, to find out whether the strata of the ocean bed will yield oil or natural gas, has introduced to many British steelwork fabricators a new phenomenon in oil exploration – the off-shore drilling rig.

Drilling in the North Sea is an expensive business. Such work under water costs two or three times as much as it does on land – one exploratory well alone can cost up to £1,000,000.

The area of the North Sea for which the British Government is responsible was divided into nearly 400 blocks covering 38,000 square miles and licences were issued giving the holders the exculsive right to search for and get oil or gas in their respective areas for a period of six years, with an option for another forty years on not more than half that original area. By the end of July 1965, seven licence holders had begun drilling.

The rigs used initially were brought from great distances, some being towed accross the Atlantic. Licences were quickly allocated to British fabricators and specially formed consortia, and now most of the constructional work is being carried out in this country. Nine rigs are being or have been built here so far and a conservative estimate shows a total of £16,000,000 being spent on this initial batch.

It is thought that self-elevating jack-up platforms will be used in depths up to 300 ft and, once safely landed on the seabed, will not be affected by average bed weather conditions. Semi-submersible 'floating' units will be more versatile, however, as they can sit on the bottom of shallow waters and, with the assistance of heavy anchors, can remain stable when drilling in depths of up to 600 ft.

The legs of these massive platforms are constructed of a chromium/molybdenum/vanadium steel and a low hydrogen electrode is available for the welding of all this high-tensile steelwork. A new 2½ per cent nickel electrode has been developed for a special nickel bearing tough steel used in the construction of the drilling platform, and highly qualified and experienced welders have been trained for these projects.

Derricks are under construction and are, on average, 140 ft high and rectangular in shape with bases 45 ft by 30 ft. They are of reinforced leg construction, jointed with high strength friction grip bolts, giving the unit a lifting capacity of 600 tons. Masts are also available averaging 142 ft high with 40 ft by 40 ft bases and, as in the case of the derricks, these are suitable for dynamic loading for both the horizontal and and vertical position. The masts are protected against the elements by coating with a zinc silicate.

From BUILDING WITH STEEL,
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AD 297
Disproportionate collapse regulations

This AD is to advise engineers how they might account for the differences between the disproportionate collapse regulations in England and Wales, Scotland and Northern Ireland. The regulation for each country has slightly different limits defining when disproportionate collapse should be considered.

The requirements for the Building Regulations of England and Wales regarding disproportionate collapse are detailed in SCI publication P341. On page 2 of P341 there is a note that suggests in Scotland and Northern Ireland disproportionate collapse only needs to be considered for buildings of five or more storeys. This AD shows why this is an over simplification for Scotland.

Scotland

In Scotland, the Building Standard 1.2 of the Building (Scotland) Regulations 2004 states:
'Every building must be designed and constructed in such a way that in the event of damage occurring to any part of the structure of the building the extent of any resultant collapse will not be disproportionate to the original cause.'

Despite this, the Technical Handbooks for domestic and non-domestic buildings states that progressive collapse should be considered only if the building is five or more storeys.

In view of this uncertainty, it is recommended that agreement is reached with the relevant building control body when buildings are less than five storeys.

Northern Ireland

The obligation to limit disproportionate collapse currently applies only to buildings of five or more storeys.

England & Wales

Although no storey limit is given in Regulation A3, Approved Document A defines four classes of building and the structural provisions required for each class to comply with the regulations. Further guidance is provided in SCI-P341.

How to comply

It is advised that to comply with the regulations in Scotland and in Northern Ireland hot-rolled steel framed buildings with five or more storeys should comply with Clauses 2.4.5.2 and 2.4.5.3 of BS 5950-1: 2000. Buildings with less than five storeys should comply with Clause 2.4.5.2 of BS 5950-1: 2000.

The next amendments to BS 5950-1 (expected summer 2006) will include the building classification system from Approved Document A. Therefore, buildings designed to BS 5950-1 will follow the classification system even though they may not be covered by the England and Wales Building Regulations.

Contact: Andrew Way
Telephone: 01344 623345
Email: a.way@steel-sci.com

AD 298
Guidance on the use of Quicon slotted hole connections

This AD presents guidance on the use of the Quicon slotted hole connection system based on experience gained during a recent application of the system. This guidance is supplementary to the design information presented in P338, which is still valid. The following issues have been identified as needing additional guidance:

- Deflections
- Precamber
- Twisting of primary beams

Deflections

The moment-rotation behaviour of a Quicon cleat when connected to a column is very similar to that of a fin plate, exhibiting significant rotational stiffness compared to a true pin. However, when connected into the web of a beam that is itself free to twist, there is less end restraint and the mid-span beam deflections approach the predicted simply supported values. The SCI recommends that Quicon should be treated like any other type of simple connection when predicting beam deflections, allowing for any flexibility in the supporting member. A beam supported by Quicon connections cannot deflect by more than its theoretical simply supported value for a given magnitude and distribution of load.

Designers should note that there has been a tendency in recent years to place the concrete in floor slabs to the required level, irrespective of the slab thickness. When deflections in the metal decking, secondary beams and primary beams are taken into account, the additional weight of concrete can be very significant, leading to deflections well in excess of those based on a uniform slab thickness. This is the case irrespective of the connection type.

Precamber

It is common practice to precamber long span secondary beams to either 2/3 or 3/4 of the simply supported dead load deflection, which assumes that the supports provide some stiffness to reduce the deflection. This approach is still recommended where Quicon connections are used, provided that the support is sufficiently stiff to prevent rotation of the cleat. This will always be the case with beam-to-column connections and should also be true for many beam-to-beam applications. Where the supporting beam is susceptible to twist (e.g. an edge beam), it may be advisable to increase the precamber to the full dead load deflection. However, all of the secondary beams, including those that connect directly to the columns, will need to be precambered by the same amount to avoid potential difficulties on site.

Twist

Where a primary beam supports a secondary beam on one side only, it will be subjected to torsion due to the unbalanced loading. The resulting twist in the primary beam will depend on the magnitude of the torsion and the torsional rigidity of the primary beam and its connections to the supporting columns. In this respect, there are two issues that could result in greater twist when using Quicon compared to other simple connections:

- Where a Quicon cleat with 2 columns of studs is used in beam-to-beam connections, the increased eccentricity associated with the second column of bolts results in increased torsion in the primary beam, thereby increasing the twist.
- As the studs in a Quicon connection are not tightened against the cleat (only against the beam web), there is sufficient slack in the connection to permit a small amount of twist between beam and cleat. This could contribute to the twist experienced by the primary beams when Quicon connections are used between the primary beams and the columns.

Designers are advised to consider the use of flexible end plates for the connections between the edge beams and the columns in cases where significant twist is expected.

Where the construction programme calls for the concrete slab to be poured on one side of a line of primary beams before the steel has been erected on the other side, the primary beams in question should be considered as edge beams in the temporary condition. It is important that twisting of these beams is limited in order to facilitate the erection of the adjacent secondary beams

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Editors: G K Raven
M D Heywood
ISBN 1 85942 167 9,
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(full colour), February 2006

NEW BOOK

Single Storey Buildings - Best practice guidance for developers, owners, designers and constructors

'Successful 'shed' construction relies on the interdependence of various parties in the supply chain – this publication aims to assist this process'

Steel-framed long-span single storey buildings, widely known as 'sheds', are a common sight across the UK, fulfilling a variety of roles from large functional distribution warehouses to modern, attractive leisure facilities. The shed sector is now one of the most efficient and successful in UK construction with an annual value of approximately £1 billion for frames and £1.5 billion for associated envelope systems.

Rising client expectations, Health & Safety regulations and sustainability initiatives are impacting on shed construction. In turn, the technologies used to meet these requirements demonstrate a willingness to embrace innovation in design, manufacturing and detailing. This demands high level of understanding of the interdependence of the supply chain. *Single storey buildings* is not a technical guide to the design and construction of sheds, but rather an attempt to make all players in the supply chain fully aware of the nature of their interrelationship, and the impact of decisions along the supply chain. It is the result of candid discussions between experts (members of the Single Storey Building Group) with practical experience and the scars that accompany many years in construction.

The publication has five sections: Introduction, Procurement Process, Overall Design, Detail Design Issues, and Client, Contractor and Professional Team Issues. Topics range from Design & Build contracts, selection of supply chains, energy efficiency, sustainable construction, social aspects, environmental considerations, emissions reduction, compliance strategy, roof drainage systems and design parameters, to name but a few.

"Even if you are not directly involved in sheds, it would do no harm to anybody in the supply chain to read it" says Mr Graham Raven, member of SSB Group.

PRICES: Non-member £40 Member £20 (plus P&P)

Catalogue Ref: P343
Authors: C Wright, M T Gorgolewski, G H Couchman R M Lawson
ISBN 1 85942 165 2, 56 pp, A4 paperback (includes colour photographs), February 2006

NEW BOOK

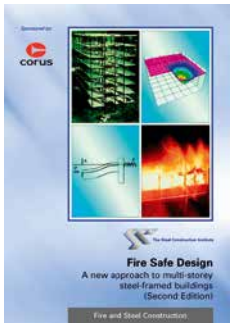
Insulated render systems used with light steel framing

This publication was prepared in response to an industry demand for guidance on insulated rendered cladding systems as applied to light steel framing

It provides design guidance on the use of insulated render cladding systems as applied to light steel framing. Good practice recommendations and advice are given on choosing details appropriate to the degree of exposure to wind driven rain. A performance scoring system is presented and the minimum requirements are based on the BRE exposure classifications of: sheltered, moderate, severe and very severe exposures.

Details are given which provide 'back-up' or robust long term performance in the event of any water ingress or condensation behind the render layer. It is suggested that for 'sheltered' or 'moderate' exposure, a cavity behind the insulated layer is not required, but a double barrier or cavity or other back-up system is generally required for severe and very severe exposure conditions. Experience from the UK is presented to justify this approach.

PRICES: Non-member £35
Member £17.50 (plus P&P)



Authors: G M Newman, J T Robinson and C G Bailey
ISBN 1 85942 169 5,
116 pp, A4 paperback,
February 2006

NEW BOOK

Fire safe design: A new approach to multi-storey steel-framed buildings (Second Edition)

'Fire performance of composite steel framed buildings is much better than is indicated by fire resistance tests on isolated elements'

The first edition of this document was published by the SCI in 2000 and was the first to offer guidance on the design of composite steel framed buildings in fire based on lessons learned from the full-scale fire tests carried out at BRE, Cardington.

This second edition includes some improvements to the recommended design method that will allow some additional economies to be made. Also, in recognition that many fire safety engineers are now considering natural fires, a natural fire model is included alongside the use of the standard fire and fire resistance.

The publication presents recommendations based largely on observation and analysis of the BRE Cardington large scale building fire test programme carried out during 1995 and 1996. The recommendations are conservative and are limited to structures similar to that tested, i.e. non sway steel framed buildings with composite floors. The guidance gives designers access to whole building behaviour and allows them to determine which members can remain unprotected while maintaining levels of safety equivalent to traditional methods

Information is also included on work carried out in other countries, and observations of the behaviour of multi storey buildings in actual fires. The background information will assist the reader to understand the basis of the design recommendations

PRICES: Non-member 40 Member £20 (plus P&P)

The British Constructional Steelwork Association Ltd

You can find out email and website addresses for all these companies at www.steelconstruction.org

BCSA is the national organisation for the steel construction industry; its member companies undertake the design, fabrication and erection for all forms of construction in building and civil engineering. Associate Members are those principal companies involved in the purchase, design or supply of components, materials, services etc, related to the industry. Corporate Members are clients, professional offices, educational establishments etc, which support the development of national specifications, health and safety, quality, fabrication and erection techniques, overall industry efficiency and good practice. The principal objectives of the association are to promote the use of structural steelwork; to assist specifiers and clients; to ensure that the capabilities and activities of the industry are widely understood; and to provide members with professional services in technical, commercial and quality assurance matters.

Details of BCSA Membership and services are available from: Gillian Mitchell MBE, Deputy Director General, British Constructural Steelwork Association Ltd, 4 Whitehall Court, Westminster, London SW1A 2ES. **Tel** 020 7839 8566 **Fax** 020 7976 1634

KEY

Categories

- **A** All forms of building steelwork
- **B*** Bridgework
- **C** Heavy industrial plant structures
- **D** High rise buildings
- **E** Large span portals
- **F** Medium/small span portals and medium rise buildings
- **H** Large span trusswork
- **J** Major tubular steelwork
- **K** Towers
- **L** Architectural metalwork
- **M** Frames for machinery, supports for conveyors, ladders and catwalks
- **N** Grandstands and stadia
- **S** Small fabrications

Quality Assurance Certification

- **Q1** Steel Construction Certification Scheme Ltd
- **Q2** BSI
- **Q3** Lloyd's
- **Q4** Other

Classification Contract Value

- **10** Up to £40,000
- **9** Up to £100,000
- **8** Up to £200,000
- **7** Up to £400,000
- **6** Up to £800,000
- **5** Up to £1,400,000
- **4** Up to £2,000,000
- **3** Up to £3,000,000
- **2** Up to £4,000,000
- **1** Up to £6,000,000
- **0** Above £6,000,000

Notes

1. Applicants may be registered in one or more categories to undertake the fabrication and the responsibility for any design and erection of the above.
2. Where an asterisk (*) appears against any company's classification number, this indicates that the assets required for this classification are those of the parent company.

* For details of bridgework sub-categories contact Gillian Mitchell at the BCSA.

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Severfield-Reeve Structures Ltd
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