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NSC

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NEW STEEL CONSTRUCTION NSC

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Designers drive to steel car parks

Nick Barrett - Editor

Car parks are one of those necessities of life which we seldom give a second thought to, until we have a problem like a scratched bumper from too tight a turn on the ramps. Car parks are hard to like. Too many have been dark, alienating and inhospitable places, obviously tagged on as afterthoughts. Design effort often seems to have focussed almost exclusively on other parts of a development, while little time has been spared for thinking about how car drivers will access it.

Not surprisingly, architectural awards for car parks have been few and far between, but that may be about to change. Our focus on car parks in this issue has revealed a new desire among clients for car parks that match the ambition seen elsewhere in their developments, by making a visual statement. Naturally enough, many are turning to steel as the best material to create the welcoming environments that they have identified as crucial to making a good first impression on visitors to shopping and leisure developments, and residential or business premises. As well as using steel architecturally, developers see the practical benefits, such as being able to provide the same number of car parking spaces in a smaller area than with concrete.

This is a market which at one time was dominated by in situ concrete, which often adds to the general drabness of the experience of visiting a car park. Pre cast enjoyed a brief vogue as labour problems turned some developers away from in situ. Steel was tried out now and again but not above five storeys, because of the perceived fire risk. But investment in discovering how fire actually behaves in car parks has removed that obstacle, and paint manufacturers have cut the cost of intumescent coatings dramatically. Tomorrow's car parks will increasingly be steel car parks, and far more pleasant to use than what has gone before.

International lessons

Car parks are proving to another example of a market previously dominated by concrete, where the potential of steel to provide a superior product was not generally realised. The recipe for successfully increasing steel's market penetration in such areas has been nearly perfected in the UK construction market – discover what the market needs; invest with industry partners in whatever has to be improved to make steel attractive in that market; further invest in technical education and marketing to make sure people know about it. As Derek Tordoff points out in his Comment this month, steel's market share in the UK is often the envy of counterparts overseas.

None of these overseas steel industries are standing still however, and they are producing their own innovative ideas on how better to help the market realise the benefits of steel and ensure that the superior promise is delivered. We will report in later issues this year on new initiatives being devised to ensure that steel's market penetration remains on an upward spiral.

Hemel's new centre nears completion

Severfield-Reeve is nearing completion of the third and final building of Hemel Hempstead's Riverside retail development.

It comprises two retail levels and with seven levels above providing car parking and a management suite. A pedestrian bridge over the river Gare links the car park to Block A, to be occupied by the Debenhams and TK Maxx anchor stores, and to a riverside terrace running the length of the block at first floor level.

Block B houses another two retail levels.

The car park features clear 16m spans with flat soffits and no downstand beams, avoiding the slightly claustrophobic feel commonly caused by the low ceiling heights.

The 35,780m^2 project for developer Nicholson Estates contains 2110 tonnes of steel and is due to open in time for Christmas this year.

Severfield-Reeve, which was also responsible for supplying and fixing metal decking and steel stair units, has been on site almost continuously since last March.

Major investment at Scunthorpe

Corus has announced plans to invest £130M at its Scunthorpe steelworks to significantly strengthen its manufacturing capability and competitiveness in structural sections, rail and wire rod.

The investments will allow improvements in operational efficiency, extensions to the product range and improved customer service. The investment builds on the company's Restoring Success programme which has already secured significant improvements in Corus' service to customers and financial performance.

The new investment will allow installation of a new steel casting machine to replace an existing caster and intermediate rolling mill. Quality and efficiency improvements will be generated by this.

A world class rail production facility is to be established at the existing section mill and an on site service centre will be created to improve the offer and service to customers.

The enhanced rail capability will allow longer rail lengths – up to 120m – to be produced in response to market demands. Rod and section mills will also be developed to enhance rolling capability, flexibility, quality and service.

The rail and sections development programme is to completed by November 2006, with contracts being let this month. The new caster and rod mill developments are to be fully commissioned by August 2007.

Corus will transfer all its rail production to Scunthorpe as part of the investment programme, moving existing rail production from Workington in 2006. Paul Lormor, Executive Director, Long Products Division said: ''This major investment will significantly improve our long products manufacturing capabilities, providing world-class processes that enable us to meet customers' future expectations in the market place. The development represents a major step forward for the Division, and is part of Corus' long products strategy to improve the competitiveness of its core products, add value and provide a platform for future growth''

A good place to unwind

Steel imitates life in the spiral ribs fabricated from plate steel to form the structure of the Spiral Café in Birmingham's Bullring Centre.

The shape of the spirals is based on the Fibonacci series, which occurs in nature in the proportions of plants and shells, and is used as a proportioning system in architecture.

The striking design was by architect Marks Barfield, best known for the London Eye, and structural engineer Price and Myers 3D Engineering.

The structure id formed by eight similar spiral ribs setout radially in plan and tilted relative to each other form the structure. The first three are supported at each end. The other five, which cantilever, are designed to act with circular hollow section bracing,which makes the shell of the building work as a truss.

The structure was modelled using the SolidWorks 3D CAD package, and laser cut from steel plate. It was designed as seven modules bolting together along the centre-line of each rib. "We designed it to be as easy as possible to make and to keep accurate," says Price and Myers 3D Engineering partner Tim Lucas. The whole building was assembled in the workshop, then dismantled into 14 sections for reassembly on site.

The steel ribs are clad in copper externally and by a stainless steel capping piece internally.

Crash barrier evidence 'seriously flawed', says Corus

Experts in steel crash barrier design have questioned the validity of the evidence on which the Highways Agency has based its recommendation in favour of concrete motorway barriers.

The agency issued an advice note last month stating that concrete should be the preferred option for new crash barriers on motorways, on the grounds of lower maintenance costs.

Dr Aled Roberts, Business Development Manager for Corus Construction and Engineering Products, said the report underlying the HA advice was "seriously flawed".

Dr Roberts accepted that concrete had some maintenance advantages. But, he said, TRL Report PR/SE903/04 on whole life costs and benefits of safety barriers did not take into account the full costs of foundations and drainage for concrete barriers. It compared steel barriers cast in concrete foundations with concrete barriers on concrete, ignoring the fact that steel barriers can be driven directly into the ground.

Dr Roberts added that the report did not fully quantify the cost of injuries caused by barrier collisions. TRL investigated impacts with steel and concrete barriers on the M25 over two years. Though there were no deaths from direct impact with a concrete barrier in that time, Dr Roberts argued that the M25 is unrepresentative, because congestion limits average speeds and therefore the likelihood of a high-speed impact.

"We don't feel our feedback on the report was properly listened to," said Dr Roberts. "We believe that if tested in UK laboratory conditions with modern vehicles under a strict regime such as Corus subjects its barriers to, serious flaws in the safety of using concrete walls would become apparent."

A claim by the concrete industry that concrete barriers are better at preventing crossover accidents compares normal containment steel barriers with high containment concrete versions, Dr Roberts said. High containment steel barriers would have equivalent performance to their concrete counterparts.

Plant blitz speeds distribution centre

Atlas Ward took just eight weeks to erect the main frame of a 72,800m^2 distribution centre in the North-East.

The project comprises over 2500t of steelwork and the company used seven cranes and 18 cherry pickers to meet the programme.

The structure, at the Faverdale East Business Park in Darlington, will be the third regional distribution centre for Argos Direct, serving the north of England, Scotland and Northern Ireland.

Atlas Ward Senior Project Manager Bill Armstrong said that keeping all the plant working presented few problems because of the size of the project. "The main warehouse is a four-span building so we could split the plant between different areas. At one stage we were working on four or five fronts at once."

The main warehouse consists of four 38m span portal frames, with 49 bays of 8m each, making the structure nearly 400m long. In addition there is a 15m x 120m office and two 'pods' for goods in and out. Atlas Ward was responsible for design, fabrication and erection.

Atlas Ward has worked with main contractor Bowmer & Kirkland on numerous occasions and is an integral part of the supply chain. The business park, located a mile from junction 58 of the A1, is an important strand in Darlington's regeneration strategy. The distribution centre covers around half the 34ha site and should be fully operational by the end of summer 2005.

Wave-shaped roof for Olympic pool bid

Zaha Hadid Architects has been chosen to design London's Olympic Aquatics Centre, which will form part of London's Olympic Park in Stratford. Structural design will be by Ove Arup and Partners.

Mayor of London Ken Livingstone has pledged that the structurewill be built whether London wins the 2012 Olympic bid or not. The structure, with a spectacular sinuous roof, supported by a 100m arch, is expected to be built in steel.

The 20,000 capacity Aquatics Centre includes two 50m competition pools and a competition diving pool.

Keith Mills, Chief Executive of London 2012, said: "This is an outstanding design that will create a spectacular building, delivering the essential 'wow' factor for the 2012 Olympic Games and Paralympic Games. It will then be cleverly transformed following the Games by taking away the majority of the 20,000 seats, turning it into more intimate spaces suitable for community use. It gives the community a lasting sporting legacy." The centre will also have an extensive health and fitness area to contribute to the long-term viability of the building.

Lord Rogers, of the Richard Rogers Partnership, who co-chaired the panel that chose the design, said: "This building has an exceptional sculptural quality that will make it a wonderful building to visit, attracting people to East London."

The International Olympic Commission will announce which city has won the bid to host the 2012 games in July.

AROUND THE PRESS

New Civil Engineer
20 January 2005
"We were one of the first to get CAD, back in 1983. Now we've got 3D drafting systems. Retrowork and lack of fit on site always used to be a big problem; now it's very unusual to come across it on any of our projects." — Billington Structures managing director Steve Fareham.

Contract Journal
9 February
Corus Construction and Industrial's Alan Todd says steel producers are currently catching up with a sharp increase in demand. "All the raw materials involved in steel making are increasing capacity and mines are opening up." Todd is quick to reassure UK customers that Corus would rather deal with a domestic market than look overseas. "We would rather sell into the UK because we don't have the transport costs, and the continent uses a pure metric range."

New Civil Engineer
10 February
"The engineer's role is to design a structure with a very clear flow of forces. If you have a very clear idea of how to organise your structure you are able to do very simple calculations to check the dimensions and forces. I don't have a computer." — Millau Viaduct designer Michel Virlogeux

Contract Journal
16 February
Contractors worried about possible effects of high alkalinity levels in cement supplied by Lafarge's Westbury Works should carry out technical reports or risk losing out, Pinsent Masons construction law specialist Catriona Dodsworth told CJ

Construction News
17 February
MP's have called for a public enquiry into Lafarge's Westbury cement works. Michael Ancram and Andrew Murrison represent constituencies around the plant and are concerned about Lafarge's ability to regulate emissions when it begins a trial of recycled liquid fuels at the works.

Eurocodes committee on course

Membership of the strategy committee which will co-ordinate the construction industry's response to the introduction of the Eurocodes has been finalised in what is seen as a significant move forward.

The steel industry is strongly represented in the committee, which has been set up by the Institution of Structural Engineers.

Establishment of the committee, which held its first meeting early last month, is seen in the industry as a positive move. It is a key element of the national strategy drawn up by the IStructE last year but there had been concern about delays in setting it up.

Its aim is to co-ordinate efforts of the structural engineering community to prepare itself for the introduction of Eurocodes, avoid duplication of effort and ensure the needs of industry are met.

Dr David Moore of the British Constructional Steelwork Association, who is on the committee in his capacity as chair of the IStructE codes panel, said: "It will be a co-ordinating committee rather than a doing committee, to ensure all the things that need to be in place for the Eurocodes to be used are in place,that each of the material sectors is doing what's required, and make sure any gaps are filled."

Initial priorities are finalising the National Annexes, which will contain information and values which are determined at national level, including some factors of safety; encouraging universities to develop educational material; and prioritising objectives for software suppliers, because software-writing capacity is limited.

Chairman is Professor David Nethercot of Imperial College. The 17 members include one representative each from the materials sectors and four IStructE members representing different types and sizes of structural engineering firms. Dr Roger Pope represents the Steel Construction Institute, Corus and the British Constructional Steelwork Association. Alan Rathbone of CSC represents software suppliers.

• *Structural materials research organisations have agreed to work with the Eurocodes Expert website to deal with queries arising from the use of the Eurocodes. SCI's John Moran said: "Eurocodes Expert is likely to become a hub dealing with low-level queries and routeing queries needing specialised knowledge to the sector experts, in return receiving a flow of information from the sectors." The SCI has been asked to co-ordinate the materials associations' response through Co-Construct. Eurocodes Expert has been set up by the ICE with ODPM funding as a reference site for users of the codes, but there had been concerns that it would compete with or duplicate efforts of the sectors' own helplines.*

Across the great divide

Five huge transfer girders, the largest of which weighs 25t, are an unusual feature of University College London's new Institute of Cancer Research Facility.

The girders, installed during late January and early February, form part of over 600t of structural steelwork supplied by Bourne Steel for the new six-storey, £19.5M building in Huntley Street. The girders are sited within the basement and are required to span across an existing plant room below, carrying loads from columns supporting the building above.

They direct loads into piled foundations installed around the plant room. The unusual configuration was designed by structural engineer Buro Happold.

The steelwork was fabricated in Bourne Steel's heavy lifting facility in Poole, Dorset. The contract with main contractor Shepherd Construction also includes the supply, delivery and erection of metal decking and precast concrete floor planks.

Caunton helps Honda accelerate

Honda UK's record production of 193,000 cars in 2004, up nearly 5% on previous years, was all the more remarkable for being achieved while the Swindon factory was being extensively remodelled.

Through the year, East Midlands based Caunton Engineering supplied and erected around 650t of structural steel as part of developments to improve efficiency and increase capacity at the plant.

Caunton Engineering worked with consulting engineer Rolton Services Consultants on a variety of projects involving building or modifying four buildings. Honda assumed project management and main contractor roles.

Caunton's Contracts Manager Tony Goodman says extension of the paint shop was technically the most challenging aspect of the work. In a bid to maximise floor space, the firm supplied a flat plate floor made of 6m by 2m plates.

Tube market on the up

The market for tubes is expected to strengthen in 2005, with the overcapacity of recent years eliminated, according to Corus Tubes.

A dip in demand in the last quarter of 2004 was a blip caused by stockholders reducing their holdings, and the business is now on the upward phase of the cycle, say managers.

"Supply and demand are in better balance and margins are healthier," said Corus Tubes Market Development Engineer Andrew Orton, "The 10 or 15% overcapacity of the last few years has come to an end."

Demand in the construction sector is more buoyant than other big users of tubes, such as energy and automotive, he added.

Construction is by far the biggest user of hot-finished tubes because of their superior material properties such as ductility and weldability. They are used in sports stadiums, motorway gantries and increasingly as the main structural columns in prestige office buildings such as the Wellcome Trust's new headquarters (page 16).

"They're now almost the default choice for big external trusses in stadiums," said Mr Orton. The strengthening in demand is being seen across the construction market, rather than in any particular application, he added.

Slim structure for Platinum Point

Use of square hollow section columns in a luxury residential development in Leith, Scotland, will allow the structure to be completely hidden — which was one of the main attractions of steel for the client. And Slimdek flooring has been adopted to allow higher ceilings while maximising the number of floor levels within the building height.

Conder Structures has won the contract to supply 3,000t of steelwork to the Platinum Point development in Leith's Western Harbour.

The development of five, eleven and thirteen-storeyapartments and penthouses forms part of a proposed billion pound regeneration of 16km of Edinburgh's waterfront.

The £4.8M contract from Gregor Shore of Edinburgh is Burton-on-Trent based Conder's largest single contract in the past 18 months. Architect is Gilbert Associates.

Conder Managing Director Gordon Ridley said: "The design philosophy, based on Corus's Slimdek floor construction, was to maximise the number of levels, while minimising building height and providing higher ceiling levels."

This has produced a maximum slab depth of 325mm and allowed a clear floor to ceiling structural height of 2.55m to be maintained throughout the building.

The design also makes use of 200mm square hollow section columns at car park level and 150mm sections above that level, which can be easily contained within the party walls. This, together with novel connection details, will enable the structure to be 'built-into' the dividing walls without the need for piers.

Conder's Design Manager, Gerrard Cox, says, "For Gregor Shore, the main attraction of the system was that no downstand beams are required within the structure."

The design also optimises framing between the lower level car parking and apartments above, removing the need for massive transfer structures.

Twin towers for European bank HQ

The new headquarters of the European Central Bank in Frankfurt will be a dramatic steel structure consisting of twin 184m towers, a low-level 'groundscraper' and incorporating the existing Grossmarkthalle, a listed building from 1928.

The design, by architect Coop Himmelblau, was chosen in a competition.

Its main element are the two polygonal, twisted towers connected by an atrium. These contain most of the office space. The atrium serves as a communication hub with and communal areas, and was considered to satisfy two elements of the design brief, to foster communication and promote teamwork. Two large platforms connect the towers in the lower third of the atrium to form a 'marketplace' with gardens, a cafeteria and informal meeting spaces.

The Grossmarkthalle will house the entrance lobby and all public functions of the bank including exhibition space, a visitors centre, the library and an auditorium for press conferences. The groundscraper, connecting the Grossmarkthalle with the office towers, contains a two-level conference centre.

The project now enters an optimisation phase in which the design will be reviewed to ensure optimal use of resources and to minimise costs. This is expected to last most of the rest of the year.

Construction is due to start in 2006, with the building scheduled to open in 2009.

NEWS IN BRIEF

The Metals Forum has made a Budget Submission to Chancellor of the Exchequer Gordon Brown calling for action on to help member industries on climate change, energy, education and training and transport. The Forum has called for extension of the Climate Change Agreement to include all metal processes, and for the Climate Change levy to be left unchanged in the Budget. Other requests include no increase in business taxes in view of rapidly rising energy prices, and an urgent review of university funding to prevent the loss of vital resources in science and engineering.

A consortium of 48 European steel organisations is to launch a collaborative R&D project to develop new steelmaking processes with drastically reduced greenhouse gas emissions. The **Ultra Low CO_2 Steelmaking** project begins with a five-year exploratory phase for which the European Commission has put up €20M (£13.8M) of the total €44M cost.

The **Competition Commission** has cleared the acquisition by Arcelor of Corus's UK hot rolled steel sheet piling business. The commission's final report concludes that the acquisition is not expected to lead to a lessening of competition. Chairman of the inquiry group, Peter Freeman, said the group was satisfied that Corus would have withdrawn from the loss-making business in any event.

The **Metals Forum** aims to raise the UK industry's profile with the publication of a new brochure describing the scope of its activities, available from postroom@steelconstruction.org. The industry employs half a million people with value added of £15bn, similar to chemicals and electricals. Chairman Derek Tordoff said: "The metals industry wants to be more effective in its representations to Government and the media." The forum has been praised by the DTI for effectively representing cross-sector interests.

Metsec's framing division has produced a new guide to the applications of its light gauge galvanised framing systems, **Metframe** and **SFS**. The guide contains performance tables, loading data, fire resistance and thermal efficiency and sound insulation ratings. It is available free in printed form or on CD with the latest version of SFS Framespec design software by contacting interactive@metsec.com or 0121 601 6000.

Letters

NSC welcomes letters from readers on steel construction related issues. Please keep your letters brief — the Editor reserves the right to condense. Address your letters to: The Editor, NSC, BBA Linden House, Linden Close, Tunbridge Wells, Kent TN4 8HH. Fax: 01892 524456. e: info@new-steel-construction.com

Eurocode safety margins

The report in NSC January 2005 (page 6) about the SCI's campaign to reduce safety factors in Eurocodes makes deeply disturbing reading. It appears that the SCI is arguing that because the new Eurocode is complicated and will increase design costs, this justifies reducing safety margins to compensate. This may make sense in crude marketing terms, but it makes no sense at all technically. If the new code is unfamiliar, over-complicated and difficult to understand, surely mistakes are more likely, so shouldn't safety factors be increased, not reduced?

Engineers are entitled to ask how the proposed reduction in safety factors is justified technically. The SCI needs to produce evidence and open it up to public scrutiny by independent engineers.

A N Beale BSc CEng MICE FIStructE
Thomasons Consulting Civil & Structural Engineers
Leeds

The Editor replies: There is no strategy to reduce safety margins to compensate for any perceived complexities that may lead to increased design costs. In the UK, BSI is responsible for the development of the National Annexes (NAs) and as with most standards the NAs will be issued as drafts for public comment, giving engineers the opportunity to review the draft documents and comment on the proposed partial safety factors and the other Nationally Determined Parameters.

The responsibility for the NAs for Eurocode 3 is split between a number of BSI Committees. This approach adds an additional level of independence to the process by giving a large pool of engineers the opportunity to comment on the NAs and to scrutinise the technical evidence for the choices being proposed.

The process by which the numerical values for the Partial Safety Factors and other NDPs are determined is called 'Calibration'. The calibration process compares the Eurocodes with the existing UK standards. The objective is to set the Partial Safety Factors and other NDPs such that there is a balance between safety and economy. The process encourages independent engineers to evaluate the evidence on which the Partial Safety Factors and other NDPs are based.

Safety margins will not be cut to encourage the use of the Eurocodes. However, where we have better information to support changes that may result in more economical designs then engineers should be allowed to take advantage of this.

Eurocode safety margins

I read with interest the piece on the Corefast lift core installed in the cinema complex at the new Dundrum Town Centre near Dublin (NSC February).

The article stated that the whole Corefast core was 'completed in five working days... six weeks quicker than a conventional concrete core'. The Bi-Steel product sounds very interesting and appears quick to build, but the important issue here is the overall cost of installation ie cost of the core and the cost of installing it.

I would be grateful if some information on this could be provided please?

Gavin Clifford
WSP Buildings, Manchester

The Editor replies: This is an important point and is one that often arises. Corus Bi-Steel typically finds that the Corefast core is marginally more expensive than a concrete core when one compares just the cost of the actual core materials, ie steel versus concrete/ rebar on a direct substitution basis. However, when one looks at incorporating appropriate design changes to utilise Bi-Steel's exceptional strength, and taking into account the benefits that accrue from a faster build sequence, Corefast is more cost-effective .

To verify this Corus has recently commissioned one of the UK's top construction cost consultants to carry out a study that involved comparing the costs of constructing a notional 20-storey office building, one with a Corefast structural core and one with a conventional insitu concrete core. The study is almost complete and its findings show that Corefast is a more cost-efficient methodology when one looks at the total cost to the client taking into account all factors including accelerated rental streams due to faster project completion, reduced finance costs and enhanced capital values due to more useable floor space. It also highlights the other benefits of Corefast including a stiffer, higher integrity and more accurate structure, more off-site content, less site congestion and enhanced site safety.

The Report will be completed shortly and will be available free of charge from Corus Bi-Steel on 01344 751670 or from our website www.bi-steel.com

Diary

8 March **BCSA National Dinner** Savoy Hotel, London. Contact: Gillian.Mitchell@steelconstruction.org

15–16 March **Construction - beyond the horizon**
The 8th National Conference of the Welding & Joining Society
Covering developments in materials, design, welding and related technology which can increase efficiency and lower costs, with presentations on a number of high profile UK construction projects, and technical developments in materials and processes, Codes and standards, problem solving and the latest methods of repair and refurbishment will also be covered. Contact Rachel Wall, meetings@twi.co.uk

6 April **Open day** at Fairfield-Mabey's factory in Chepstow, combined with a visit to the nearby Costain project at Sirhowy. This includes Arup's 227m Pont Dewi Sant cable stayed bridge. Contact: tracy.booth@fairfieldmabey.com

23 June **Structural Steel Design Awards Luncheon** Savoy Hotel, London. Winners of the 2005 awards, sponsored by Corus, the BCSA and SCI, will be announced. Contact: Gillian.Mitchell@steelconstruction.org

September **Fairfield Mabey open day** at the Swale crossing site in Kent, based around the design and construction of this major new structure. Contact: tracy.booth@fairfieldmabey.com

20–21 September **Architecture and Steel International Symposium,** Palace de la Méditerranée, Nice (part of the ECCS 50th anniversary event)

15 November 2005 **Steel Construction Conference,** The Brewery, Chiswell Street, London EC1 (organised by BCSA) Contact: Gillian.Mitchell@steelconstruction.org

Derek Tordoff

Lessons to learn from overseas

BCSA Director General Derek Tordoff has just returned from an international fact-finding trip to learn how other steelwork industries are faring. Implementing some ideas from overseas could help steel advance in several market sectors, he finds.

As national economies around the world grow and develop, their building processes need to become more efficient. Steel's usage then increases as steel's off-site manufacturing processes result in accurate and "greener" structures, which are safe and fast to erect, resulting in overall best value.

A consequence of this is a steady decline in the use of concrete: according to the Concrete Centre, the UK now has "one of the lowest per capita consumptions of cement and concrete in the world". Global statistics from the Concrete Centre show, for example, that the 2002 consumption of cement in kg per head of population in Spain was 1063, Italy was 721, Australia was 396, Sweden was 299 and the UK was only 192.

These figures for concrete are reflected in construction market share statistics; again according to the Concrete Centre: "Steel's market share against concrete in the UK has grown by 2% pa since 1978 and steel now enjoys a market share of 96.5% of industrial buildings and 70% of multi-storey buildings".

The UK now has the global highest market share for steel in single and multi-storey buildings, but there are still UK market sectors where further growth can be expected. For example steel's share of the multi-storey residential market (five storeys and above) increased from 39% in 2003 to 44% in 2004. Other growing market sectors include hospitals, schools and car parks.

However there is more that can be done to further improve the situation in the UK; steel's market share continues to grow in other countries and there are lessons which can be learned by looking at what is happening globally. For example:

Canada: implementation of full scale steel construction "teaching aids" at Universities and Colleges

USA: a structured approach to understanding and forecasting construction market dynamics and future market trends

South Africa: development of an in-depth steelwork estimating course to provide a better understanding of cost drivers

Australia: a comprehensive steel construction kit for students to help them to learn the design and construction techniques

New Zealand: a movie for architects of the steel construction process (starting with a "walk through" 3D model)

There are global trends in other areas which impact on the UK, such as increasing raw material prices. UK cement prices increased dramatically in January and last year saw some of the steepest global price rises for steel in recent memory as the industry faced worldwide cost rises for raw materials (iron ore, scrap and coke) and freight shipping.

However greater stability has returned to the steel market and prices for fabricated steelwork used in the construction industry are expected to be more stable in 2005 than during 2004, with increases in the range of some 5% forecast for the whole of the forthcoming year.

In real terms, steelwork prices are still at the same level as 15 years ago.
The volume of steel construction output last year was the best for 15 years at 1.3million tonnes and steelwork contractors' order books are healthy; problems are not anticipated with supplies of steel or availability of fabrication capacity.

To sum up, the future for steel construction is good with new market opportunities, new support tools for designers and specifiers, plus greater price stability.

A classroom module being lifted into place at a in school Essex

Kingspan backs off-site boom

After several false starts, could the tide finally be turning for off-site construction? Kingspan thinks so, and is backing its hunch with substantial investments to produce systems which will be fully accredited, reports Nick Barrett.

Off-site construction methods look like coming into their own over the next few years if the government's ambitious accommodation, education and healthcare building targets are to be met. Nobody seems to know where the Deputy Prime Minister's fabled £60,000 house is going to come from, but traditional approaches, it is widely agreed, stand no chance of delivering the quality or quantity needed in the timescales required. Innovative approaches are called for and will surely have to involve at least a substantial off-site element.

North Yorkshire based Kingspan MetI-Con has made what is claimed to be the industry's biggest investment yet in the manufacturing equipment and engineering accreditation of products which will be needed if UK construction is to undergo the transformation from a site based industry to one in which off-site, factory based solutions dominate. The demand might yet turn out to be so much political hot air, but Kingspan is convinced enough to have invested £9.5M in new roll forming production lines dedicated to cold form steel sections, which has just come on stream.

The United States sourced production line is state of the art. "There is nothing like it in the UK or elsewhere in Europe," says Kingspan's Off-site Sales and Marketing Manager Gary Crosby. "We have a capacity from just these machines of some 35,000 steel frames a year from a normal shift, so we could double that with shift working, and we have plenty of room to expand on our site." The building which houses the plant is a massive 368m long and 32m wide, with overhead cranes capable of lifting 20 tonnes. Galvanised sections in thicknesses of 0.7mm to 4.0mm, in section depths of 70mm to 450mm, can be produced.

"We can produce to tolerances of 0.5mm, which is far in excess of what the site based industry is used to," says Mr Crosby. The new line is fully automated and flexible. It allows rapid changing from coil to coil and from one section size to another. "There is little downtime whereas some of our rivals spend as much time making changes as they do actually rolling."

A crucial element in the Kingspan recipe, one which has been conspicuously lacking from off-site related efforts in the past, is substantial engineering input. Kingspan's products are to be fully accredited, with input from the Building Research Establishment and consultant Arup.

Off-site has stalled over the past 10 years or so, for a variety of reasons, some to do with demand and others to do with the industry's readiness to invest to meet a demand which remained uncertain. Mr Crosby says the construction industry failed to take the right approach to a cautious marketplace. "Nobody has approached it wholeheartedly before from the standpoint of a fully accredited system. In the past suppliers have just assembled components. But you need to supply the market with data on all the qualities of the product, like acoustics, thermal performance, and structural performance. We are accrediting the entire system. Arup will help us produce the first fully accredited system for frames and facades. This has been the downfall of modular approaches in the past. We will provide BRE accreditation and certification, along with quality assurance, guarantees and warranties."

Software and architectural design packages

Kingspan MetI-Con is a stock market listed company with a turnover of some £500M, employing 400 at its Sherburn site and 3,500 worldwide. Some 80% of employees are in the UK and Ireland. Some 50,000 tonnes of cold formed steel is output a year. Its biggest single market is the United Kingdom.

The company was founded in 1949 as Ward Brothers (Sherburn) Ltd, manufacturing agricultural implements and later Dutch Barns. In 1970 a Building Components division was formed to manufacture products like purlins and rails.

By 1976 it had started making single skin cladding profiles and customers could have one of three variants, all one metre wide. By 1987 expansion was started into composite cladding panel manufacture for roofs and walls. Profiled metal floor decking was soon added to the product range.

In 1997 the manufacturing arm split from Ward Contracting which became Atlas Ward Structures, which still occupies an adjacent site in Sherburn. The year 2002 saw the launch of Topdek, a single ply roofing panel. Panel systems have been the core of the Kingspan business in recent years. In 2004 there was an internal company split of the Structural Products division from the roofing and cladding panels business. The Off-site business was launched in 2004 at Interbuild.

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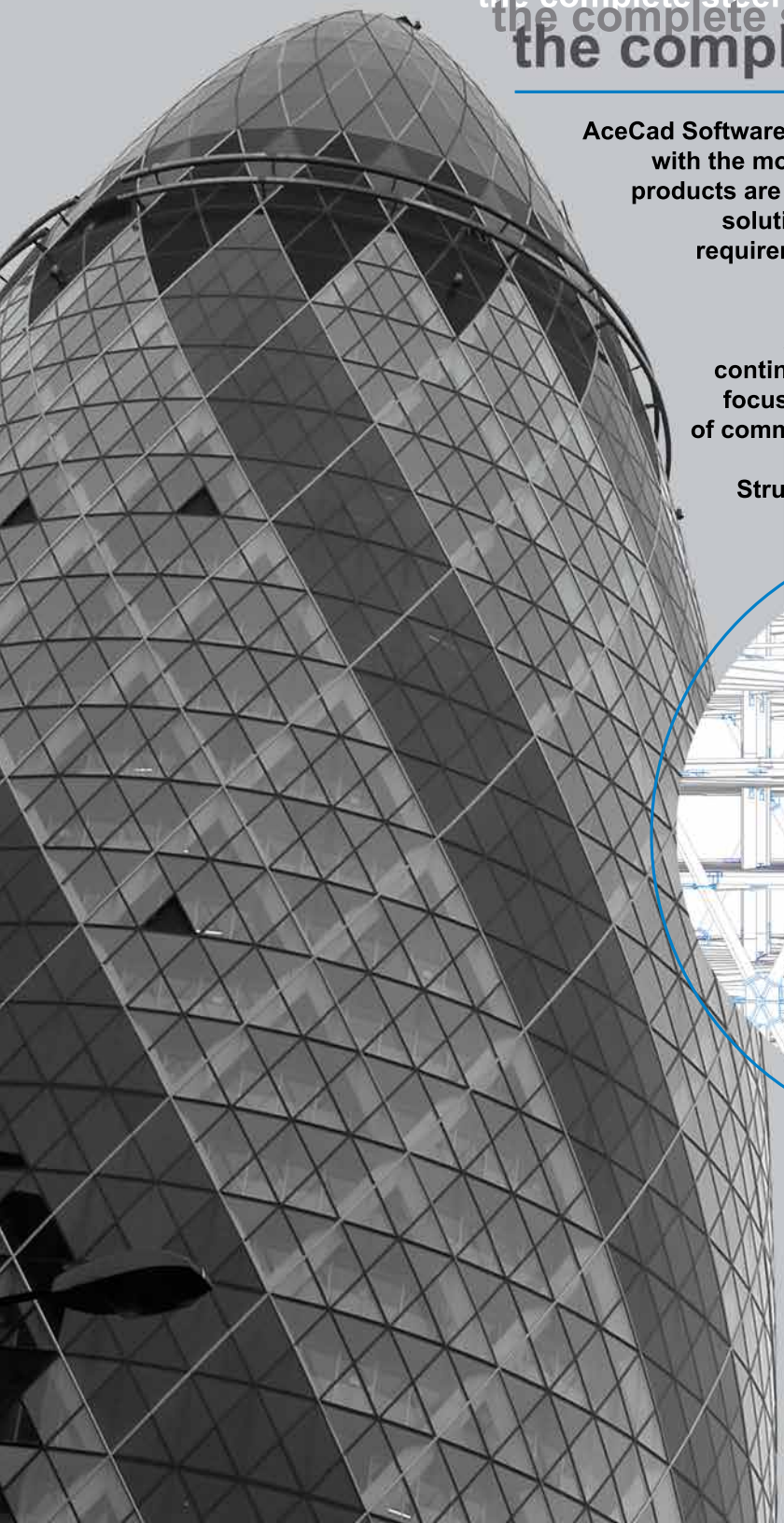

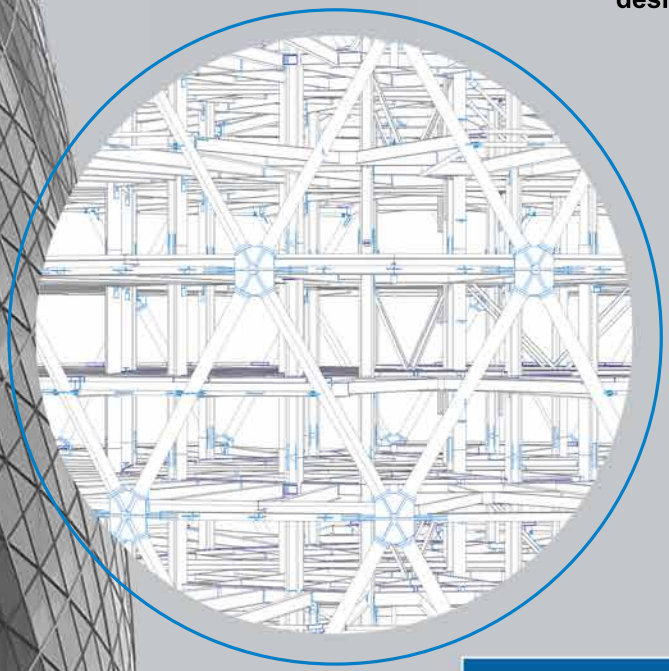

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Right: Bedroom and corridor unit for a hotel

Below: Multi deck steel flooring from Kingspan's traditional product range was provided for this 11 storey twin tower office in Arnhem, Netherlands.

The first major jobs are already running off the new production line. One is for Dane Architectural for frames for a residential and offices complex in Liverpool called the Unity Building. This is a 30 storey structure for which Kingspan is supplying its architectural facades. "We deliver complete units to site, frames with substrate board, insulation and facade support system," says Mr Crosby.

Kingspan is prototyping two school projects for Essex County Council, in conjunction with Pyramid Building Systems, Kingspan's construction partner, and consultant WS Atkins. 'This is an alternative to the traditional temporary buildings which growing schools often have need of. Instead of those we provide permanent structures which will have a lifespan of some 60 years for the frame and perhaps 30 years for the facades. We deliver flat pack frames to Pyramid who fit drywalling, and all plumbing and electricals and deliver the nearly completed classrooms to site for quick assembly. '

Healthcare projects include one just finishing for the John Radcliffe Hospital in Oxford. Over 500 half tonne cold rolled frames to support facades have been supplied here. Some of these were supplied from Kingspan's older production line and some off the new line.

will be supplied to key partners like architects. Customer requirements can be directly input to the manufacturing plant which will mean shorter lead times. The idea is to make the system easy to use, so software investment is crucial. Designs can be simply transferred to the manufacturing plant.

Kingspan's aim is to develop its off-site business away from being simply a supplier of components to a fragmented market, towards being a key player in the target markets. The plan has three stages. First, the architectural facade systems are launched this month, providing conventional construction, render systems, ventilated rainscreen systems and insulated panel systems. This involves creation of a 600 page facade handbook containing some 500 construction details. It is designed as a technical handbook for specifiers. "All traditional architectural facades are covered," says Mr Crosby.

Phase two concerns cold rolled structural framing systems and structural framing sections. These will be introduced in the second quarter of 2005. Various footprints and quick erection compatible with all facades will be possible. "This will all be fully accredited." stresses Crosby, "underpinned by engineering input from Arup. A detailed accreditation programme through the Building Research Establishment and design work from Arup will accelerate the engineering programme." The cost of all the technical input to back up the systems is understood to be in excess of £1M.

Kingspan reckons it can go to 10 storeys with its structural systems, and expect to be able to go beyond that in due course. Combining cold with hot rolled sections means 14 storeys can be done now.

Finally, at the end of the third quarter of 2005 Kingspan will launch its space systems, targeting education, healthcare and single living accommodation.

Kingspan sees off-site becoming a main driver of the business. "We aim to fully develop the manufacturing site and to be a leader in driving the off-site market. There is massive interest from main contractors, government, local authorities – across the board.

"The time is right for off-site, we are certain. There have been false starts before but the market conditions are right and we and our partners are bringing all the construction elements together now."

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Warm Wellcome for a quality building

Early involvement of the steelwork contractor helped deliver a quality solution for Wellcome Trust's new corporate headquarters building. David Fowler reports.

FACT FILE
The Wellcome Trust
Client:
The Wellcome Trust
Architect:
Hopkins Architects
Structural Engineer:
WSP Cantor Seinuk
Steelwork contractor:
William Hare
Project Manager
Mace
Steel tonnage:
2100 tonnes

Wellcome Trust's brief for its new headquarters in central London called for a building that was prestigious without being ostentatious. The medical charity, which provides £400M annually to medical and scientific research, also wanted a flexible working space for the 500 staff to be based there.

Hopkins Architects' design, of what is called the Gibbs building achieves those aims in typical style, making effective use of of steel, with the structure expressed internally and externally.

On a prime site with a 100m frontage along the Euston Road, the 22,000m^3 building has its offices arranged in two longitudinal blocks. The front or north has 10 storeys and the south five; a glazed canopy swooping over the whole structure, and a central atrium running the length of the building between the two blocks, combine to produce the effect of a street bathed in natural light.

In the north block, the office space is divided into five column-free bays of 12m x 18m. They are separated by the stair and lift cores, and two-storey-high mini-atria designed to encourage interaction between teams on adjacent floors. Link bridges span across the main atrium to connect to stairs and lifts. Formal and informal meeting areas are provided throughout, including a ground floor cafe. The staff canteen sited on the fifth floor boasts impressive views looking south toward the City.

A total of 2100 tonnes of steelwork was used in the main structure (excluding the main atrium steel which was supplied under a separate contract). Hollow sections are used for key components including the main columns, for reasons of aesthetics as well as structural efficiency.

Leaving the steel exposed meant that a lot of attention to detail was required in designing the structure, says Andrew Woodward, Technical Director of structural engineer WSP Cantor Seinuk. "We went into a lot more detail at tender stage about such things as connections, details that would normally be developed after appointing the steelwork contractor, to demonstrate the level of quality we were looking for. We spoke to steelwork contractors while working on this to get advice and to make sure they were practical."

One of the contractors involved in this process was William Hare Ltd, which eventually won the steelwork contract. Project manager Dave Moylan says: "That approach paid dividends in time saved later in the process."

Improvements were still possible later, however, an example being the column splices. The hot finished S355J2H grade circular hollow sections are filled with concrete and act compositely, which was an efficient solution both structurally and from the point of view of fire. Hopkins and WSP wanted a clean, unfussy connection at the column splices and had designed a straight welded boss. A temporary bolted cleat was specified for initial erection of the frame, with the permanent welded connection to be added in a separate operation later.

William Hare Ltd proposed an alternative which required less making good. The welded boss was changed to a machined collar welded to the top of the lower column section, with elongated 'spears'

to acting as guides for the upper section. Through bolts were then used as temporary fixings.

Mr Moylan says: "The upper column just slid over the collar and was already weld-prepped. We think it was a clearer and cleaner detail."

The columns were supplied to site pre-filled with concrete except around the splice and pre-coated with intumescent paint. The area immediately around the splice was grouted afterwards, to avoid the possible risk of steam being generated from concrete during welding.

The floors of the north block are of composite construction with lightweight concrete floor slabs. The mini-atria are created by leaving out a section of floor on alternate storeys to create a double storey height space, but they are framed with a standard beam arrangement so that the voids can be filled in, or others added, in the future.

The south block comprises compositely designed secondary beams supported on 9m long tapered plate girder primary beams, on columns at 6m intervals to match the grid of the north block.

Steel link bridges connect the north and south blocks at first to fifth floor levels and provide the landings for the lifts. The bridges are formed from stiffened steel plates, acting as permanent formwork for reinforced concrete slabs. These are supported on fabricated T-section secondary beams cantilevering from twin primary beams, which themselves consist of a fabricated T-section welded to a circular hollow section. The whole structure is suspended using Macalloy tie rods.

The main structural cross-bracing is left exposed in the east-west direction and uses high strength tie rods between independent columns. In the north-south direction bracing consists of vertical panels formed from steel plate running between four pairs of columns. Together the columns and steel plates act as a large vertical beam. This is another typical Hopkins detail.

Tolerances were tight and, after fabrication, William Hare match-drilled the plates in its workshop to ensure a perfect fit on site.

The building would normally be expected to have a two-hour fire rating but following a fire engineering study by Arup Fire, the rating of the key structural members was reduced to 60 minutes on the basis that there was little combustible material present. Floor edge beams had their rating reduced to 30 minutes on the evidence of fire tests at Cardington which showed they would not get as hot in a real fire as previous theories had predicted.

This allowed the coating of intumescent paint to be thinner. "The intumescent paint would otherwise have been so thick that definition of the exposed bolted connections would have been lost," says Woodward.

The existing Wellcome building, which is adjacent and dates from the 1930s, is undergoing refurbishment and will be opened to the public in 2006, with spaces for exhibitions and conferences and the Wellcome Library. At the same time Euston Square underground station, located in the north-west corner of the site, is being refurbished and extended.

The building is arranged as two blocks, one 10-storey, and one five (top left). The old Wellcome HQ will be integrated with the new (top right). The glazed atrium contains a Thomas Heatherwick sculpture (main picture). Column splices were bolted initially and welded later (right).

Car parks move to front of house

Steel is better suited to meet clients' wishes for car parks with more individuality.

Developers are making statements with their new car parks, and the statement is increasingly 'do it in steel'. Car park design specialist Hill Cannon predicts that more aesthetically pleasing, easy to use car parks will be made possible by steel.

Once car parks were hidden round the back of a development and forgotten. Recently developers' attitudes have begun to change; clients no longer go for the cheapest structure possible. It is one of a number of reasons why more car parks are being built in steel nowadays.

Historically, car parks were regarded as low value structures. "It used to be thought, 'it's only a car park — it doesn't matter. Now car parks are considered much more 'front of house'. People are not prepared to tolerate an unmaintained car park anymore — they look for a safe, secure and easy to use facility. In a shopping centre, for instance, developers are realising that parking forms part of the overall experience," says Christopher Whapples, Senior Partner of consultant Hill Cannon.

The practice has made car park design in all materials a speciality since 1967, and, though it undertakes other work, car parks form about half the company's workload. Along the way the firm developed and patented its Vertical Circulation Module (VCM) system which provides a space-efficient ramp layout and minimises the length of steep ramps, improving pedestrian access to the whole deck.

"At one time the majority of car parks were in situ-concrete," says Mr Whapples. "Then the market went towards precast because of risks from labour shortages and weather."

There have been examples of steel car parks since the late 1960s, but until recently fire regulations prevented steel being used for structures over 15m or five storeys. That requirement has been relaxed because of a better understanding of how fires spread in car parks. If a vehicle catches alight, the blaze tends to remain localised rather than spreading to adjacent cars, as had originally been assumed. At the same time, intumescent paint has become more affordable.

A significant landmark was Gateshead's Metro Centre, which at the time it was built in the mid 1980s was the UK's biggest shopping mall. Hill Cannon was brought in by steelwork contractor Conder as consultant on the parking structures, which were built in steel because the whole of the rest of the development was steel. But now other trends favour steel.

"There's a real push now to produce something really different, to make a statement," Chris Sharpe, Associate at Hill Cannon responsible for steel car park development. "That's more difficult to create in concrete."

Mr Whapples adds: "With steel, rather than

FACT FILE
Ringway Ford Showrooms, Leeds
Structural Engineer:
Hill Cannon
Architect:
Archtectural Design Services
Project Manager:
Rex Procter
Main Contractor:
Houseman & Falshaw
Contract Value:
£1.6M
Steel tonnage:
100 tonnes

Hill Cannon is not only a car parking specialist but is involved in many other projects, using steel when possible. When car dealer Ringways Ford decided to redevelop its Leeds site it decided that a dramatic structure (left) should be built on the prominent ring road site.

The enthusiasm of client and architect provided an opportunity for Hill Cannon, as structural engineer, to create a striking and innovative design. "We always try to be innovative," says Hill Cannon partner Mike Wilford. "Good, well thought-out design does not have to cost a fortune."

The key requirement was for a column-free showroom (second from left); beyond that, Hill Cannon and architect Archtiectural Design Services were given a relatively open brief.

The solution uses curved space frames (third from left), spanning 12m on to elliptical tubular columns. The longitudinal axis of each column was set parallel to the space frames and curtain walling mullions (right). This has aesthetic advantages, says Senior Engineer Dave Topping. "From inside the building you see the ellipse. Externally you see a very slender section. Because the columns and trusses are parallel with the window mullions, from outside you don't see the column, giving maximum visibility."

The corner columns are set back from the facade so that the external full-height glazing can meet at a point. For connections between the structural members, end plates with visible bolts were avoided — instead connections were concealed where possible. Bracing is concealed within the roof space.

For the smaller commercial vehicle showroom adjoining the main car showroom, a more functional approach was adopted, using standard cellular roof beams, though again the bracing is concealed. Mezzanine offices and a stair core are situated at the back of the building.

Between the two showrooms, facing on to the forecourt, is a GRP canopy supported on three slender, circular columns, one raking. This is where new cars are handed over to customers. The canopy required very tight tolerances in the steelwork and accurate setting out, to allow the GRP to be prefabricated. This was achieved successfully despite the fact that the columns are cantilevering over 11m. "It shows the precision you can achieve with steel," says Mr Topping.

cladding the structure as is normal with concrete, steel tends to be used architecturally, making a feature of items such as the vehicle impact barriers. You get a more honest building that looks like a steel-framed car park, rather than being hidden behind brickwork."

Hill Cannon also carries out consultancy for refurbishments of multi-storey car parks. "A badly designed and maintained car park deteriorates very quickly," says Mr Sharpe. "Clients are now looking to long-term maintenance, which plays to steel's strengths. Paint systems have improved as have elastomeric deck waterproofing membranes. "If painted, kept clean and waterproofed a steel structure will last a considerable time," he says.

Typical of the new philosophy is the parking structure designed by Hill Cannon as part of a joint venture with main contractor Makers and Conder Structuresand built for a pharmaceutical company in Amersham in 2003, for which Conder was again the steelwork contractor. There are three storeys, the bottom one , the lower level being partially below ground and with the decks coated at every level. Nautical-style handrails are used around the deck edges. Columns are on a 7.2m grid with tubular impact barriers spanning between them. The use of cellular beams to support the decks gives the impression of a higher ceiling, creating a much lighter and airier structure. The car park was commended in the 2003 British Parking Awards.

A car park now under construction by Amec at Norwich is replacing a concrete structure. Using the VCM system, a similar number of spaces has been engineered to fit into a smaller area, liberating land for housing. Steelwork contractor was Quantrill Steel.

A future trend will be to create more space on surface car parks by adding extra decks. Again, steel is well-placed to do this quickly and with minimum disruption. Hill Cannon is working on an interlocking precast deck system which would eliminate the need to use wet trades, and speed up construction even more.

Another likely development is to open up column spaces beyond the norm of 7.2m, equivalent to three vehicle widths, as used at Amersham. "With steel you could go to 16m," says Mr Wilford. "The ideal would be a column-free space with a column at each corner and a truss spanning between them. Typically, there's a tubular impact barrier, a steel tie beam and the handrail. If you designed those elements as a truss you could open up the spans."

Centrale takes upwards spiral

The most challenging aspect of the car park at the new Croydon Centrale shopping centre was the problem of giving cars access on a constricted site. The design solution was an unusual arrangement of spiral ramps. David Fowler reports

Croydon Centrale is the busy Surrey town's newest shopping complex, a £100M development by St Martins Property Corporation that was built partly on the site of the former C&A retail unit. But with three levels of parking for 1,100 cars above three levels of malls, and a constricted street layout around the outside of the centre, fitting in the car park access ramps caused headaches for the design team.

The design went through several stages of evolution before the final stepped spiral ramps were chosen, a solution which probably could not have been designed or built without 3D CAD systems.

Architect John Clark Associates initially considered two spiral ramps on the rear elevation of the shopping centre, on an island site separated frm the centre by a road, with a bridge at the top over to the car park at Upper Mall level. Local planners considered that the ramps would overshadow a row of houses behind the centre, and wanted a feature archtietectural solution.

This led to the solution of stepping the ramps back towards the centre and away from the houses as they rise. The stepped geometry is achieved by adding one elongated side to the ramps, which are otherwise circular in plan; there are three and a half revolutions from the base of the ramp to the first car parking level.

This solution was adopted and work progressed on the structural design. Initially the offset between levels was such that vertical supports could not be fitted in because the roadway beneath would have been in the way. Instead,

Croydon Centrale has been built on the site of the former C&A store, and a Mecca bingo hall, which was moved to the basement of the new development. Above that there are three levels of malls and three levels of car parking over the malls. the existing Drummond centre has been refurbished and integrated into the new development.

The new centre is steel-framed, and on the upper floors universal columns, used as edge beams, are left exposed as an architectural detail. The ends of the transverse floor beams are tapered to create a soffit which curves upwards at each edge.

Columns are arranged on an 8m grid except for the main House of Fraser store, the anchor store for the development in retailing parlance. Here a wider grid was called for. It was achieved by leaving alternate columns out to create an 11.3m grid at 45degrees, though this complicated the steelwork layout where the two grids met.

Because ground level varies considerably around the site, it was more convenient to support part of the upper mall level from above rather than support it from below. At the main entrance the floors cantilever out to support escalators positioned behind a three-storey high glazed facade.

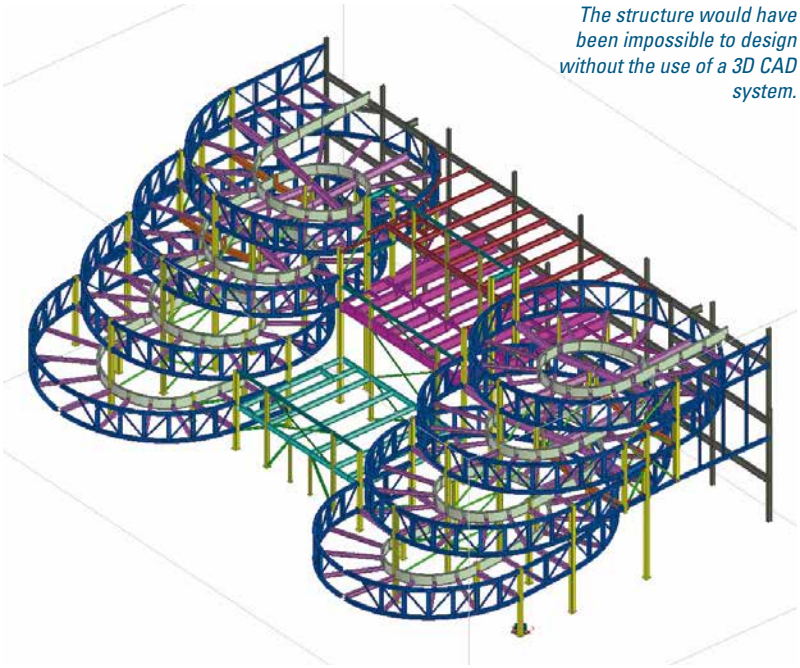
The centre opened in stages starting in autumn 2004.

A curved truss runs around the outside of the ramps (left). The finished ramps with the cladding in place. (below)

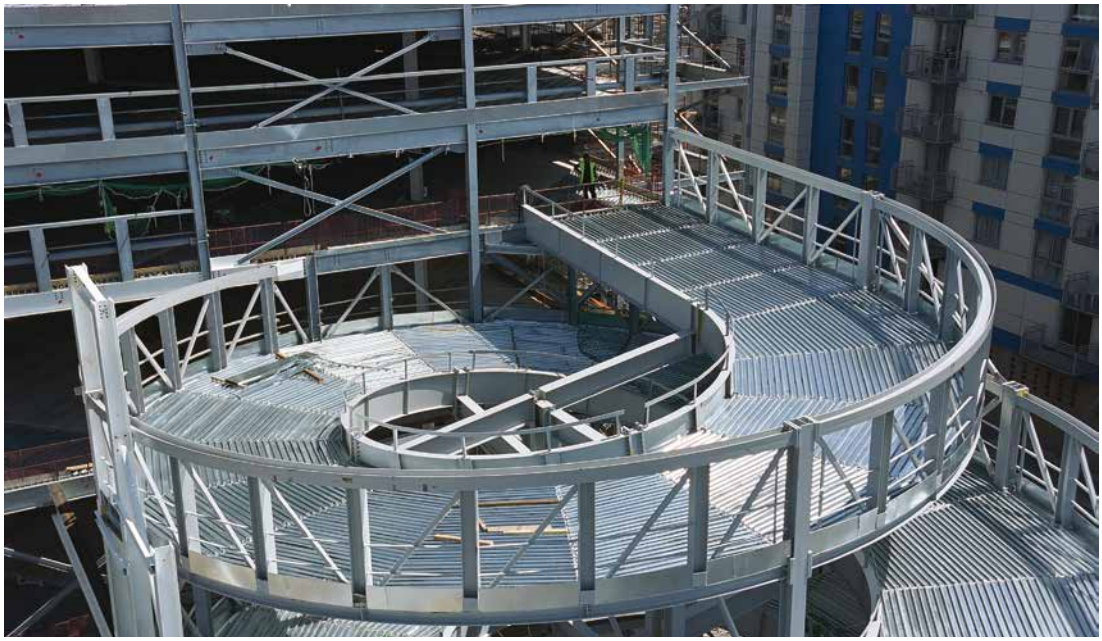
a large and complex sloping cantilevered spine beam in the central void of the ramps was proposed. Secondary beams cantilevering from the spine beam would support the roadway ramps. Though this arrangement went out to tender with the rest of the steelwork on the project, the cost of the spine beam led to a rethink. “We made it work as a design, but it would have been expensive, and because it was cantilevered it would have needed a huge foundation block,” says Edwin Bergbaum, Senior Associate Director of structural engineer Waterman Partnership.

So the ramp geometry was modified to allow columns to be fitted in on both the inside and outside circumferences, at least at each quadrant point. In the final alignment, the ramps have an outer radius of 10m and an inner one of 5..5m. Steel and concrete were both considered as construction materials, but the complex geometry made steel a hands down winner.

Structurally, a curved perimeter truss on the outside of the spiral spans between columns at



The structure would have been impossible to design without the use of a 3D CAD system.



Steel decking acts as permanent formwork for roadway.

quarter points. Around the inner radius a plate girder is used. Radial beams span from inside to outside to support the road deck.

For the roadway precast and insitu concrete were considered before deciding on metal decking acting as permanent formwork to an insitu slab. Because the ramps slope at one in 14, with a cross-fall of 1 in 20, the roadway is significantly warped, which would have made a precast solution too expensive. Metal decking was flexible enough to follow the correct profile naturally once laid on the supporting steelwork, says Bergbaum. The decking is not, however, designed to act compositely with the 200mm concrete slab. Much consideration was given to the orientation of the metal decking to give the most pleasing appearance when seen from below.

The structure was modelled in three dimensions using the Integer Superstress analysis program, starting with a quadrant on four supports and progressing to the whole structure. Design drawings were produced using CDC's 3D+.

"I've spoken to some of our senior draughtsmen," says Bergbaum, "and no-one is sure how you'd have drawn it on a board in two dimensions."

The stepped arrangement avoids overshadowing nearby houses

FACT FILE
Croydon Centrale
Client:
St Martin's Property Corporation
Architect:
John Clark Associates
Structural Engineer:
Waterman Partnership
Steelwork Contractor for Centrale Project:
Severfield-Reeve Structures
Steelwork contractor for car park ramps:
Watson Steel Structures Ltd
Construction Manager:
Bovis Lendlease
Traffic Engineer:
Denis Wilson Partnership
Steel Tonnage:
424 tonnes (ramps)
5800 tonnes (centre)
Contract Value:
£3.2M (ramps), £00M (centre)

Severfield-Reeve Structures was appointed steelwork contractor for the project as a whole, but subcontracted the ramps to Watson Steel Structures Ltd. After further development of the design and slight modifications, Watson Steel produced its fabrication drawings using Xsteel.

Because the ramp erection was on the critical path at the end of the steelwork contract, the unusual nature of the structure, and the fact that the ramps were needed to provide access for some of the following trades, a trial erection was undertaken at Watson's works.

Mr Bergbaum says: "We wanted to understand how the structure would deflect while being erected, and to make sure the design was what everyone wanted. It allowed the cladders to see what they would be cladding, and the client to see the soffit.' He adds that the trial went very well; on site, erection went "like a dream".

The car park is now in use, but with cladding to the sides of the spiral now in place, little of the structure is visible to the casual observer. So although drivers could hardly fail to notice the unusual geometry of the ramps, the chances are that few have any inkling of the ingenuity which went into building them.

Experimental behaviour of a steel structure under natural fire

A full scale European collaborative test has shown that the fire performance of a steel building was better than that predicted by calculations or design codes.

AUTHORS
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Chladná, M.,
Santiago, A.,
Beneš M.,
Borges, L.

Current design codes for determining the fire resistance of structures are based on isolated member tests subjected to standard fire conditions. Such tests do not reflect the behaviour of a complete building.

The performance of real structures subject to real fires is often much better than that predicted from standard fire tests on isolated members due to structural continuity and the provision of alternative load paths.

The high cost of full-scale fire tests and the size limitations of existing furnaces has limited studies to isolated element tests. However, the failure of the World Trade Centre on 11th September 2001 and, in particular, of building WTC 7, alerted the engineering profession to the possibility of connection failure in fires.

The aim of this project was to investigate the global structural behaviour of an 8-storey steel framed building subjected to a design fire in one of its compartments. The results presented include the temperature development within structural elements, the distribution of internal forces and the behaviour of the composite slab, beams, columns and their connections. The results suggest that the inherent fire performance of a lightly reinforced composite slab is significantly higher than calculated using traditional design methods, and confirm the conservatism of the fire engineering approach given in the Eurocodes.

The development of the Building Research Establishment's facility at Cardington provided the construction industry with the opportunity to carry out research projects that included full-scale fire tests. It contains three experimental buildings, including an eight storey steel structure.

The steel building simulates a real commercial office in the Bedford area and was designed to comply with British Standards and the Structural Eurocodes.

It consists of a steel frame with steel and concrete composite floors. It is eight storeys (33m) high and is five bays wide and three bays deep. The building is a non-sway structure with a central braced core containing a lift shaft and a braced core at either end. The connections consist of flexible end plates for beam-to-column connections and fin plates for beam-to-beam connections.

The building was designed for a dead load of 3.65 kN/m² and an imposed load of 3.5 kN/m². The floor construction consists of a profiled metal deck acting compositely with lightweight in-situ concrete and incorporates anti-crack mesh.

Test programme

The fire test was carried out in a centrally located compartment of the building, enclosing a plan area of 11m by 7m on the 4th floor

The load was simulated using sandbags, each weighing 1100kg. The sandbags represented 100% of the dead load other than the self-weight of the structure and 56% of the live load. The load was chosen so that local collapse of the floor would be expected under fire, based on analytical and FE simulations.

The fire load was provided by 40 kg/m² of wooden cribs covering the floor area of the compartment. The fire compartment was bounded with three layers of plasterboard. In the external wall the plasterboard was fixed to a 0.7m high brick wall. An opening 1.27m high and 9m long simulated an open window to ventilate the compartment and to allow the behaviour of the various structural elements to be observed. The thermal load and the dimensions of the opening were designed to be representative of a fire in an office building. Preliminary calculations predicted a hot but short duration fire.

The columns, external connections and connected beams were all fire protected with 15mm of Cafco300 vermiculite-cement spray.

Sections exposed to the fire were 356 x 171 x 51 UB, 305 x 165 x 40 UB, 305 x 305 x 198 UC and 305 x 305 x 137 UC. Connections were a cruciform arrangement of a single column with either three or four connected beams respectively, to the column flange and web.

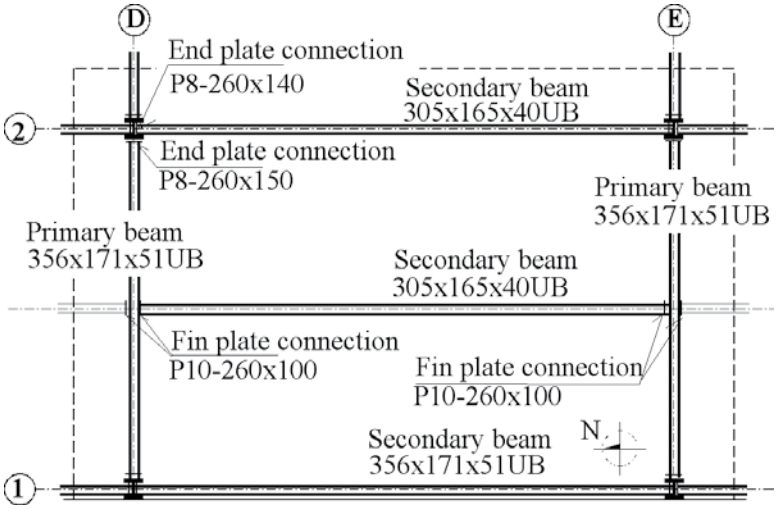

Figure 1.
Arragement of members in selected fire compartment

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Instrumentation

Instruments measured the temperature, the distribution of internal forces, and the deflected shape of the floor and the main structural elements.

Some 133 thermocouples were used to monitor the temperature in the connections and beams within the compartment, the temperature distribution through the slab and the atmosphere temperature within the compartment. Another 14 thermocouples were used to monitor the temperature of the protected columns.

High temperature and ambient temperature strain gauges were used to measure stresses and deformations. High temperature gauges were used in the connections only. In the protected columns and unexposed elements, 47 ambient temperature strain gauges were installed. 25 vertical displacement transducers were installed directly above the fifth floor to measure the deformation of the concrete slab.

12 additional transducers were used to measure the horizontal movement of the columns and the slab. 10 video cameras and two thermal imaging cameras recorded the fire and smoke development, the structural deformations and the temperature distribution with time.

Observations

During the test the predicted local collapse of the structure did not occur. The maximum recorded compartment temperature near the was 1107.8°C after 54 minutes, compared with a prediction of 1078°C in 53 minutes.

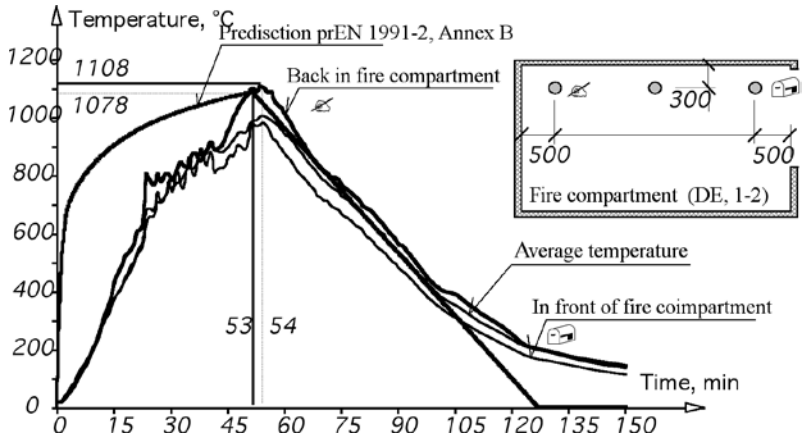


Figure 2
Compartment temperature

The maximum recorded steel temperature of 1087.5°C occurred after 57 minutes, on the bottom flange of beam DE2 in the middle of the section. A temperature of 1067°C after 54 min was predicted. Measurements of the temperature in the connections showed that in the heating phase, the connection temperature is significantly lower than that of the remote bottom flange, which is usually the critical element that defines the limiting temperature of the beam. In contrast, the connections cool more slowly than the beam. Using the thermal cameras it was possible to observe this effect, which is shown in figure 3.

At the maximum temperature, the joint temperature was around 200°C lower than the limiting temperature of the beam.

The maximum deflections exceeded the range (1000mm) of the displacement transducers, but from the video cameras on the fifth floor it was possible to calculate the maximum vertical displacement which was about 1200mm.

Local buckling of the beam lower flange was one of the main failure mechanisms. It is observed in the lower beam flange and web adjacent to the connections. This local buckling occurred during the heating phase after about 23 minutes, due to the restraint to thermal elongation provided by the adjacent cooler structure. As the temperature and the associated deformations increased, the shear resistance of the beam web was also reached.

The formation of a plastic hinge in the beam cross-section next to the protected zone was one of the main observed mechanisms in beam D1/2. This hinge is induced by lateral-torsional buckling during the heating phase, due to the restraint to thermal elongation provided by the adjacent protected section. This behaviour is associated with the local loss of stability in the bottom flange.

Buckling of the column flange in compression was observed in the major axis beam-to-column connections.

Behaviour of connections

Fracture of the end-plate along the welds was observed, caused by the horizontal tensile forces during cooling of the connected beam under large rotations associated with the flexible end-plate joints. The fracture occurred along one side of the connection only.

Elongation of the holes in the beam web in the tension/compression part of the fin plate connection was due to the associated large rotations. The fin-plate remained intact.

Composite Slab Behaviour

Fracture in the concrete slab was observed with a large crack propagating from the face of the column flange parallel to the beam D-E2. This crack developed due to tension in the concrete slab, along the weak zone in the composite beam-flange extremity. Secondary cracks occurred perpendicular to, and continuous across, the connections on both sides of the slab. The maximum vertical displacement occurred along a line of overlapped mesh reinforcement without adequate attachment, so that the slab behaved as if unreinforced.

The cameras above the fire compartment recorded loss of integrity in the concrete slab after 54 minutes, by a punching mechanism due to tension in the slab in the edge compartment.

Conclusions

Although temperatures in excess of 1000°C were achieved in the main supporting steel members, and displacements of approximately 1200mm were observed in the composite floor, collapse of the structure was not reached. It should be noted

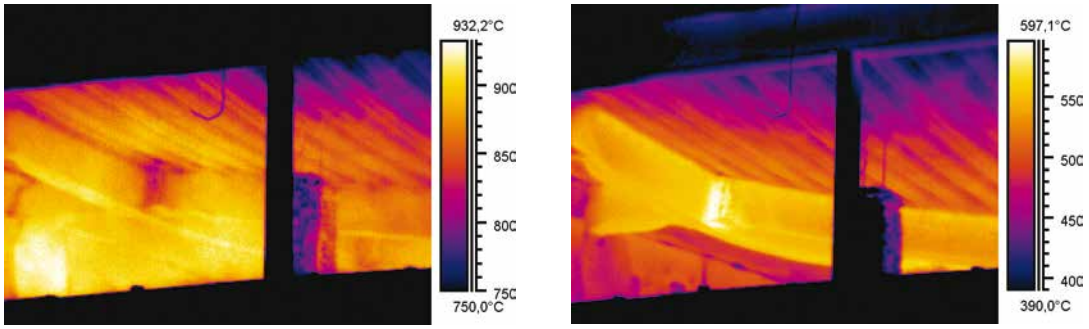


Figure 3
Fin plate connection D1-2 recorded by thermo imaging camera during heating after 58 minutes of fire (left) ans during cooling after 92 minutes (right).

that the applied mechanical load was higher that the typical serviceability condition. This suggests that the inherent fire performance of a lightly reinforced composite slab is significantly higher than calculated using traditional design methods. The test results support the concept of using unprotected internal beams with protected perimeter beams and columns as a viable fire engineering solution for steel framed buildings with composite floors.

The test also confirmed the conservatism of the fire engineering approach given in the Eurocodes. The calculated values gave conservative predictions of the temperature in the fire compartment, the transfer of heat into the structure and connections and of structural behaviour.

This is a condensed version of a paper which presents the results of a collaborative research project (Tensile membrane action and robustness of structural steel joints under natural fire, European Community FP5 project HPRI - CV 5535) involving the following organisations: Czech Technical University (Czech Republic), University of Coimbra (Portugal), Slovak Technical University (Slovak Republic) and Building Research Establishment (United Kingdom). This project was supported by a grant from the European Community FP5 HPRI - CV 5535 and COST C12 and this paper has been prepared as part of the Czech Grant Agency project 103/04/2100.
The full paper is available at www.steelconstruction.org

Better predictions for cellular beams

Designers using the old Yellow Book guidelines may have been led to be more conservative than needed. SCI's Manager for Fire Engineering, Gerald Newman, describes efforts to develop better methods for predicting the required thickness of an intumescent coating for cellular beams.

Beams with web openings, including traditional castellated beams, cellular beams with circular openings, and beams with multiple openings of varying size and shape have traditionally been fire protected using the guidance given in the "Yellow Book", *Fire protection for structural steel in buildings*[1]. This gives an empirical rule for calculating the passive fire protection thickness to be applied to castellated and cellular beams, in which the thickness required for the solid parent beam is increased by 20% in recognition of the fact that beams with multiple, closely spaced holes have been found to heat up at a slightly faster rate than solid beams. The limited tests from which this conclusion was drawn were carried out on loaded castellated beams protected with board and spray-applied fire protection materials.

The Yellow Book states that the rule applies to passive fire protection materials and that no general guidance is available for active (intumescent) materials. However, because no other guidance was available, the rule was widely applied to perforated or cellular beams protected using intumescent coatings.

During 2001 and 2002, the Steel Construction Institute (SCI) was involved in the development a fire engineering solution for a beam with web openings protected with an intumescent coating. It became apparent during the testing which accompanied this development that the Yellow Book guidance for beams with web openings was probably unconservative in a great many cases. It was observed that a narrow web post-heated up at a faster rate than a solid area of web and the beam could fail prematurely because of web post instability. The increase in temperature was inversely proportional to the width of the web posts, i.e. narrow web posts suffered the greatest rise in temperature.

In 2003, further tests on cellular beams protected with intumescent coatings were performed. These showed the same trend previously observed. However, in a test on an unprotected cellular beam, no increase in web post temperature was observed. This test indicated that the phenomenon was related to the properties of the intumescent coating. Careful observation is difficult in a fire resistance test because of the high temperatures within the furnace but it is likely that the increase in temperature was occurring because the coating was being either eroded from the edge of an opening or was shrinking away from the edges.

Late in 2003, SCI published Advisory Desk Note 269 (AD269), *The use of intumescent coatings for the fire protection of beams with circular web openings*. Shortly afterwards an SCI report was also published, *Interim guidance on the use of intumescent coatings for the fire protection of beams with web opening (RT983)*[2]. These outlined interim, generic, guidance for fire protection manufacturers to follow to determine the protection thickness for beams with web openings. In general the guidance recommends higher added values than the 20% factor from the Yellow Book.

Nevertheless, the SCI recognised that this was not the end of the matter. The guidance in the Advisory Desk Note had been developed mainly on the basis of fire testing using a single material and there was some concern that it was product specific. As a consequence of this, The Association for Specialist Fire Protection (ASFP), the representative body for fire protection manufacturers and applicators, set up a group to develop a general fire test protocol for cellular beams protected with intumescent coatings. The working group incorporated members from the ASFP, SCI, Corus, Warrington Fire Research Centre, BRE and two leading intumescent coating manufacturers. A protocol has now been produced and to date two companies have had products tested to this and assessed; others are expected to follow.

The new test protocol includes a fire test on a loaded beam spanning 4.2m and a number of short unloaded specimens to gather thermal data on other web post geometries. All the test beams have a number of openings and a variety of web post widths. The loaded beam geometry is shown in Figure 1.

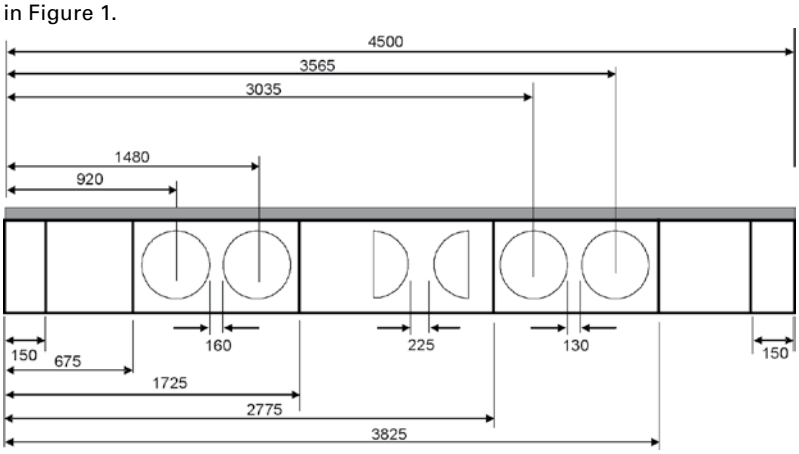
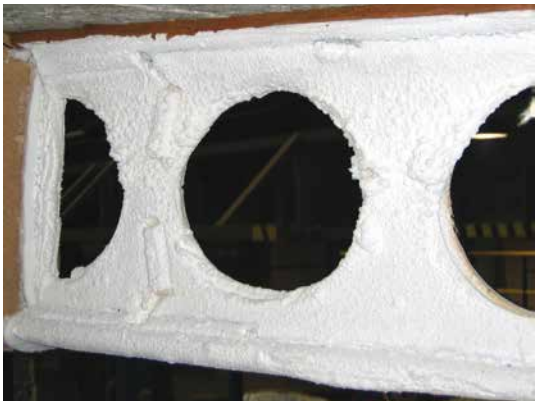


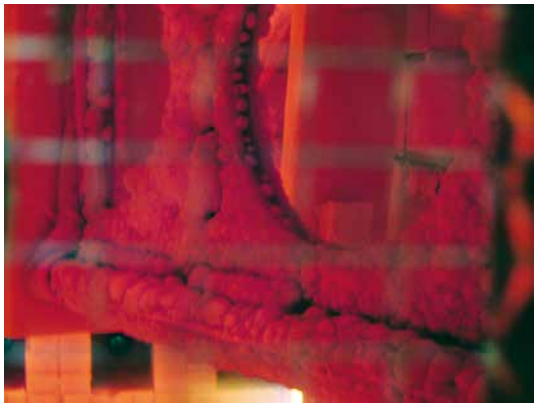
Figure 1: Schematic of the loaded beam

The assessment of the thermal performance of each product is carried out by the test laboratory (Warrington or BRE). SCI then carries out a structural assessment and produces design tables. These tables are similar to the generic tables in AD269 and RT983 but are specific to a

References:

1. *Fire Protection for Structural Steel in Buildings. Available from the Association for Specialist Fire Protection or via their web site at http://asfp.associationhouse.org.uk/*
2. *Interim guidance on the use of intumescent coatings for the fire protection of beams with web opening (RT983). Available from the Steel Construction Institute or at http://www.steelbiz.org/*
3. *BS5950 Structural Use of Steelwork in Buildings. Part 8, Code of Practice for Fire Resistant Design. Available from HMSO.*





Figures 2 & 3 Unloaded test pieces following the fire test

particular product.

Early indications are that some of the generic information published by SCI in RT983 may be conservative. It is clear that web posts appear not to get quite as hot as SCI originally predicted. However, some of these gains are lost because the thickness of intumescent needed to maintain these higher beam temperatures may be greater than the generic values used by SCI. In any case, it is clear that different intumescent coatings behave slightly differently.

During the next few months one can expect to see assessments using the ASFP/SCI protocol produced for many products. On occasions, specifiers may find that some suppliers of intumescent coatings are not using the new protocol, but instead are relying on the old Yellow Book 20% rule. Although for some intumescent coatings, this may be appropriate, specifiers should be aware that the use of this rule, without supporting evidence, is not supported by SCI, ASFP or permitted by BS5950-8[3].

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Two interesting bridges

1. New Bridge over the River Calder at Huddersfield. *(left)*
The £3 million scheme for the extension and modernisation of the Corporation of Huddersfield's sewage purification system includes the provision of a bridge over the River Calder. The bridge unites the two halves of the plant, and carries a glass fibre aquequct for the conveyance of sewage with various pipes and mains, and a light walkway for foot traffic. It is a two-pinned tied arch with a 171-ft span and a rise of 20 ft. The main booms are constructed from Universal columns in high yield steel and the splices in these, and the portal cross frames also, are made with high strength friction grip bolts. High yield stress steel was used in order to keep down the dead weight of the bridge, which is an appreciable part of the load to be carried.

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2. Hamilton River Bridge, Labrador. *(right)*
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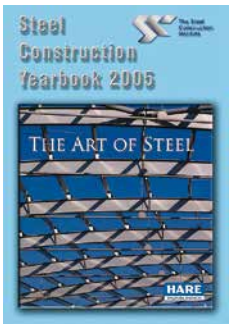

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New and Revised Codes and Standards

(from BSI Update January 2004)

BRITISH STANDARDS REVIEWED AND CONFIRMED

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.

BS 4395:
Welding. Recommendations for welding of metallic materials

BS EN 1011-8:2004
Welding of cast irons
Supersedes BS 4570:1985

BS EN 10025:-
Hot rolled products of structural steels

BS EN 10025-1: 2004
General technical delivery conditions
Supersedes BS EN 10025:1993, Parts 1-3 of BS EN 10113:1993, Parts 1 & 2 of BS EN 10137:1996, and BS EN 10155:1993

BS EN 10025-2:2004
Technical delivery conditions for non-alloy structural steels
Supersedes BS EN 10025:1993

BS EN 10025-3:2004
Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
Supersedes Parts 1 & 2 of BS EN 10113:1993

BS EN 10025-4:2004
Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
Supersedes Parts 1 & 3 of BS EN 10113:1993

BS EN 10025-5:2004
Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
Supersedes BS EN 10155:1993

BS EN 10025-6:2004
Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
Supersedes Parts 1 & 2 of BS EN 10137:1996

BRITISH STANDARDS WITHDRAWN

If any standard in this list has been amended since publication, all amendments published to date are also withdrawn.

BS 4570:1985
Specification for fusion welding of steel castings
(superseded by BS EN 1011-8:2004)

BS EN 10025:1993
Hot rolled products of non-alloy structural steels. Technical delivery conditions
(superseded by Parts 1 & 2 of BS EN 10025:2004)

BS EN 10113:-
Hot-rolled products in weldable fine grain structural steels

BS EN 10113-1:1993
General delivery conditions
(Superseded by Parts 1, 3 & 4 of BS EN 10025:2004)

BS EN 10113-2:1993
Delivery conditions for normalized/normalized rolled steels
(Superseded by Parts 1 & 3 of BS EN 10025:2004)

BS EN 10113-3:1993
Delivery conditions for thermomechanical rolled steels
(Superseded by Parts 1 & 4 of BS EN 10025:2004)

BS EN 10137:-
Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions

BS EN 10137-1:1996
General delivery conditions
(Superseded by Parts 1 & 6 of BS EN 10025:2004)

BS EN 10137-2:1996
Delivery conditions for quenched and tempered steels
(Superseded by Parts 1 & 6 of BS EN 10025:2004)

BS EN 10155:1993
Structural steels with improved atmospheric corrosion resistance. Technical delivery conditions
(superseded by Parts 1 & 5 of BS EN 10025:2004)

NEW WORK STARTED

BS 5400:-
Steel, concrete and composite bridges

BS 5400-5 (Revision)
Code of practice for design of composite bridges
(will supersede BS 5400-5:1979)

DRAFT BRITISH STANDARDS FOR PUBLIC COMMENT

04/30124987 DC
EN 1090-1 Steel and aluminium structural components. Part 1. General delivery conditions.

CEN EUROPEAN STANDARDS

EN 1998:-
Design of structures for earthquake resistance

EN 1998-5:2004
Foundations, retaining structures and geotechnical aspects

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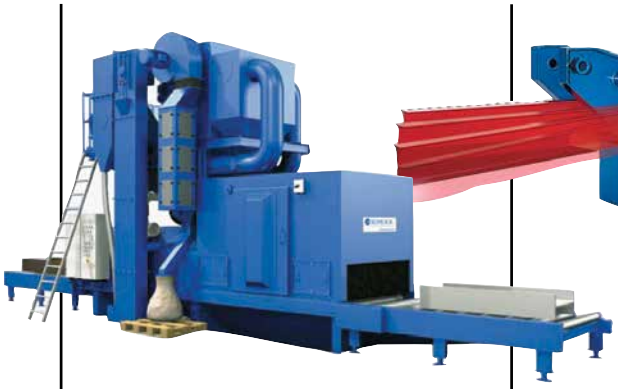

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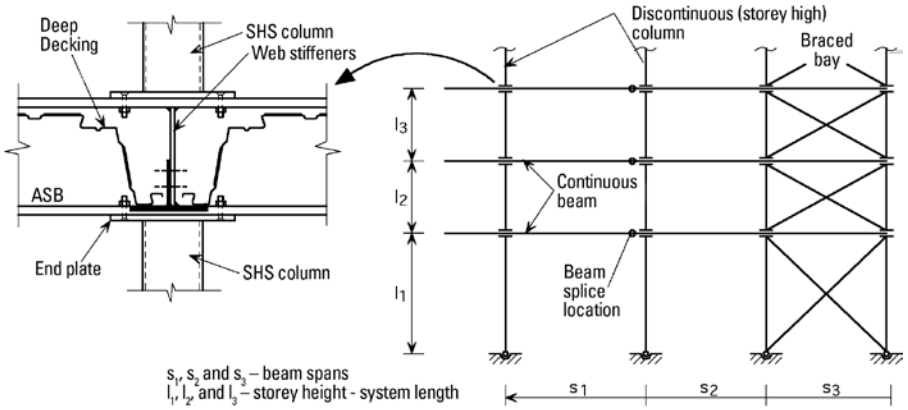
AD 283
The Use of Discontinuous Columns in Simple Construction

Figure 1. Connection detail and framing system



This AD provides advice on the design of discontinuous (storey-high) columns in simple construction. This is the second in a series of ADs dealing with discontinuous columns and continuous beams as a form of simple construction. General advice on this form of construction is given in AD 281 and the framing system and connection detail illustrated in that Advisory Note is reproduced here in Figure 1.

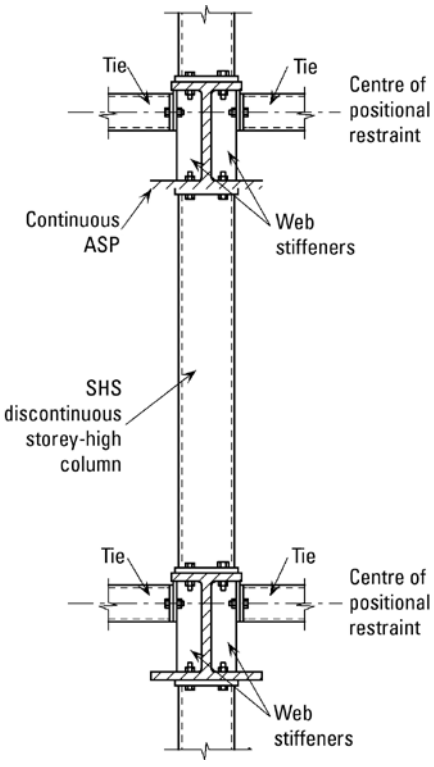


Figure 2 Typical Column

Columns in simple construction

Clause 4.7.7 of BS5950-1: 2000 gives the design rules for columns in simple construction and the assumptions that underpin this clause are explained in AD 275. A single interaction equation needs to be satisfied, encompassing both cross-section and member buckling checks. This is a safe and easy to use method, and should be applied to the design of discontinuous columns in this form of construction.

For circular and square hollow sections columns, M_{bs} should be taken as equal to the moment capacity of the cross-section M_c. For rectangular hollow sections, M_{bs} may also be taken as M_c subject to the limits of clause 4.7.7, clause 4.3.6.1 and Table 15. If doubly symmetric open sections are used, an equivalent slenderness λ_{LT} of 0.5 L/r_y is taken in order to calculate M_{bs} (where L is the storey height).

The effective length of the column is required to determine its compression resistance and to check the slenderness limits in Table 15, if required.

The eccentricity of the beam reaction (relative to the column centreline) is required in order to calculate the nominal moments for use in the interaction equation.

Column effective length

A typical storey-high column is shown in Figure 2. For this form of construction it should be assumed that the column is a pin-ended member (prop) and the effective length should be taken as the length between positional restraints. When similar depth beams are used in each floor, this is usually the same as the storey height (sometimes referred to as system length).

As mentioned in AD281, full depth web stiffeners are provided on the beams at the connections. This will ensure that the effective pin-ended column will have sufficient stiffness over its end portion (i.e. over the beam depth). The design of the beam-column connection will be covered by a future AD.

Positional restraint

In order to ensure that the effective length of a pin-ended strut may be taken as the system length, BS 5950-1 has particular requirements concerning restraint.

Clause 2.4.5.2 in BS 5950-1: 2000 requires that each column be held in position or laterally restrained in both directions at each floor level. The ties or concrete floor plate should be designed for the tying requirements of clause 2.4.5, as appropriate for the permanent condition. The ties should also be checked against the positional restraint requirements of clause 4.7.1.2 for both the permanent and, particularly, the temporary condition.

Members providing positional restraint should be connected to an appropriate shear diaphragm or system of triangulated bracing.

Column Design and Nominal Moments

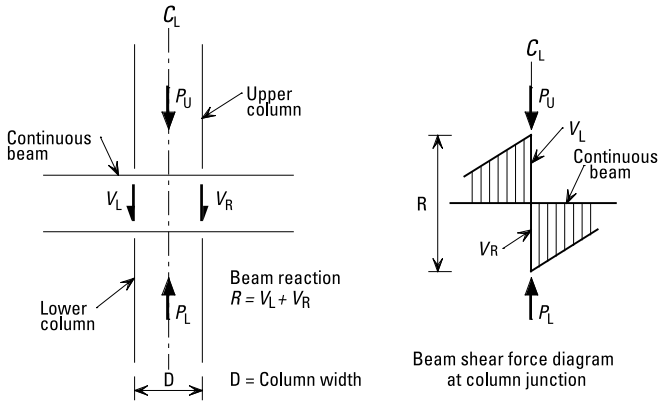
The loading at the beam-column interface is illustrated in Figure 3 and the following simplified design procedure is recommended:-

The lower column should be designed for the axial load P_L and nominal moment M. Assuming that the centre lines from the upper and lower columns coincide, the axial load P_u from the upper column passes straight through the beam and therefore no moment is induced in the beam or in the lower column from the effects of P_u.

The nominal moments at the top of the lower column should be taken as the total beam reaction multiplied by half the column width. No nominal moment is taken at the bottom of the column.

Note: The floor beams in this form of

construction may be designed as continuous and hence pattern loading must be considered in their design. However, it is not necessary to consider the effect of pattern loading on the column when determining the nominal end moments. Thus the beam reactions for use in column design will arise from the case where the beams on both sides carry their full loading. Note also that, in determining the reaction at the top of each column, the reaction under a beam that is analysed as continuous may be greater than if pin ended beams were assumed.



Lower column axial load $P_L = P_U + R$

Lower column nominal moment $M = \frac{R \times D}{2}$

Contact: Thomas Cosgrove
Email: t.cosgrove@steel-sci.com
Telephone: 01344 623345

AD 284
BS 449 and Approved Document A – Structure (2004 Edition)

Approved Document A – Structure – of the England and Wales Building Regulations has been revised. The "2004" Edition came into effect on the 1st December 2004.

Approved Document A includes three sections, A1 Loading, A2 Ground Movement and A3 Disproportionate Collapse, which expands on the Buildings Regulations for Structure. Moreover, Section A3 contains lists of codes, standards and references that may be complied with in order to meet the Building Regulations.

Steelwork designers should note that BS 449 does not appear in any of the lists of Codes, Standards and References in Approved Document A – Structure (2004 Edition). However, BS 449 has not been superseded, declared obsolete or withdrawn by BSI. It has simply not been included in the latest Approved Document A. BS 449 is still a current British Standard, though it has not been maintained by BSI since the issue of Amendments 6255 and 8859. Currently, BS 449 may be used for the design of steel framed buildings where it adequately covers the type of frame being designed.

However, designers still wishing to use BS 449 are advised to check the terms and conditions of their professional indemnity as it may only cover designs carried out to codes and standards listed in the current Approved Document A. In addition, designers requiring local authority approval for their calculations are advised to check with the local authority on the acceptability of BS 449 prior to starting work.

Contact: Thomas Cosgrove
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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 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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