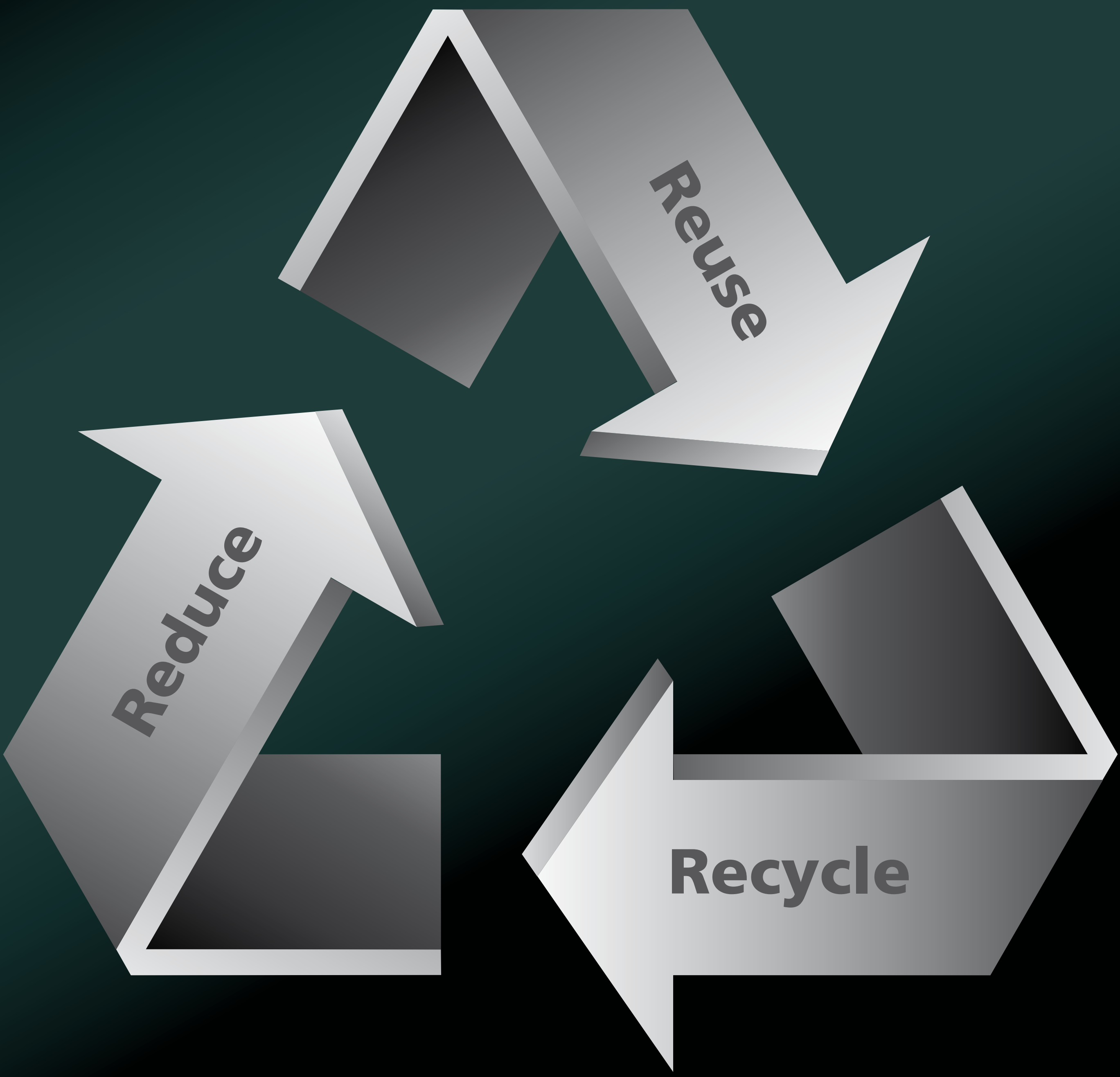
STEEL CONSTRUCTION
Carbon Credentials



Steel for Life and the British Constructional Steelwork Association (BCSA) are working closely together to promote the effective use of structural steelwork. This collaborative effort ensures that advances in the knowledge of the constructional use of steel are shared with construction professionals.

Steel is, by a considerable margin, the most popular framing material for multi-storey buildings in the UK and has a long track record of delivering high quality and cost-effective structures with proven sustainability benefits. Steel can be naturally recycled and reused continuously, and offers a wide range of additional advantages such as health and safety benefits, speed of construction, quality, efficiency, innovation, offsite manufacture and service and support.

The steel sector is renowned for keeping specifiers abreast of the latest advances in areas such as fire protection of structural steelwork, CE Marking and achieving buildings with the highest sustainability ratings. The 'Steel Construction' series of publications has provided detailed guidance on a range of key topics and market sectors. Guidance is provided on all relevant technical developments as quickly as is possible.

The sector's go to resource website – *www.steelconstruction.info* – is a free online encyclopedia for UK construction that shares a wealth of up-to-date, reliable information with the construction industry in one easily accessible place.

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Introduction
by David Moore, Chief Executive Officer,
British Constructional Steelwork Association

Steel fully supports zero carbon drive

It is unarguable that the world is facing a carbon-related climate emergency, and the window of opportunity to tackle it is a narrow one. Industries across the world are rising to the challenges from international bodies like the United Nations, as well as the UK government which has made carbon reduction a legal obligation.

The steel construction sector has been at the heart of sustainable construction for many years, and steel is in fact about as sustainable a material as you can get.

We have not rested on our laurels, far from it, and plans are in place and being further developed all across the steel construction supply chain, from steel manufacturers to BCSA members' workshops and on-site practices, to take us successfully along our zero carbon journey.

A vital message is that steel construction should be seen as part of the solution to the climate emergency, not part of the problem. The steel sector is collaborating all along the supply chain on strategies like more carbon-efficient building designs, and thinking about eventual reuse, disassembling or recycling issues at the design stage. The inherent properties of steel make it ideal for reuse and recycling and early involvement of steelwork contractors will benefit that process.

Construction clients as well as the industry itself will be increasingly focussed on sustainability, and making sure that all of the supply chain is playing its part. This brings into focus initiatives like the BCSA's Sustainability Charter which imposes mandatory audits of sustainability performance on signatories.

This successful scheme is only available to BCSA member companies and insisting that your steelwork contractor has this is one of the best ways of ensuring that there is no weak link in your own carbon reduction strategy.

This publication has been produced by the BCSA and Steel for Life as part of our drive to provide guidance to designers, to assist them in their decision making as they strive to address the climate emergency. We hope you find it useful and informative.

October 2020

Contents

Building the sustainable future

Steel construction provides the most sustainable as well as the most economic buildings, representing the most efficient use of world resources, so should be viewed as an investment and not a cost. This guide explains why.

In this guide construction designers – architects as well as engineers – will find much of what they need to know about the sustainability benefits of selecting steel for buildings and other structures.

Much more detail can be found by tapping into the wealth of technical information held on the free to use steel construction website *www.steelconstruction.info*, and more will be provided as the steel sector's research and development produces new information relevant to the drive to zero carbon.

Steel has a strong case for being called the most sustainable of all construction materials, uniquely capable of repeated reuse or recycling without degradation of the material. Some 75% of all steel ever produced is estimated to be still in service, according to World Steel Association data, and when scrapped is still invaluable for use in both Electric Arc Furnace (EAF) and Basic Oxygen Steelmaking (BOS) methods of manufacture. It is a permanent store of value.

Steel's sustainability advantages come into their own with the increasing focus on the circular economy, which aims to design out waste and pollution, maximise the service life of products and materials and avoid sending materials to landfill after their first-life use.

This signals an end to the 'take-make-dispose' attitudes that have contributed to the climate emergency crisis, and underlines the importance that the steel construction sector has for many years attached to proper whole life analysis of materials.

The strong economic option

- Steel has long been recognised as the economic option for a range of building types, because it represents the most efficient use of resources.
- Steel dominates the markets for both single storey industrial and multi-storey buildings across a range of sectors.
- Regularly updated cost comparisons demonstrate the real value of steel.
- High strength-to-weight ratio of steel minimises the structural weight of superstructures, and thus minimises the substructure costs.
- The versatility and adaptability of steel construction means that buildings can readily be repurposed to suit a change of use, ensuring the long-term viability of projects.
- This longevity combined with the inherent value of an asset can be recycled or reused at end of life means that steel is not a cost, it is an investment.

Central London's skyline is dominated by steel-framed towers

Social impacts need to be considered

- Offsite fabrication in a factory environment provides jobs for a workforce close to where they live, which benefits family life and promotes stable communities.
- The stable, long-term nature of jobs in a steel fabrication factory, creates a highly trained and skilled, specialist and well-motivated workforce.
- Continuous investment in new plant and machinery ensures an efficient steel fabrication industry.
- Offsite fabrication in controlled factory conditions with automated production makes for safer working environments.
- The lightweight nature of steel construction and the fact that the components are manufactured offsite means far fewer site visits from heavy vehicles, benefiting local communities.
- Steel's speed of construction minimises the impact of site work on local people and businesses.

Steel has a great depth and breadth of sustainability advantages, apart from those directly related to minimising carbon emissions, all of which are of value as the world strives to combat our carbon-related climate emergency.

Legislation and international agreements to which the UK is a signatory are key drivers of measures being adopted across industries to minimise carbon emissions. In 2015 there was the Paris Agreement, a landmark environmental accord by national governments to address climate change by reducing carbon emissions.

This was followed by the UK government's 2019 declaration of a climate emergency, which led to a target of the UK being net carbon zero by 2050. The UK was the first country in the world to make such a legal target backed by legislation and, with the world's building stock forecast to double by that date, others will surely follow.

One of the construction industry's responses has been the formation of Construction Declares, part of a global, publicly announced commitment by industries supported by individual companies and organisations to take positive action to combat the climate emergency. The steel construction sector fully supports the declaration that we face a climate emergency and that radical, collaborative action across the industry is needed to help meet it.

Steel manufacturing accounts for 7% to 9% of global CO_2 emissions, according to World Steel Association calculations, and manufacturers have their own strategies for tackling the climate emergency and are committed to net zero carbon targets.

Key clients like property developers have also adopted ambitious carbon reduction policies, with British Land for example having committed to be net zero carbon by 2030, with 100% of developments delivered from this year to be net zero embodied carbon.

The construction industry accepts that it has a large role to play in reducing carbon emissions. One tactic is to make sure that more is achieved with the resources we use – or have used in the past as we recycle and reuse steel.

As well as developing ever better materials and products used in construction, that means a focus on more efficient design by engineers and architects. The steel construction sector has for many years played a leading role in making sure that designers are fully backed with support and guidance that enables them to make the best use of steel.

Engineers and architects now routinely think about minimising the use of scarce resources like steel in their designs, and consider how the structures will eventually be disassembled for reuse or recycling or modified or extended to allow a new use for the existing building.

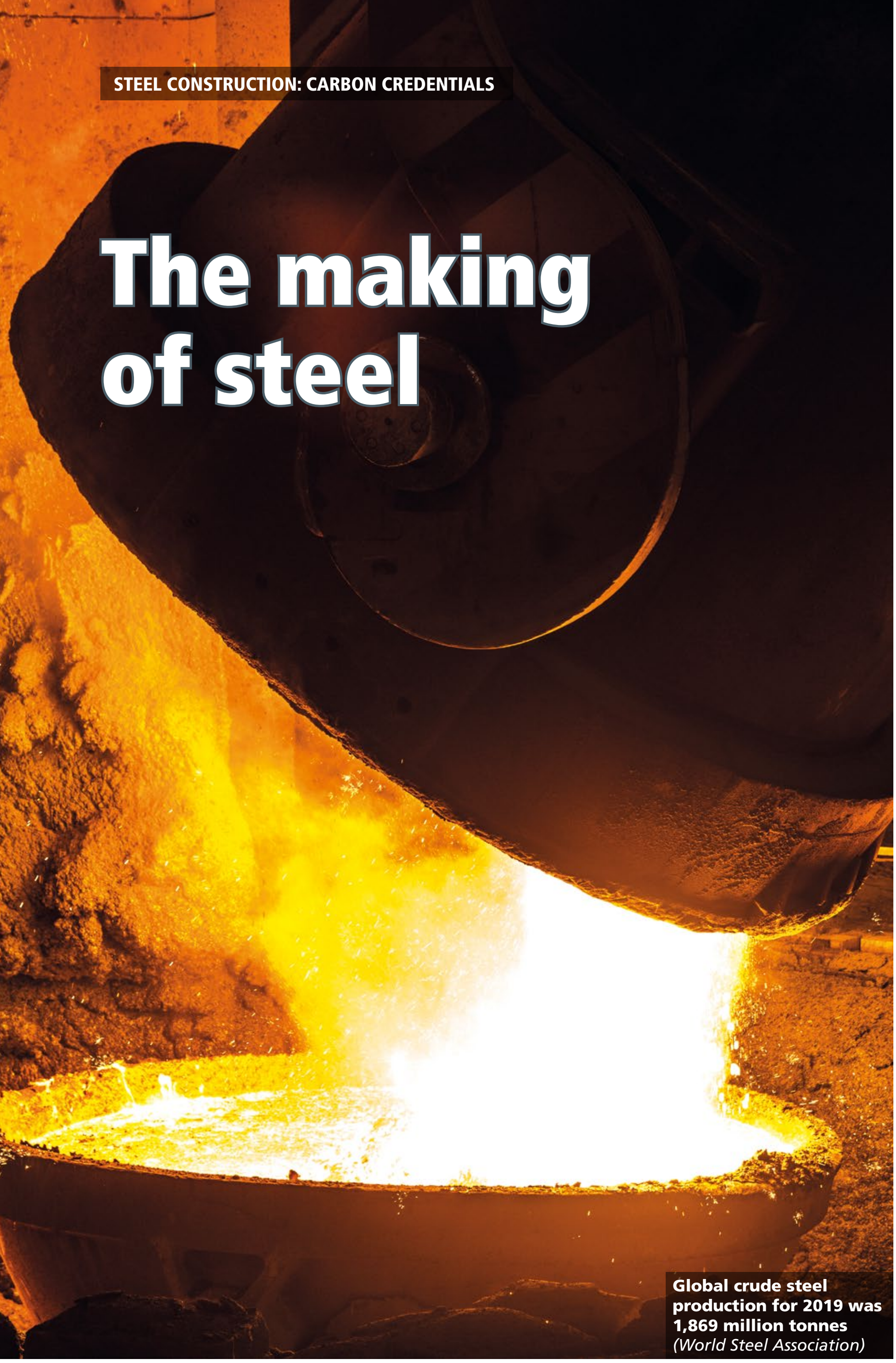
Offsite manufacture is increasingly acknowledged as being essential for the future of an efficient construction industry and sustainable buildings, and steel has always been valued for the fact that it is manufactured in steelworks where the latest technology for emission controls is employed; it is in the steel manufacturer's own interests to minimise the energy used in producing steel as energy is an expensive resource.

Steel goes from the mill to the stockholder or steelwork contractor where it is processed into fabricated steelwork in factory-controlled conditions using CNC machinery that is constantly being developed to minimise waste and maximise productivity.

Higher strength steels are being made available that allow more to be achieved in terms of structural strength with less steel. Steel composite and CLT floor systems that deliver greater sustainability advantages than precast concrete slabs are being appreciated by a growing number of clients.

While steel is determined to deliver on carbon reduction targets we should not forget that a sustainable future will also depend on some other benefits that flow from using steel, factors that support a viable UK economy and jobs that support local communities.

The making of steel



Global crude steel production for 2019 was 1,869 million tonnes *(World Steel Association)*

The Electric Arc Furnace method is one of the two major steelmaking processes, but due to its reliance on recycled content it is fast-gaining in worldwide popularity.

Steel remains the backbone of the modern industrialised world and it's hard to imagine a global economy without the material.

Whether it is the construction of high-rise buildings and iconic structures, or the production of vehicles, engines or machines, steel is ever present in all that we see, make and use.

Steel's versatility, due to its composition and properties, its strength-to-weight ratio and its ability to be infinitely recycled into new products sets it apart from other materials and makes steel the ultimate product of the future and one that already contributes to the development of the circular economy.

Structural steel is an alloy of iron and other metals with most of the carbon removed to make it tougher and more ductile. There are many grades of steel, each with its own specific chemical composition and properties to meet the needs of the many different applications.

When it comes to the production of steel, there are two main processes, Basic Oxygen Steelmaking (BOS) and Electric Arc Furnace (EAF). Together, both comprise a single global system of supply to meet the increasing worldwide demand.

The principal materials used in the BOS process are molten iron, produced in a blast furnace from iron ore and coking coal, and steel scrap. Modern BOS furnaces, or 'converters' take up to 350t of these materials and convert it into steel in around 15 minutes.

A water-cooled oxygen lance is lowered into the converter and high-purity oxygen is blown on to the metal at very high pressure. The oxygen combines with carbon and other

Future production will be greener

ArcelorMittal currently operates 33 Electric Arc Furnaces, 51 Blast Furnaces and 13 Direct Reduced Iron (DRI) plants and produces approximately 90mt of crude steel each year.

The company says it is currently pioneering two breakthrough carbon-neutral technology routes: the first, called Smart Carbon and the second is an innovative DRI-based route.

The Smart Carbon technology will enable the company to reduce CO_2 emissions by 30% by 2030, and beyond 2030 hydrogen based DRI steelmaking will feature more and facilitate its ambition to be carbon neutral by 2050, in line with The European Green Deal and the Paris Agreement.

Both technologies have been developed as circular manufacturing processes, and in the case of Smart Carbon for each tonne of carbon neutral steel produced there will also be 250kg of carbon neutral cement and 200 kg of carbon neutral bio-materials, with potential to become carbon positive through the use of Carbon Capture Storage.

unwanted elements, eliminating them from the molten charge.

These oxidation reactions produce heat, and the temperature of the metal is controlled by the quantity of added scrap.

After the steel has been refined and samples taken to check temperature and composition, the converter is tilted and the steel is tapped into a ladle. Typically, the carbon content of the steel at the end of refining is about 0.04%. During tapping, alloy additions can be made to adjust the final composition of the steel.

The EAF process uses cold scrap metal and can make up to 150t of steel in a single process or 'melt'.

The electric arc furnace consists of a circular bath with a moveable roof, through which three graphite electrodes can be raised or lowered. Once the steel scrap is placed in the furnace the electrodes are lowered. A powerful electric current is passed through the charge, an arc is created, and the heat generated melts the scrap. Lime and fluorspar are added as fluxes and oxygen is blown into the melt to remove impurities.

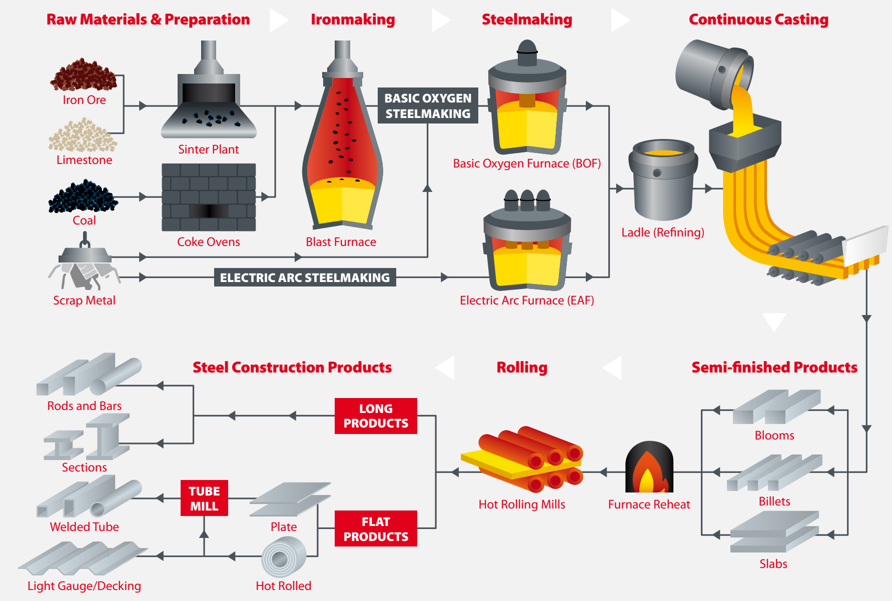
The latest data from the World Steel Association shows that currently 70% of global demand for steel is met by BOS and 30% by EAF. Highlighting the processes' sustainability credentials, both BOS and EAF require significant amounts of recycled content for their production, up to 30% for the former and 100% for the latter.

These figures are predicted to change significantly in the coming years with the drive towards low and zero-carbon steelmaking coupled with increased availability of scrap driving new steelmaking capacity towards EAF rather than BOS.

European steel producers have worked diligently over the past two decades to reduce the carbon footprint of the steel produced through traditional integrated steelmaking, having accomplished the lowest levels possible from a scientific perspective.

All in all, steelmaking is going to inhabit a very different landscape in the coming years.

Figure 1: Steelmaking process routes



Road to carbon neutral production

Tata Steel says its steelmaking ambition is to produce steel in a carbon-neutral way by 2050, and to have reduced 30% of its CO_2 emissions by 2030.

Damien Brook, European Media Relations Manager Corporate Communications & Public Affairs at Tata Steel says: "In our products and services, we are continually innovating. We are finding sustainable solutions which are lighter, last longer and use fewer resources to produce.

"For example: Stronger steels which allow cars to be lighter and more fuel efficient, designing solutions with our customers to reduce waste and make steel products safer, encouraging recycling and reuse, and using the latest technology to design products which support a circular economy and the use of renewable resources."

Recycled content

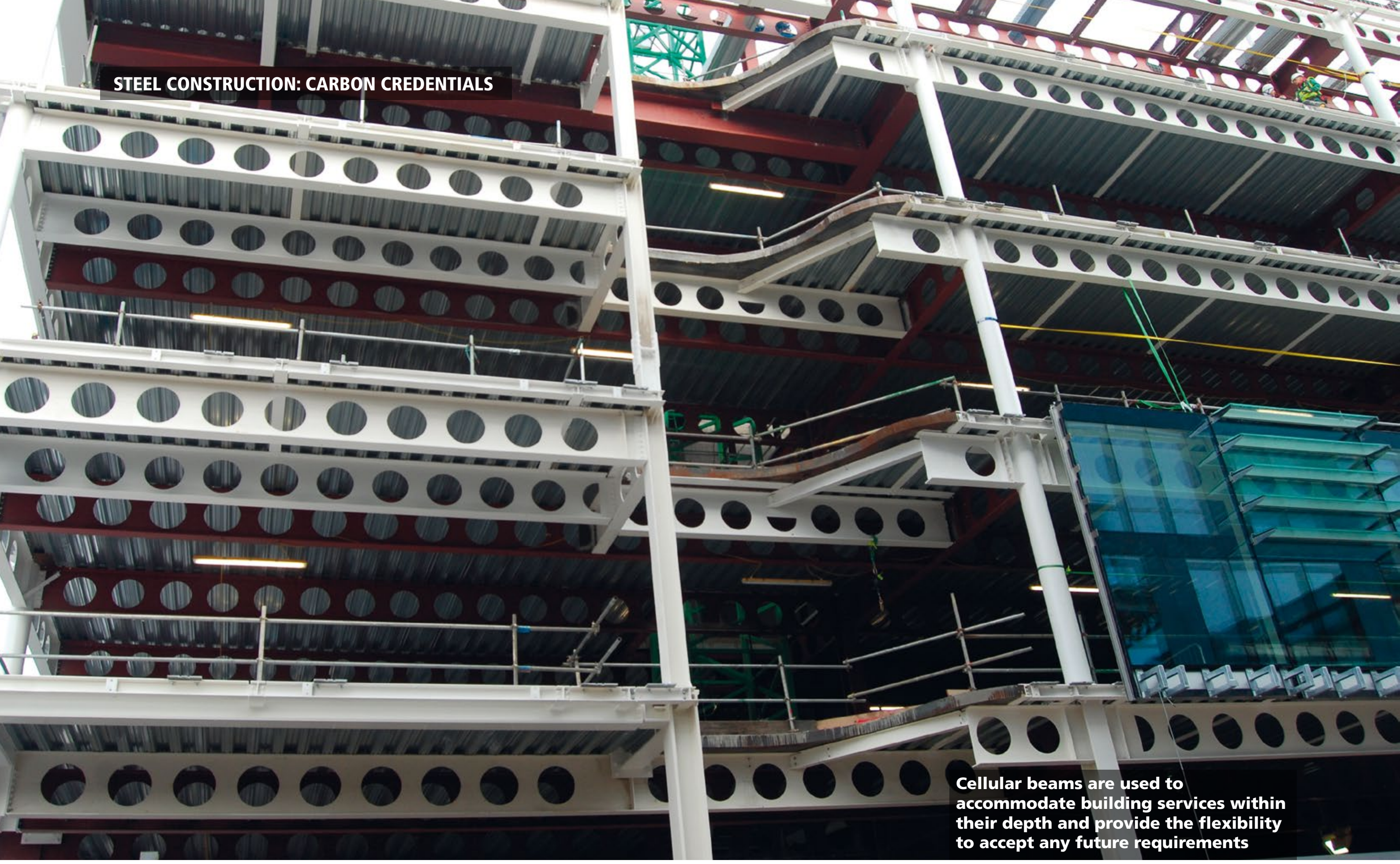
Designers are increasingly seeking figures for the recycled content of steel as such data is required for schemes such as LEED that are used to measure the sustainability of a project.

As there are two main production routes for steel with very different values for the recycled content, this is not an easy question to answer.

However, if the steel supplier is known at the design stage, then actual data from the manufacturer can be used. However, if the steel supplier is not known at the design stage, which is usually the case, then an appropriate published average value can be used.

For example, British Steel advise: "In the European steel industry as a whole, recycled scrap steel accounts for 56% of total steelmaking, being made up of 32% pre-consumer and 24% post-consumer scrap.

"For purchases of European Steel, we recommend using a recycled content figure of 56% which reflects the total industry position." (July 2020).



Cellular beams are used to accommodate building services within their depth and provide the flexibility to accept any future requirements

Steel carbon credentials embodied in action

Steel fully supports the drive towards decarbonisation, which is now being hailed as an unstoppable megatrend. An increasing focus on embodied carbon will enhance the attractions of steel as a construction material as appropriate Whole Life Carbon assessments are adopted.

Climate change might have been momentarily nudged from its position at the top of the political and corporate agendas by COVID-19, but one likely longer term impact of the pandemic could be to accelerate the trend of investment towards low and zero carbon infrastructure projects.

Governments will be in a strong position to insist on lower carbon returns on the huge economic relief infrastructure and building investments that they and the private sector will make as the world now strives to alleviate the economic impacts of the pandemic.

Even before the pandemic the construction industry was setting itself ambitious targets for reducing its carbon footprint. The World Green Building Council for example in 2019's "Bringing Embodied Carbon Upfront: Coordinated action for the building and construction sector to tackle embodied carbon", has targeted at least a 40% reduction in embodied carbon from new buildings, infrastructure and renovations by 2030 and net zero by 2050.

Also by 2050, all buildings, including existing buildings, must be net zero operational carbon.

Decarbonisation is now acknowledged as an unavoidable and unstoppable megatrend, and all construction materials are coming under the harsh spotlight of public as well as scientific opinion as they strive to prove their sustainability credentials.

Fortunately, the steel manufacturing and steelwork construction industries have been establishing and improving their sustainability performance for many years and are in a position to welcome the increased focus.

As the title of the World Green Building Council's report acknowledges, a key milestone on the transition to a zero-carbon future will be ensuring that the embodied carbon content of buildings and other structures is minimised.

Properly tackling the carbon issue will demand taking account of Whole Life Carbon rather than the more simplistic, and potentially misleading, 'cradle-to-gate' calculations that served for some materials in earlier periods of the construction industry's zero carbon journey.

The steel sector has always insisted however on the more meaningful Life Cycle Assessment approach of considering a 'cradle-to-cradle' – or Whole Life Carbon – approach, which takes account of how, or if, a material can serve a meaningful purpose beyond simply being reduced to hardcore for example, after its original use has ended.

Steel has outstanding credentials on this key carbon score as it is typically either reused or recycled. Steel almost never adds to the construction and demolition waste sent to landfill.

Life Cycle Assessment shows that steel's long-proven sustainability advantages over rival construction materials are even stronger when account is taken of what happens to the material when a building or other structure reaches the end of its useful life. The steel of course is not difficult or expensive to dispose of. On the contrary, it has a continuing value to society when recycled or reused.

Embodied carbon rising in relative importance

Embodied carbon refers to life cycle greenhouse gas emissions – measured in units of carbon dioxide equivalents – that occur during the manufacture and transport of construction materials and components, including the construction process and end of life aspects of buildings.

Total carbon emissions of a building over its life cycle can be looked at as the sum of its embodied carbon plus operational carbon. Reducing operational carbon emissions from buildings is a key sustainable construction driver in the UK, where the Government has set legally binding targets to reduce greenhouse gas emissions. The operation of buildings currently accounts for nearly half of these emissions.

Operational carbon refers to the carbon dioxide and other greenhouse gases emitted over a building's lifetime use, which include emissions from heating, cooling, ventilation and lighting. The relative importance of these aspects of operational carbon can vary depending on a host of factors, but climate change itself brings a new focus on cooling for buildings in the UK as temperatures rise, and the COVID-19 pandemic might usher in a new emphasis on ventilation.

Steel buildings are of course highly regarded for the ease with which they can be altered to accommodate changing uses, including installation of additional plant for services like ventilation if needed. The use of cellular beams for example provides such future flexibility. As operational carbon reduces, embodied carbon becomes relatively more important for architects and engineers to properly understand.

Structural framing materials are not usually regarded as directly contributing to the operational impacts of a building. However, it is important to realise though that calculations of the embodied carbon of structural framing materials should not be considered in isolation. Such calculations should include the impacts at a whole building level and through the whole life cycle.

Robust Life Cycle Assessment data

Proper assessment of embodied carbon of materials has to be based on robust data that is derived from use of a Life Cycle Assessment as set out in BS EN 15804. A key distinction has to be drawn between assessments based on all of the life cycle stages identified in this standard – which is steel industry practice – and materials that only include some of these life cycle stages.

These partial and incomplete analyses use data that can be called 'cradle-to-gate', as they only consider the impacts from extraction and manufacturing processes – Modules A1-A3 – ignoring whole life data.

The steel sector is among those that present data for their products that consider all of BS EN 15804's life cycle stages, sometimes called 'cradle-to-cradle' to reflect the inclusion of reuse and recycling data, and increasingly referred to as Whole Life Carbon assessments.

A Life Cycle Assessment can be straightforward enough, but it is crucial that it is properly understood what the assessment should include. It comprises three steps:

1. Compiling an inventory of relevant energy and material inputs and environmental releases (outputs) associated with a defined system. Releases can be solid wastes or emissions to air or water.
2. Evaluating the potential impacts associated with these inputs and releases, e.g. the global warming impact from greenhouse gas emissions.
3. Interpreting the results to help make informed decisions.

A common failing of some studies that try to compare one construction material with another, either at structural frame or whole building level, is an inadequate appreciation of the importance of system boundaries in the analysis.

System boundaries determine which processes are included or excluded in a Life Cycle Assessment or other embodied carbon study, or an Environmental Product Declaration (EPD) which would be developed by a Life Cycle Assessment. EPDs are increasingly used by construction product manufacturers to provide environmental assessments of their products. Such analyses must be clearly defined and consistent with the system boundaries.

Different scopes and systems boundaries that can be considered, and must be clearly defined, include:

- Geographical area.
- Time horizon, i.e. when the data were collected.
- Boundaries between the specific system studied and related technical systems, for example, the production of capital goods used to manufacture a product.
- Boundaries between the technological system and nature, i.e. which life cycle stages are included within the system boundary, such as cradle-to-gate and Whole Life Carbon system boundaries.

Table 1: Life cycle stages and modules			
Construction works life cycle information			
Stage	**Module**	**Type**	**Cradle to gate with modules C1 to C4 and D**
Product	**A1**	Raw material supply	Mandatory
	A2	Transport	Mandatory
	A3	Manufacturing	Mandatory
Construction process	**A4**	Transport	
	A5	Construction / installation process	
Use	**B1**	Use	
	B2	Maintenance	
	B3	Repair	
	B4	Replacement	
	B5	Refurbishment	
	B6	Operational energy use	
	B7	Operational water use	
End of life	**C1**	Deconstruction / demolition	Mandatory
	C2	Transport	Mandatory
	C3	Waste processing	Mandatory
	C4	Disposal	Mandatory
Supplementary information beyond construction works life cycle			
Benefits and loads beyond the system boundary	**D**	Reuse, recovery, recycling potential	Mandatory

Apologists for adopting a cradle-to-gate rather than a more comprehensive Whole Life Carbon approach in LCA and carbon footprinting studies have in the past cited a lack of sufficiently robust data on what happens to materials during and after demolition. This is the Module C and D information as defined in BS EN 15804.

This issue was addressed for steel by PE International, now called thinkstep, several years ago who examined these factors for a range of materials commonly used in building framing systems and derived Module C and D data for steel, concrete and brick/block products.

At the level of individual products it is mandatory in BS EN 15804 to report Module D information, for very good reasons. At the level of an entire building, Module D reporting is not yet mandatory in EN 15978 but this is currently under revision and the two standards are likely to be aligned.

Steel Construction Institute Associate Director Dr Michael Sansom said: "There is growing appreciation of the need to include building end of life impacts (Module C) and Module D benefits from reuse and recycling as part of a robust, Whole Life Carbon assessment. Limiting the scope to just Module A equates a 100% recycled building to one which is 100% landfilled when it is demolished.

"Landfill avoidance through downcycling construction materials is unsustainable and if we are going to deliver a truly circular, zero-carbon built environment, then we have to move up the waste management hierarchy and reuse our buildings and their constituent parts. Designing new buildings for deconstruction and reuse isn't rocket science but we need to start routinely doing this on all new projects.

"While reducing 'upfront' carbon emissions is a short-term priority, this has to be achieved in tandem with longer-term, smarter thinking that is compatible with broader sustainable development objectives.

"As a reminder, the original 1987 Brundtland definition of sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'."

EPDs

Table 2: European Average EPD					
			Modules		
Company	Product	Valid until	A1 to A3 Product stage	D Recycling potential	Whole Life Carbon
bauforumstahl	Section and plates	24/10/2023	1.130	-0.413	0.72

Designers and specifiers looking for evidence that they are making low carbon selections of products can use the appropriate steel manufacturer's Environmental Product Declaration (EPD), assuming that they know where their steel product will be sourced from.

At the design stage however this will usually not be known, so an appropriate published average value should be used. The most appropriate average value for steel on the European market is published by bauforumstahl, the independent steel promotional organisation in Germany. This is based on data collected from the biggest hot rolled steel sections and plates manufacturers in Europe and includes the most up to date embodied carbon data currently available.

Circular economy action plan

The European Union has adopted a Circular Economy Action Plan, one of the main blocks of The European Green Deal, the EU's new agenda for sustainable growth.

The Action Plan chimes with the steel sector's long-standing insistence of the importance of proper analysis of carbon impacts.

It refers to the Levels study which recommends the Whole Life Carbon approach, i.e. including Modules C and D.

The Action Plan incorporates initiatives throughout the life cycle of products, targeting their design, promoting circular economy processes and promoting sustainable consumption, with the aim of ensuring that the resources used are kept in the EU economy for as long as possible.

The Plan introduces legislative and non-legislative measures targeting areas where action at the EU level brings real added value.

Among other things the measures aim to make sustainable products the norm in the EU, focussing on the sectors that use most resources and where the potential for circularity is high, which includes construction and buildings.

Even post-Brexit, such a plan must surely be welcomed.

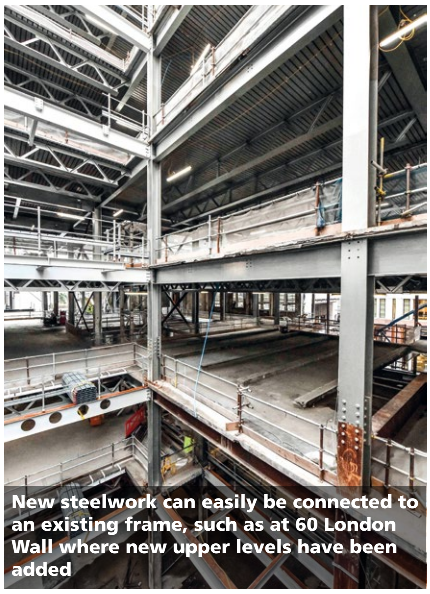
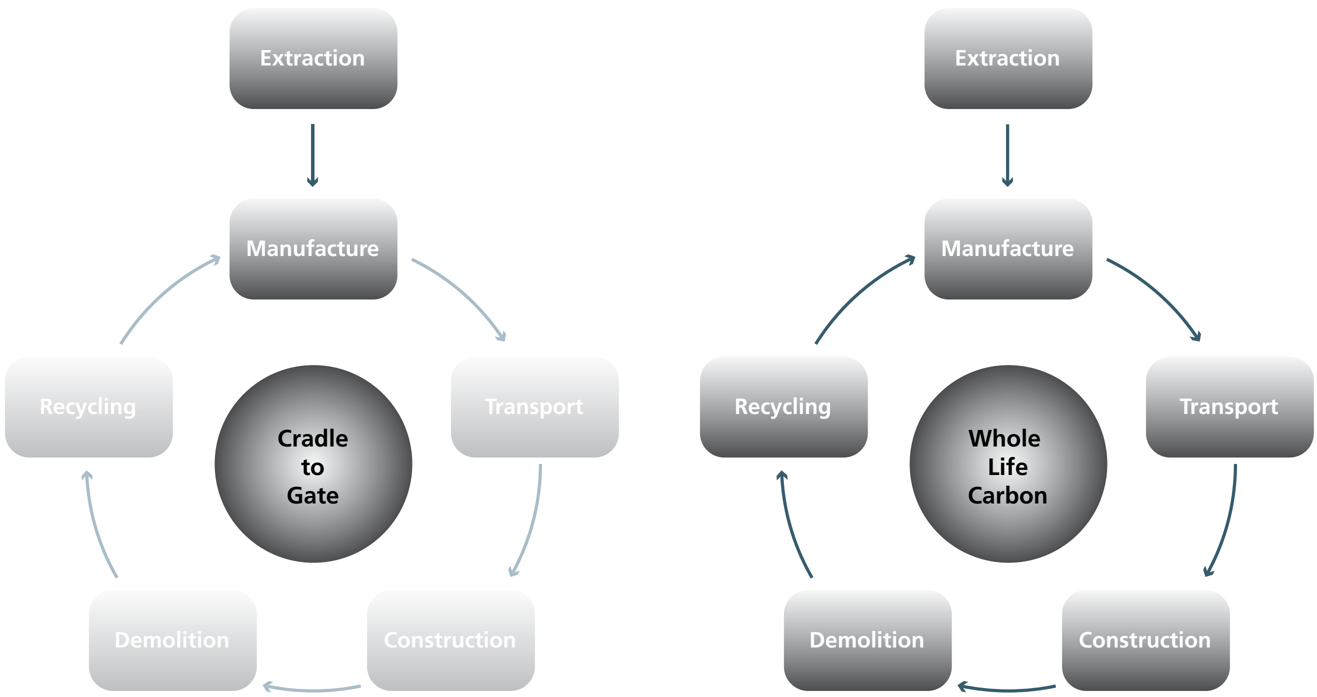

New steelwork can easily be connected to an existing frame, such as at 60 London Wall where new upper levels have been added

Figure 2: Comparison of Life Cycle Assessment scopes and system boundaries



Operational Carbon and Thermal Mass

Steel-framed buildings are capable of meeting the most stringent operational energy requirements and contribute to the drive to net zero carbon emissions.

Significant steps have been taken over recent years to reduce the carbon emissions associated with the use of buildings, driven principally by increasingly stringent requirements in Building Regulations. However, the government's declaration of a climate emergency and the resulting target for the UK to be net carbon zero by 2050 is further focussing the minds of engineers and architects.

Operational carbon is the term used to describe the emissions of greenhouse gases during the operational phase of a building.

Emissions arise from energy consuming activities including heating, cooling, ventilation and lighting of the building, so called 'regulated' emissions, and other, currently 'unregulated' emissions, including appliance use and small power plug loads such as IT.

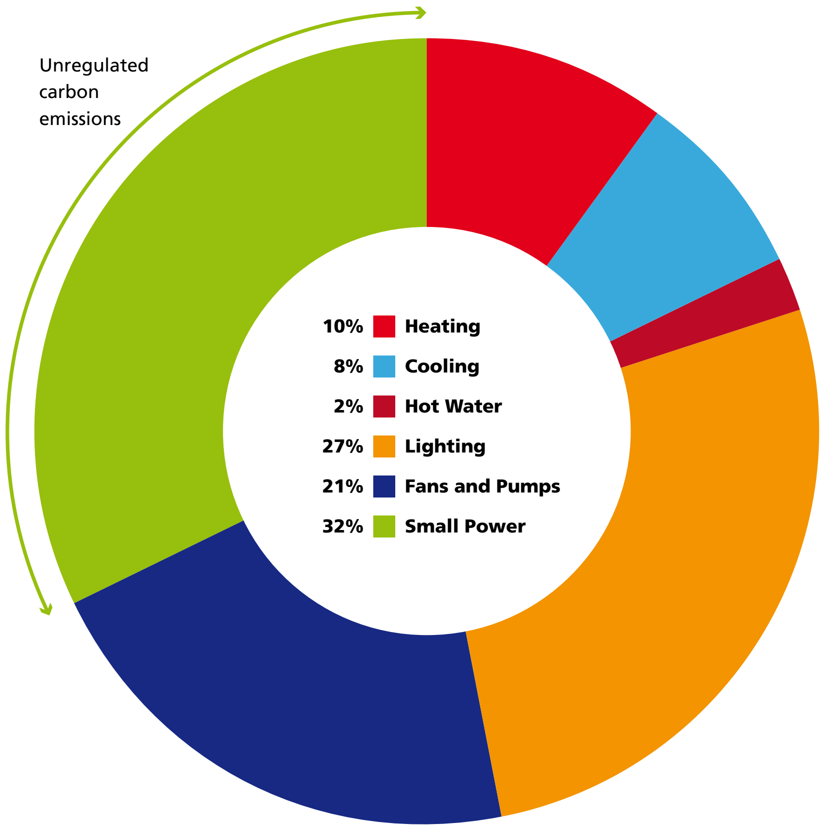
These appliances are not currently regulated because building designers generally have no control over their specification and use and they are likely to be changed every few years.

To design more energy efficient buildings, it is important to understand the breakdown of energy use in buildings.

The pie-chart (Figure 3) shows the breakdown of carbon emissions by energy demand in a typical, large city centre office building and reveals that unregulated demands including appliances, IT, etc. make the biggest contribution to the total.

Of the regulated energy demands, lighting, fans and pumps are the greatest contributors. This breakdown can help to identify where the biggest savings can be made most cost-effectively. For example, for this office building, analysis showed that the energy efficiency with the greatest predicted impact are those related to space cooling and fan and lighting efficiencies.

Figure 3: Breakdown of carbon emissions by energy demand for a typical city centre office building



Energy efficiency measures include improved thermal insulation levels and airtightness, better lighting, glazing and solar control measures as well as improved HVAC efficiencies, etc. They can often represent the most cost-effective means to reducing operational carbon emissions.

However, as operational carbon reduction targets become more onerous, the whole life cost-effectiveness of many energy efficiency measures becomes less attractive than other measures, such as low and zero carbon technologies.

Low and zero carbon (LZC) technologies are broadly defined as technologies which meet building energy demands with either no carbon emissions, or with carbon emissions significantly lower than those of conventional methods. Generic LZC technologies include wind turbines, solar (hot water and pv), ground and air source heat pumps, combined heat and power (CHP) and combined cooling, heat and power (CCHP).

Another option that can often be used to significantly reduce the operational carbon emissions of buildings is to utilise thermal mass, which is the ability of the fabric of a building to absorb excess heat. Effectively utilised, it can reduce cooling loads and, in some cases, remove the requirement to provide air conditioning entirely in some buildings.

The climate emergency has prioritised the need to construct and operate buildings in the most energy efficient way and thermal mass is being used in many buildings to contribute to such carbon reductions.

There is a common misconception that buildings must be heavyweight to achieve an optimum level of thermal mass. This myth has probably arisen because large buildings such as churches are always cool, even in the hottest summer. However, the main reasons that churches stay cool is because they have very few windows, which reduces solar gain, and have low internal heat gains.

In modern buildings, the greatest accessible mass is found in the upper floor slabs and to work efficiently, the floor soffit has to be exposed. Independent research has shown that in a UK climate, the optimum thickness of concrete floor slab for providing thermal mass is 75-100mm. This thickness of concrete floor slab is routinely available in almost all steel-framed buildings.

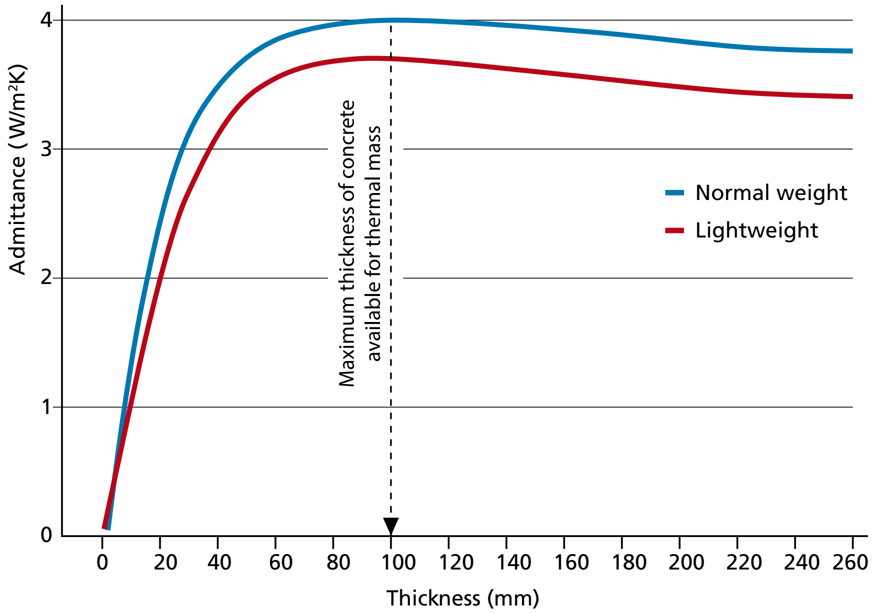
So how does thermal mass work? During the day, solar gain, electrical equipment as well as human activity generate heat, which warms the air in a building. The warmed air rises, flows across exposed surfaces and is absorbed into the fabric of the building.

At night, cool air is allowed into the building and flows across surfaces which have been used to absorb heat during the day. These surfaces are cooled and then ready to absorb heat again the following day.

Systems for mobilising thermal mass are generally described as either passive or active. All of these systems can be utilised effectively in steel-framed buildings.

Passive thermal mass systems rely on natural ventilation to disperse the heat absorbed by the upper floor slabs. As they are dependent

Figure 4: Thermal admittance against thickness for an exposed, flat concrete floor slab – 24 hour diurnal cycle



on wind direction and speed, they are only suitable for buildings with relatively simple requirements and low cooling loads (up to 30 W/m²). They are easy to operate, with low capital, maintenance and operation costs.

Natural ventilation can be achieved from one side only, by cross ventilation or by stack ventilation, generally using atria. The control of the ventilation is fundamental to the optimum operation of passive thermal mass systems.

In active thermal mass systems, the heat exchange with the structure is enhanced by mechanical ventilation, either within the core of the slab or over its surface. In practice, the methods used to mobilise thermal mass in the UK are usually mixed-mode systems combining natural and mechanical ventilation, with natural ventilation being the default mode to minimise energy consumption.

When considering whether to use thermal mass, important factors to consider include:

- Location – air quality, external noise and security issues, particularly in city centres, often preclude a natural ventilation strategy.
- Occupancy – thermal mass strategies are best suited to buildings with intermittent occupancy patterns such as offices and schools, which enable night cooling to take place outside normal working hours. Buildings which are permanently occupied, such as hospitals, are less suitable.
- Building form – Natural cross-ventilation is only effective in narrow plan buildings. In deeper plan buildings atria can be used to provide natural ventilation. Ventilating highly compartmented buildings naturally is difficult and this can preclude effective thermal mass strategies in buildings such as hospitals, hotels and some schools.

Utilising thermal mass has the potential to save carbon and operational costs over the lifetime of the building. Nevertheless, as it involves exposing the upper floor soffits, there are other consequential factors that should be considered early in the design process. These include:

- The quality of the soffit finish.
- The routing, co-ordination and integration of services.
- The acoustic properties of the occupied space – to avoid reverberation and echo, sound-absorbing baffles suspended from the slab may be required.

The use of steel composite construction naturally provides a quality soffit finish at no extra cost, and the use of cellular steel beams readily facilitates the integration of services.

Recycle and reuse

There are considerable savings to be made from recycling steel as landfill is no longer considered to be an option for construction products and materials

Steel has a unique characteristic as it can be reused and recycled repeatedly without losing its qualities as a building material.

Steel is 100% recyclable, and unlike other construction products it can recycled and reused repeatedly.

Steel is routinely recovered for recycling, and a highly-sophisticated industry has developed to take advantage of this. In construction, the current recovery rates from demolition sites in the UK are 99% for structural steelwork and 96% for all steel construction products.

These impressive figures far exceed those for any other construction material, as most other demolition products are downcycled into products of a lower quality or function, rather than being truly recycled.

Why is it important to recycle? The short answer is that we live and work in a resource-constrained world and consequently the cost of new materials and components used to construct buildings is rising. Crucially, recycling materials saves on generating further carbon emissions which makes a significant contribution to help governments achieve carbon reduction targets.

The traditional end-of-life scenario for buildings was demolition and landfill, which is no longer acceptable; although steel has always been recovered as it retains a value.

There are considerable carbon savings in recycling steel, compared to producing new material from iron ore, and it makes economic as well as environmental sense to recycle and make use of the material that is already in use.

All steel used in today's construction projects has some recycled content. Steel's attributes in terms of recycling and reuse make a significant contribution to the circular economy (see page 16).

As well as recycling, there is a growing trend towards the reuse of structural steelwork, as again, there are significant carbon savings to be made if a new project simply uses steel sections obtained from an older demounted or disassembled structure.

For example, reusing a steel beam in its existing form is better than re-melting it and rolling a new steel beam, as the energy used to re-melt the beam is saved.

Reuse offers even greater environmental advantage than recycling as there are minimal environmental impacts associated with reprocessing.

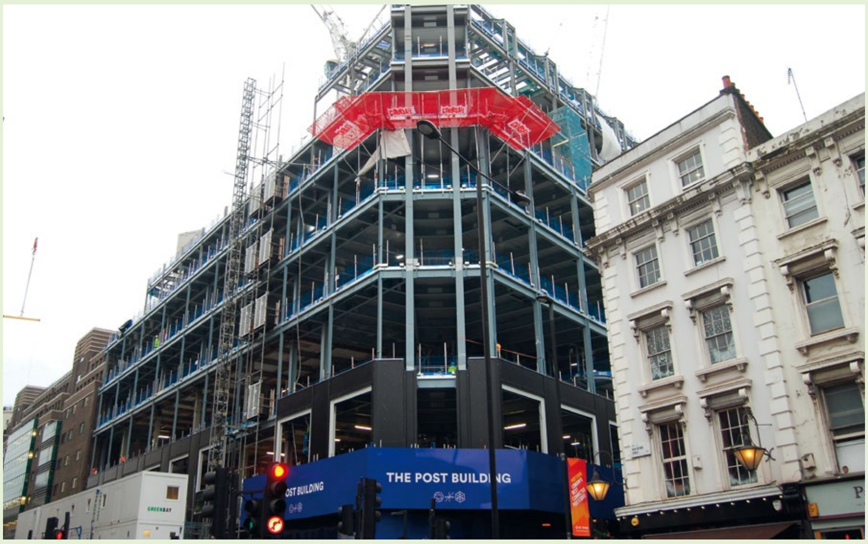
As with recycling, some construction products and systems are more amenable to reuse than others and therefore designers should be encouraged to think about not only how their buildings can be easily and effectively constructed, but also how they can be efficiently deconstructed. This is a new discipline for most designers.

According to the Steel Construction Institute's Protocol for reusing structural steel, the case for reusing steel is strong and reclaimed and refabricated sections can be CE Marked (or UK equivalent) in accordance with BS EN 1090-1.

Structural steel sections are robust and dimensionally stable elements that are generally bolted together to form structural assemblies, which are inherently demountable. As such, they are seen as an obvious candidate for reclamation and reuse.

Steel Construction Institute Associate Director Dr Michael Sansom said: "The average price differential between new and scrap sections is £313 per tonne, representing the potential saving through reuse of structural steel today. While there are additional cost elements through reuse, including deconstruction and testing, it

Reuse is in the frame



Juanan Barros Moreno – Shutterstock

The redevelopment of the former Royal Mail sorting office on London's Oxford Street made use of significant elements of its existing frame, highlighting the fact that the reuse of steel can produce highly-desirable modern spaces.

A horseshoe-shaped zone in the middle of the site containing ground, first and second floor levels was left in place. These floors were originally used for mail sorting duties, while the building's upper four floors, now demolished, accommodated administrative offices and a plant level.

"It was all about gaining planning permission and getting the most efficient use of the existing structure," explains Laing O'Rourke Project Manager Andrew Veness.

"The retained element had high floor-to-ceiling heights and so we were able to insert three mezzanines and consequently add more office space."

Keeping some of the original steel frame also fitted into the overall design aesthetic, which revolved around the new building having exposed steel beams and columns, creating a modern 'white collar factory' office building.

Meanwhile, the original column grid pattern of 12m × 20m was designed to suit post office vehicle movements, and a series of deep transfer beams supported these spans.

These were redundant in the new build and so they were slimmed down from 1.8m-deep to 500mm-deep members. This involved a large amount of site modifications to the existing plate girders, with a large team of welders on-site.

Steelwork contractor BHC, also erected an entirely new steel frame around the retained portion, completing the lower three floors and filling up the entire site's footprint to produce an eight-storey scheme, The Post Building.

is clear that economic savings are achievable in addition to the environmental benefits."

Steel buildings and steel construction products are highly and intrinsically demountable, which aids their reuse. This potential is also illustrated by the large number of temporary works systems that use standardised steel components, such as scaffolding, formwork and sheet piles.

Provided that attention is paid to eventual deconstruction at the design stage, there is no technical reason why nearly all of the steel building stock should not be regarded as a vast 'warehouse of parts' for future use in new applications.

Steel can be reused at both the product and the building level. Already some industries, such as the agricultural sector, commonly reuse steel structures and cladding components.

Many steel construction products and components are highly re-usable including piles, structural members and light gauge items like purlins and rails.

The reuse process is straightforward. For example, deconstructed sections are inspected to verify their dimensional properties, then tested to confirm their strength properties. The sections are then blast cleaned to remove any coatings. They are then refabricated and primed to the requirements of the new project.

There is significant scope for increasing reuse of steel construction products and work is underway within the sector to promote and facilitate this. The proportion of recovered products that are reused will increase as design for deconstruction becomes better understood, and a stronger market for reusable steel construction products is stimulated.

The ability of the steel construction sector to facilitate these advantageous processes has been enhanced by the standardisation of components and connections.

At the building systems level, modular construction offers the greatest opportunities for reuse. Modules or pods can be deconstructed from the building and refurbished and reused on the same or an alternative building.

Designers of steel structures can maximise the potential for the reuse of their project's steelwork by taking certain steps. These include the use of bolted connections in preference to welded joints, as they allow the structure to be dismantled during deconstruction.

Other suggestions include making sure steelwork, where feasible, is free from coatings or coverings that will prevent visual assessment of its condition. Fixings to structural steel elements that require welding, drilling holes, or fixing with nails should be minimised in preference to clamped fittings.

"Looking to the future, capturing and securely storing BIM models of new steel frames is a low-cost solution to facilitate future deconstruction and reuse. By storing the relevant material and section properties today, reclaimed steelwork can be safely and efficiently reused in the future and the need for and cost of testing is eliminated," sums up Dr Sansom.

The ultimate sustainable material

Client demand as well as legislation are key drivers of the increasing focus on the circular economy, an approach to sustainability that aims to design out waste and pollution, maximising the service life of products and materials and avoiding sending materials to landfill once their first-life is over.

An end to the 'take-make-dispose' attitudes that have been at least partly culpable in creating the climate emergency crisis is in sight, and governments, consumers and the corporate world seem agreed that a more circular built environment is a vital part of the way forward to tackling the world's carbon-created problems.

An ideal construction material under circular economy principles would, among other things, be capable of 100% recyclability; if it actually would be recycled because there was an inherent financial incentive for doing so, then so much the better. It would also have an extended life due to being capable of reuse without further energy consuming processing.

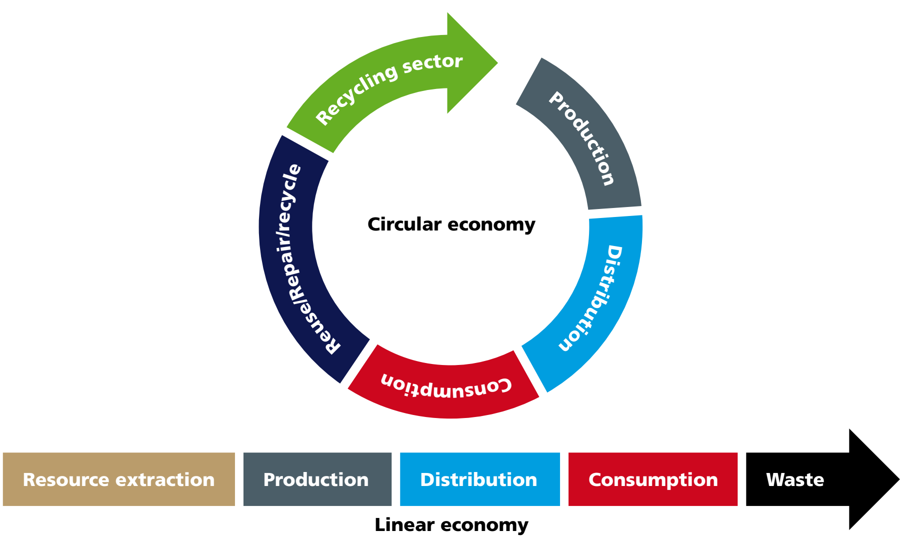
Constructional steelwork meets these ideal construction material requirements better than any alternative material. Steel, once manufactured, can be seen as a store of value that will never be fully consumed.

Steel always has a value to society whether it is performing its original purpose in a school or hospital or vital transport link, or is being disassembled to be put to a new use, or is being fully recycled without any degradation of the material's quality to be used again, perhaps by a future generation.

Some 75% of all the steel products ever made are still in use today, according to World Steel Association figures, and the evidence for that is all around us: it is a large part of the world's industrial archeological and building heritage.

Properly designed and, where appropriate, properly protected steel structures provide long-term durability. Buildings like the National Liberal Club in London (1887) and structures like the Forth Rail Bridge (1890) demonstrate the longevity of steel buildings and structures.

Figure 5: Comparison of Circular and linear economies



Supply chain sustainability

Steel's circular economy advantages mean the material fully supports the worldwide drive to lower carbon emissions to tackle the climate emergency. If the old linear economy is to be replaced by something better and more sustainable steel will play a crucial role.

The circular economy will be one in which resources including construction materials are used long enough to ensure the maximum societal value is gained from them. At the end of the useful service life of a building or other structure, products and materials used in the original construction, and those added to accommodate changing uses, will be recovered and regenerated by being recycled and/or reused.

There is an important distinction to be drawn between recycling and reusing. When a material is recycled it is converted into new materials and products, usually requiring the use of energy to fuel the related industrial processes. Reusing materials and products on the other hand means applying a used resource in its original form, perhaps with minor modifications. Both have circular economy benefits that steel automatically delivers.

Another distinction to be understood is that there are different types of recycling that deliver different circular economy benefits. With true, or closed-loop, recycling, products are recycled into new products with exactly the same material properties.

An example would be re-processing steel through a steelworks, which could be called

100 Liverpool Street

An example of the circular economy credentials of steel construction is the 100 Liverpool Street project in the City of London. This recently completed job has linked together two existing buildings, added a curving façade and revamped the public realm.

All of the substructure was retained as well as approximately 50% of the original steel frames that extend up to eight-storeys high. New steelwork was erected to knit the structures together, replace the demolished areas and add four new floors to the top, creating a new 12-storey landmark building.

Sustainability was at the core of this design, as only steel construction would have allowed the project to reuse the foundations, and then strengthen retained steelwork to allow them to support new lightweight steel floors thus extending the life of the existing buildings.

upcycling. On the other hand, downcycling describes the process of converting materials into materials of lesser quality and reduced functionality. Examples of downcyling in construction include crushing concrete to produce aggregates for fill and chipping timber to produce chipboard. Steel is too valuable to be subjected to downcycling, and is almost always recycled or reused.

How steel benefits the circular economy

As well as its excellent circular economy credentials, steel is valued as a strong, durable, versatile material that provides structural framing systems that are lightweight, flexible, and adaptable as well as reusable.

Its high strength-to-weight ratio means other sustainability benefits can be created, such as lighter and smaller foundations. Steel's combination of strength, recyclability, availability, versatility and affordability makes it unique.

Maintaining products at their highest utility and value for as long as possible is a key component of the circular economy as the longer a product lasts the less raw materials will need to be sourced and processed and less waste generated.

Steel-framed buildings are among the most adaptable and flexible assets a business can invest in. The steel frame itself can be easily adapted, with parts added or taken away, and its light weight means that extra floors can often be added without overloading existing foundations, as frequently seen in inner city projects. This can add many years to the useful life of a building.

Steel structures are commonly used to renovate buildings, for example behind retained façades. This allows the historic value, character and resources of the façade to be retained, and the building structure can be reconfigured to create open, flexible internal spaces that meet modern client requirements and maximises net lettable floor area.

The easy adaptability of existing steel-framed buildings will come into its own if office and other premises layouts have to accommodate new measures like social distancing.

Reuse and remanufacture

Reusing simple, low-rise structures such as portal frames is relatively common, particularly in the agricultural sector. Larger, whole building reuse is less common but there are examples where this has worked well.

One example is the International Aviation Academy, Norwich, where an historic steel-framed hangar has been refurbished into a new academy specialising in education and skills in aviation.

Reuse of components, i.e. beams or columns, is still relatively rare but this is changing. The widespread use of Building Information Modelling (BIM) technologies overcomes some of the barriers to the reuse of materials by providing certainty about material properties, traceability and provenance, and perhaps even eliminating the need for testing in the future.

The ability to reuse building components is largely dependent on how buildings were originally constructed. Designers routinely consider the constructability of buildings, but historically, little thought was given to their deconstruction and how elements and components could be reclaimed and reused.

This is all changing thanks to the circular economy focus on Whole Life Carbon, supported by new approaches involving technology such as BIM.

New legislation, technical developments and different business models are required to realise all the benefits that the circular economy philosophy promises, but the steel sector is already working in partnership with its supply chain to deliver the essential benefits.

World's most sustainable office

Structural steelwork has helped to create a sustainable landmark in the confines of the City of London.

In 2017, the steel-framed Bloomberg headquarters in the City of London set a world record BREEAM sustainability rating for an office building at design stage.

Bloomberg's new European headquarters achieved an 'Outstanding' rating against the BREEAM sustainability assessment method, with a 98.5% score. This was, and still is the highest design-stage score ever achieved by any major office development.

Michael R. Bloomberg, Founder of Bloomberg L.P. said at the time: "We believe that environmentally-friendly practices are as good for business as they are for the planet. From day one, we set out to push the boundaries of sustainable office design - and to create a place that excites and inspires our employees. The two missions went hand-in-hand, and I hope we've set a new standard for what an office environment can be."

Compared to a typical office building, the new Bloomberg building's environmental strategies deliver a 73% saving in water consumption and a 35% saving in energy consumption.

Norman Foster, Founder and Executive Chairman of architect Foster + Partners, said: "In some of our first discussions on the project, Mike Bloomberg and I arrived at a 'meeting of minds' on how the design of the new Bloomberg headquarters should incorporate the highest standards of sustainability. The project evolved from thereon into a building that is one of the most sustainable in the world."

Further accolades were received by the building, as during 2018, the Bloomberg headquarters was a Structural Steel Design Award (SSDA) winner and the year's RIBA Stirling Prize winner, which is given to the best new UK building.

Working on behalf of the main contractor Sir Robert McAlpine, William Hare fabricated, supplied and erected the structural steelwork for the project.

The design of the headquarters was dictated by the surrounding roads and consists of two adjacent 10-storey buildings (north and south) with a pedestrian thoroughfare cutting diagonally between the structures.

Structural steelwork was considered to be the best framing solution for the sustainability-driven design because of its speed of construction and its ability to form the required column-free spaces.

The steel frame's stability-giving cores are all located along the project's perimeter in order increase uninterrupted floor space.

One of the steelwork highlights of the scheme is the fact that the building's structural grid is interrupted in a number of locations with transfer structures to create unique spaces. The most significant of these occurs above level eight in the south building, and involves a storey deep truss within the level nine plant floor, spanning up to 26m between columns.

This allows the suspension of level eight and the removal of four main internal columns to create a two-storey high communal space with spectacular views of St Paul's Cathedral.

Meanwhile, the north building has a feature ramp, which provides access between floors from level two to level eight. The steel ramp structure is 1.5m-wide and spans 30m between floors, measured along its centreline.

The elliptical oculus within the floorplates through which the ramp passes also rotates 120 degrees at each floor level following the route of the ramp.

BREEAM for sustainability

Developed by the Building Research Establishment (BRE), BREEAM is said to be the world's leading environmental rating and sustainability assessment tool for buildings, master planning and infrastructure. A BREEAM assessment focuses on sustainable value and efficiency throughout a number of life cycle stages, including new construction, refurbishment and in-use.

BREEAM was created as a cost-effective means of recognising the value of sustainable development. It helps investors, developers, design and construction teams and occupiers to use resources more efficiently. There may be additional capital cost to building to the enhanced standards of BREEAM, but this cost needs to be seen in the context of the overall life cycle value that sustainable development delivers for a multitude of stakeholders.

Most types of buildings can be assessed such as commercial offices; industrial buildings; retail and hospitality establishments; schools, colleges and halls of residence; healthcare facilities, hospitals and care homes, as well as domestic and non-domestic refurbishments.

Building projects are assessed by registered assessors and reviewed by a third party (BRE Global) before being awarded a certificate. Since 2008 it has been compulsory to undertake a 'Post Construction Review' to confirm that the 'as built' information correlates with the design information.

The following four-pages feature four steel-framed projects that have been rated as either 'Outstanding' or 'Excellent', the two highest BREEAM ratings.

BBC hub spurs capital regeneration

Rated as BREEAM 'Outstanding', the steel-framed BBC Wales building in Cardiff is an important element in the regeneration of the city centre.

Designed by Foster + Partners, the five-storey building is home to some 1,200 BBC staff. It has been designed to be open and welcoming, visitors enter via a full-height atrium with views up to the working spaces above, as well as into a café facing the square.

The design is also said to establish a sense of openness and transparency between different departments to create new opportunities for collaboration and interaction.

Project teams worked with predominantly local suppliers and materials, which helped the project achieve a BREEAM 'Outstanding' rating.

Also, aiding this BREEAM 'Outstanding' rating were strategies such as locally-sourced and recycled materials and an efficient envelope. It was estimated that approximately 95% of all waste generated by the fit-out exercise was recycled.

Mechanical systems have been carefully integrated to create a highly flexible interior, which can anticipate and respond to changing technologies.

This was achieved by using cellular beams, up to 18m in length, which accommodate building services within their depth. The beams also create the desired long span column-free spaces, which give the project maximum flexibility.

The heart of the headquarters is a 4,000m² 'hub', which extends across three linked levels and incorporates studios, offices and production facilities.

The scheme also includes a sheltered garden on the roof of the hub, which is connected to a restaurant and provides a unique venue for filming, as well as a valuable social amenity for staff.

Structural steelwork played an important role in the scheme. Working on behalf of main contractor ISG, Severfield fabricated, supplied and erected more than 2,000t of steelwork for the project.

The majority of the project's steelwork has been left exposed within the completed building and consequently aesthetically-pleasing circular hollow section (CHS) columns were predominantly used.

Meanwhile, visible connection details were designed to be as attractive as possible, with many beams tapering to provide a very slim connection.

According to Arup Director Ben Tricklebank, the exposed steelwork allows the building to achieve its maximum internal height, while also creating the desired open spaces that can be flooded with natural daylight, which cuts down on electricity usage.

As well as its architectural qualities, steel was also chosen for its speed of construction, which is an important consideration when working in a city centre. Steel was fabricated offsite and brought to site in erectable loads, which minimised truck movements to and from site as well as limiting any disruption to the surrounding streets.

Gerard Evenden, Head of Studio, Foster + Partners said: "Working on this project was a truly collaborative effort. The design of the building is inspired by its unique location and the institutional heritage of the BBC, to create a distinctive icon that the people of Cardiff can be proud of.

"A progressive, state-of-the-art workplace for the BBC, it also forms the central focus for the regeneration of this urban quarter."

© AKT II

Outstanding campus addition

An exposed steel frame embellishes the London School of Economics' tallest and most sustainable building to date.

Situated in the heart of the London School of Economics (LSE) estate the steel-framed 13-storey Centre Building has been described as a bold and beautiful structure, the highest on the campus, and offering spectacular views across the capital's skyline.

Part of a much-larger campus-wide redevelopment programme, the Centre Building offers an internal floor area of 15,507m², while a modern and stylish environment has been created by leaving much of the building's steel frame exposed.

Tracy Meller, Partner and architect, Rogers Stirk Harbour + Partners, says: "The Centre Building project presented us with a unique opportunity to work with the LSE to design a building which really reflects the values of the school, creating innovative and inspirational spaces for students and staff in which to learn, socialise, study and collaborate.

"Embracing sustainable design principles from the offset the BREEAM 'Outstanding' building provides good daylighting and natural ventilation to over 70% of the accommodation, creating workspaces which enhance the wellbeing of its occupants. In addition, it reduces embodied carbon by 30%, harvests rainwater and utilises a biomass boiler and PVs as part of its renewable energy strategy."

Max Fordham were appointed by the LSE as the project's Sustainability Consultant and BREEAM Assessor to help deliver a project that reflected its ethos.

The company says by working with LSE, it developed a set of tailored environmental performance standards that built upon the lessons of BREEAM, explored sustainable development elements not captured by BREEAM, and pushed the design team to deliver an exemplar sustainable building fit-for-purpose.

This included a greater focus on reducing embodied carbon and on material specification – which included the choice of structural steelwork – while procurement was reviewed throughout design and construction to achieve a significant reduction over standard specifications.

Overall, the building consists of two conjoined steel-framed parts; the 13-storey Tower Block and the six-storey Houghton Block. At either end of the blocks, that sit side-by-side for just under half of their lengths, exposed SHS bracings bookend the project and form another highly visible exposed steelwork element.

This exo-skeleton bracing, which sits approximately 300mm outside of the building envelope, is not just an aesthetic element, as it is also a structural requirement, sharing the stability with two concrete cores.

Explaining the structural design, AKT II Director Ricardo Baptista says: "The frame solution is a hybrid steel and concrete solution, with precast concrete hollowcore planks supported on the bottom flange of bespoke steel beams, which are contained within the plank's depth.

This system ensures a greater degree of flexibility by providing clear soffits throughout, as well as thermal mass that contributes to the building's ambitious environmental strategy, whilst producing an economy of intumescent coating. These qualities, combined with the inherent material and waste efficiencies of steel's offsite manufacturing, contributed to the building's BREEAM 'Outstanding' rating."

Working on behalf of main contractor Mace, Billington Structures fabricated, supplied and erected 1,100t of steel for the project.

© Joas Souza

Salford has excellent towers

A twin office block development in Salford has achieved a BREEAM 'Excellent' rating for both of its structures.

Known as 100 and 101 Embankment, the twin office blocks in the Greengate neighbourhood are situated at the point where the two cities of Salford and Manchester meet, opposite Manchester Cathedral.

The nine-storey 100 Embankment is the second and final phase of the scheme and it offers 15,400m² of Grade A office space, together with a two-tier roof terrace, which is available for occupiers to use at their leisure or book for events.

Both of the towers are steel-framed structures and working on behalf of BAM Construction, Elland Steel Structures (ESS) fabricated, supplied and erected 1,800t of steelwork to complete 100 Embankment.

ESS previously erected another 2,700t of steel to complete the earlier 101 Embankment and the podium on which both buildings sit.

Explaining the choice of steel and how it helped the project achieve its 'Excellent' rating, Ramboll Senior Structural Engineer Allan Wilson says: "Using a fully steel superstructure minimised the overall weight of the superstructure, which minimised the size of foundations.

"In addition, the use of long-spanning steel composite beams was selected to maximise open spans and allow maximum flexibility of the office floorplates."

Such flexible office floorplates allow multiple users to reconfigure the space over the building's lifespan, maximising its usefulness. An added benefit is that steel concrete composite floor slabs on shallow metal decking have an A+ rating in the BRE Green Guide.

The project's podium was formed around the retained façade of the former Exchange railway station which had occupied the site, before it closed down in 1969.

A steel frame infills the façade, with the exception of the rounded corners, creating 442 car park spaces within a three-storey structure.

The roof of the car park or podium deck initially presented the design team with the project's biggest challenge. Both of the office buildings have a similar design that includes main columns set at 7.5m centres, which does not match the car park grid below.

The client's requirement to maximise the number of car parking spaces did not permit either of the building cores to continue down through the podium structure. Therefore, steel-framed braced cores sat on transfer structures positioned at podium deck level were adopted to minimise the loads.

Encompassing an area around each of the building's cores, which equates to approximately one third of their footprints, the two transfer slabs have employed an innovative design, with a 1,500mm thick RC slab built off a 130mm thick composite slab acting as permanent formwork.

The remainder of the podium slab is 170mm thick. In order to resolve complex punching shear issues, 914UB cruciform sections were cast within the depth of the transfer slabs.

Commenting on the completion of 100 Embankment and the achievement of building the second BREEAM 'Excellent' structure on the plot, Ian Fleming, Regional Director at BAM Construction, added: "We combined our well-known collaborative working approach with both classical and digital construction techniques to achieve these ultra-modern offices and to overcome some considerable technical and logistical challenges."

Charter promotes sustainable procurement

Care for the environment and responsible procurement and sourcing of materials is embedded all along the steel construction supply chain, part of a wider corporate responsibility that has sustainability at its heart.

Sustainable and responsible procurement of materials is at the heart of major steel manufacturers' commitment to champion sustainable practices throughout the supply chain. In their own operations, major manufacturers like ArcelorMittal, Tata Steel and British Steel are engaged in a drive towards low and even zero carbon steelmaking.

Steelwork contractor members of BCSA also have their own strong commitments to sustainable and responsible procurement which means they demand assurances from all suppliers that they have sourced materials in line with increasingly challenging international standards, often setting new higher standards of their own.

Steel manufacturers were early leaders in the drive towards reducing carbon and other emissions, always willing to cooperate with government and other initiatives, and some of the work we are beginning to see the benefits of has been underway throughout the past two decades.

The success of these initiatives means the amount of energy used in steel manufacture has now fallen by some 61% since the 1960s, according to World Steel Association data, and further improvements are being sought from steel sector research and development investments.

All the major UK manufacturers and suppliers of structural steel have been certified under the BRE Environmental and Sustainability standard BES 6001, a responsible sourcing certification that has enjoyed wide take up across the UK construction market.

For these companies, sustainable procurement is part of a wider corporate responsibility that involves the integration of financial and strategic goals with a commitment to the health, safety and well-being of their employees and communities; a focus on improving environmental performance and providing sustainable products, and conducting all aspects of their business with honesty and integrity.

Developers and designers can be confident that steel materials supplied by BCSA's manufacturer members have been responsibly sourced, which in turn provides a clear route for them to obtain credits under the BREEAM certification schemes.

The focus of steel manufacturers is both upstream and downstream, towards both their own suppliers and their customers. Manufacturers use their influence as large customers for the components of steel production like iron ore to encourage suppliers to adopt responsible practices in their own operations.

BHC aims at 100% self-sufficiency

Lanarkshire based steelwork contractor BHC has invested heavily in reducing its own carbon consumption through numerous sustainability initiatives. In 2015 the company installed a 500kW wind turbine which produces an average of 1.2 million kWh per year, subsequently saving a total of 1,574 tonnes of CO_2 emissions since its installation.

BHC Energy and Sustainability Analyst Jessica Downey said:"BHC have additionally installed 12 biomass units, which in 2019 produced over 6.3 million kWh. The heat generated is used to heat its offices, workshop and paint facility using locally-sourced woodchips approved by the Biomass Supplier List (BSL)."

All fuel supplied under the BSL must be sourced from fully legal sources to ensure no fuel enters the supply chain which has been illegally felled. Ms Downey said: "As part of BHC's future energy needs we have also planted 80 acres of trees which will be used to supply our wood chips for the biomass plants, as well as assist in carbon sequestration and subsequently reducing our carbon footprint".

The biomass units have generated over 31 million kWh of 'Green Heat' since their installation in 2015, saving on average 1,025 tonnes of CO_2 emissions per year.

BHC's 500kW wind turbine located at their production facility in Carnwath, South Lanarkshire

BHC is approximately 89% energy self-sufficient and is in talks to implement further sustainability initiatives including an anaerobic digestion plant. "This will allow the company to become 100% self-sufficient," says Ms Downey.

Potential suppliers are screened for compliance with good practice, for example by using online supplier assessment tools. The performance of existing suppliers against good practice measures is also closely monitored.

Environmental impact monitoring by the major manufacturers does not stop at the plant gate. The properties of steel products manufactured to the high standards typical of UK steel companies as well as the technical and design back up provided through them and the British Constructional Steelwork Association and the Steel Construction Institute has a beneficial impact on the environmental performance of buildings and other structures during their working lives and beyond.

Sustainability Charter

The BCSA as long ago as 2005 became the first representative organisation in the UK to launch a Sustainability Charter, setting environmental and other sustainability targets for its members. The Charter states its aim as being: 'To develop steel as a sustainable form of construction in terms of economic viability, social progress and environmental responsibility.'

The Charter allows measurement of how BCSA members perform against a range of key criteria that must be achieved. Support is provided to help members to continuously improve their environmental performance, which is regularly audited with sanctions to be applied in the event of non-performance.

Charter Members must publish a sustainability policy, measure progress using specific management targets, be involved with their local communities on social issues, cooperate with the steel construction community, have an Environmental Management System (EMS) accredited to BS EN ISO 14001, operate a structured programme for personal training, development and communication, publish an Equal Opportunities Policy and an Ethical Trading Policy.

Also required is a Health and Safety Management System accredited to OHSAS 18001. Process improvement must be monitored using Environmental Impact Assessments.

Carbon emissions targeted

Steelwork contractor Severfield has reduced group carbon emissions associated with electricity consumption by 36% in the last year

Sustainability is one of the key elements of the business improvement programme of leading steelwork contractor Severfield, with reducing carbon emissions a priority.

A sustainability committee of directors and senior managers, most of whom sit on the plc Executive Board, this year launched the new policy, covering fair and safe ways of working, environmental protection and management, people and communities and economic delivery.

Safety, Health and Environmental (SHE) Sustainability Coordinator Sara Halliday said: "We have in fact monitored and reported our carbon performance since 2013, regularly reporting progress against five-year targets. At the end of the five-year reduction plan in 2020 the emissions reduction target was exceeded by 7%, with emissions reduced by 21.4%.

"We regularly review and report our progress against targets and publish these in our Annual Report. By using renewable electricity at our Dalton and Lostock locations, generating a portion of our electricity by solar power at our Enniskillen factory and using a biomass electricity supplier at our Sherburn location, we have reduced group carbon emissions associated with our electricity consumption by 36% in the last year."

Emissions from vehicles have been reduced by 44% over the last five years. All scope 1 and 2 emissions, as defined in the Greenhouse Gas Protocol – from the World Business Council for Sustainable Development (WBCSD) and World Resources Institute – are collected from all manufacturing facilities, offices, and a large portion of directly controlled construction sites. Scope 3 emissions have broadly been captured within this time.

New targets based on climate science have been set for the next five years, when Severfield aims to reduce Scope 1 and 2 carbon emissions by at least 25.2%.

Carbon Footprinting Tool

Since 2008 the BCSA has made available a Carbon Footprinting Tool to allow member companies to measure the carbon footprint of both their own operations and that of their products. Using the tool ensures a robust and consistent basis for measurement of carbon impacts.

The calculation of the company footprint is based on guidance issued by DEFRA and the Greenhouse Gas Protocol. Product footprint calculations are based on PAS 2050.

Steel for Life

Steel for Life is a wholly owned subsidiary of BCSA, created in 2016, with funding provided by sponsors from the whole steel supply chain. The main purpose of Steel for Life is to communicate the advantages that steel offers to the construction sector. By working together as an integrated supply chain for the delivery of steel-framed solutions, the constructional steelwork sector will continue to innovate, educate specifiers and clients on the efficient use of steel, and market the significant benefits of steel in construction.

British Constructional Steelwork Association

BCSA is the national organisation for the steel construction industry: its Member companies undertake the design, fabrication and erection of steelwork for all forms of construction in building and civil engineering. Industry Members are those principal companies involved in the direct supply to all or some Members of components, materials or products. Corporate Members are clients, professional offices, educational establishments etc which support the development of national specifications, quality, fabrication and erection techniques, overall industry efficiency and good practice.

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