1.Get informed

Addressing the biodiversity emergency: what role can structural engineers play?

Natasha Watson and Mike Sefton **introduce biodiversity concepts and explain how structural engineers can influence design and construction decisions at each stage of a project to ensure that biodiversity is protected.**

Introduction

Many practices have signed up to the Structural Engineers Declare Climate & Biodiversity Emergency initiative (www.structuralengineersdeclare.com/), but to date much of our focus has been on the climate part of this declaration. The recent launch of the United Nations Decade on Ecosystem Restoration (**Figure 1**; www.decadeonrestoration.org/), an initiative which aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean, reminds us of the need to consider the biodiversity aspect of the declaration too.

In the UK, there is existing policy and legislation with regards to nature, such as the National Planning Policy Framework[1] and the government's 25 Year Environment Plan[2]. Yet, the UN call to action follows publication of two major reports, the UN's *Making Peace with Nature*[3] and the UK Treasury's *Dasgupta Review of The Economics of Biodiversity*[4], which go outside legislation and demand a shift in our global economic systems to include natural capital in decision making. Their intention is that our economic system should give real value to the preservation and restoration of nature, not just the materials which can be extracted from it for human consumption **(Figures 2 and 3)**.

Over the last year or so, *The Structural Engineer* and the 'Climate emergency' section of the IStructE website (www.istructe.org/climate-emergency/) have provided much project-level guidance to help structural engineers respond to the climate emergency. The clarity of carbon counting has helped simplify a complex problem.

However, the biodiversity emergency and supporting nature remain more esoteric to many structural engineers. Fortunately, specialist knowledge does exist in this field which structural engineers may not be aware of. This article looks to introduce biodiversity concepts to help engineers understand the importance of engaging with ecological specialists on their projects. The advice reflects the authors' experience in UK practice, but the principles are applicable to any location.

The article is split into three sections to cover the different roles that structural engineers play in a project. The first, *Project kick-off*, looks at the start of a project, where the largest opportunities can be taken or lost. The second, *Design,* is targeted at the structural engineer's influence on design; and the last, *Construction phase impacts*, looks at ways of reducing the impact of site work on nature.

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

FIGURE 1: The UN Decade on Ecosystem Restoration aims to reverse the degradation of the natural environment

Project kick-off

This section is intended to give a general overview of how to ensure that, during the development of your project, design decisions are made to enhance and protect biodiversity, and impacts that damage biodiversity are mitigated. It is aimed at those who have an influence in the overall project brief, such as directors and project leads.

Reuse of existing buildings and previously developed areas

The UK National Planning Policy Framework[1] states that 'Planning policies and decisions should contribute to and enhance the natural and local environment by … minimising impacts on and providing net gains for biodiversity' (Section 15, cl. 170 d). This clause is not just applicable to recognisable areas of biodiversity such as ancient woodland, but also previously developed and now abandoned 'brownfield' areas.

Brownfield areas are typically a mix of bare ground, short grassland and scrub, and temporary pools with low levels of human intervention. These conditions provide opportunities for burrowing and foraging, and in the case of reptiles, sheltered warm areas and basking sites.

Brownfield sites are listed as a priority habitat on Section 41 of the Natural Environment and Rural Communities Act 2006 under the name 'Open Mosaic Habitat on Previously Developed Land' (OMHPDL). Brownfield sites along the Thames Estuary are home to around 400 nationally scarce species. However, over half of these sites important to invertebrates were lost, partially lost, or damaged between 2007 and 2013 due to development, despite their recognition as a priority habit.

The reuse of an existing building should typically be the first choice from a biodiversity standpoint, not to mention the additional benefits that can be realised in terms of embodied carbon and material reuse. However, each site is unique, and there may be cases where larger intervention could allow for biodiversity enhancement or regeneration, such as the creation of habitat corridors. The complexity and uniqueness of each site needs to be considered by an ecologist to ensure that the right decisions are made.

Biodiversity objectives and checklist

The sooner a package is discussed, and a strategy developed, the better integrated it will be into the whole project; and the same is true for biodiversity. In an ideal world, an experienced, reputable ecological resource is embodied into the project at inception.

If there is no defined biodiversity strategy on a project, a useful resource to begin the discussion is the Biodiversity checklist from the Responsible Property Management Toolkit[5] **(Figure 4)**. This has been developed by the Better Buildings Partnership (BBP), a not-for-profit collaboration of the UK's leading commercial property owners working together to improve the sustainability of existing commercial building stock, and may help promote the need for specialist ecological advice.

General concept building design

During the design of a new project, there are several key areas that can enhance surrounding flora and fauna if managed correctly **(Figure 5)**.

Top three things to do:

- Promote the creation of a Biodiversity Action Plan if one isn't in place.
- Typically promote the reuse of existing buildings on site.
- Take time to get a better understanding from the architects and relevant consultants about how the wider design of the project considers ecological improvement.

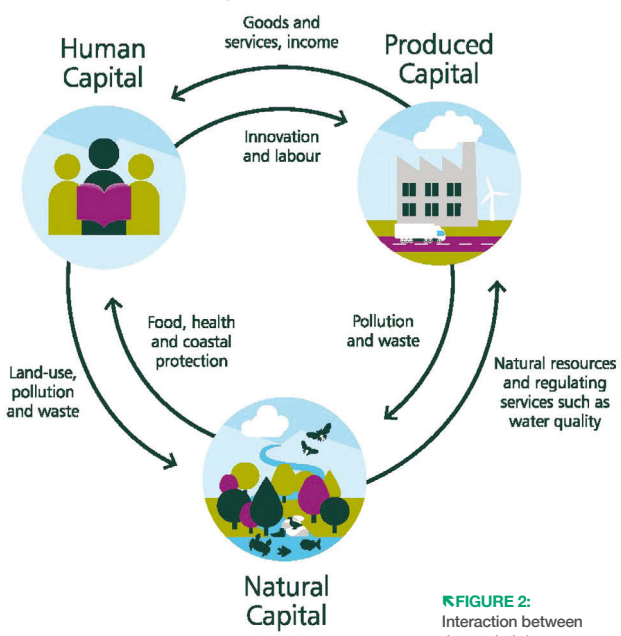


FIGURE 2: Interaction between the capitals[4]

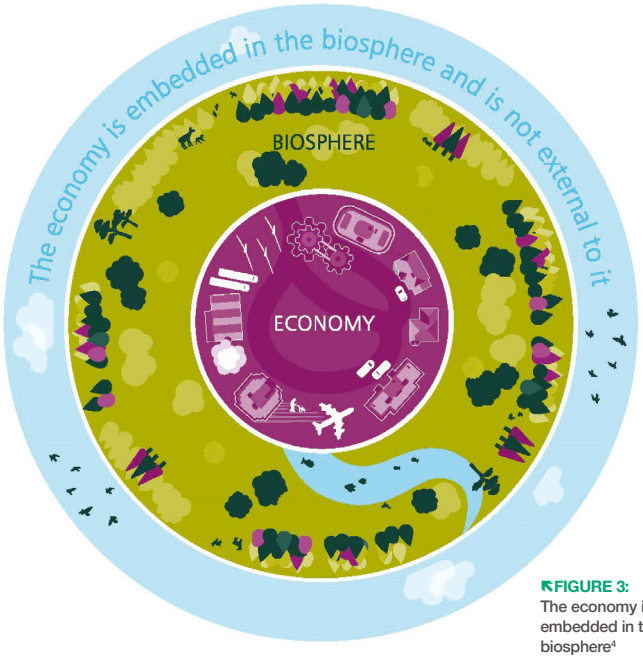


FIGURE 3: The economy is embedded in the biosphere[4]

Design

This section aims to educate structural designers in how to maintain and encourage biodiversity within areas of their control, i.e. using construction materials that have been sourced with biodiversity in mind.

The embodied carbon of the building materials we use is a priority for structural engineers. However, through lean design, the embodied carbon of different structural options can become quite similar. In these instances, structural options which minimise biodiversity loss, protect what we already have, and enhance biodiversity should be pursued.

According to the UN (2019)[6], 90% of biodiversity loss and water stress is caused by resource extraction and processing. Between 1970 and 2017, the annual global extraction of materials tripled from 27bn tonnes to 92bn tonnes. This has included a steady 2.7% annual growth in the use of metal ores since 1970, with the extraction of sands, gravels and clays increasing from 9bn tonnes to 44bn tonnes in the same period.

To mitigate resource extraction, we need to move to a circular economy model[7,8] and reuse existing material stock where we can. Where this is not possible, we need to secure virgin materials that are appropriately certified and responsibly sourced, which we can ensure though appropriate specifications.

Reuse of existing material stock

Box 1 presents a few key points and suggestions for further reading on the reuse of typical structural materials.

General responsible sourcing

The BES 6001 Framework Standard[9], developed by the Building Research Establishment (BRE), is widely accepted for assessing the responsible sourcing of building materials. BES 6001 provides an approach to the management of the environmental and socioeconomic impacts of a building product, focusing on three areas:

1) Management requirements of the organisation applying for certification, which cover elements such as legal compliance and established quality management systems.
2) Supply chain management requirements, which ensure traceability of constituent materials, ensuring the purchaser has confidence in the sourcing of the product.
3) The overarching management of sustainable development, which covers elements such as measuring, reducing and reporting of the company's water use and environmental impacts.

The following sections look in detail at specific sourcing practices for concrete, steel and timber.

Responsible sourcing of concrete

It is generally understood that UK-sourced materials have been subject to good environmental regulations. For example, trade bodies such as the Mineral Products Association (MPA) review and set continuous improvement goals for the industry. As a direct result, 93% of all UK concrete and constituent production sites operate environmental management systems (EMS) to ISO 14001.

Internationally, the Concrete Sustainability Council (CSC; www.concretesustainabilitycouncil.com/), a global group of 25 major cement producers, launched a responsible sourcing certification scheme in 2017, with v.2.1 released in January 2021. This scheme covers similar elements to BES 6001 and has four levels: Bronze, Silver, Gold and Platinum. The scheme was developed in consultation with the International Union for Conservation of Nature and the World Business Council for Sustainable Development.

Several points that could be included within your concrete specifications are suggested below:

- →| Specify the use of vegetable-based formwork release agents.
- →| Request evidence that reinforcement manufacturers use biodegradable hydraulic oils and non-chlorinated solvents where appropriate to do so or operate closed-loop cooling systems and water treatment plants. Cooling water can become contaminated with mill scale or machine oils. These precautions reduce the risk of discharging contaminated water.
- →| Request evidence that all suppliers operate an effective EMS to ISO 14001. In addition, aggregate providers should provide a community liaison plan and/or quarry restoration plan where relevant, and all suppliers, manufacturers and contractors should detail efforts to reduce water use.
- →| Allow the use of recovered water in concrete mixes, to BS EN 1008.
- →| Use 40mm max. aggregate size for unreinforced and large concrete pours. This reduces the cement and water volume required for strength and workability by up to 8%. However, it increases reinforcement cover and spacing requirements as well as the risk of segregation across pump pressure gradients.
- →| Stipulate that cement and concrete suppliers are to be members of the MPA.
- →| Specify recycled aggregates to BS EN 12620.
- →| Do not allow the use of riverbed aggregates nor the use of marine aggregates unless there is a Biodiversity Action Plan in place.
- →| There is scope to specify the use of plasticiser admixtures when water and cement content is governed by workability or durability and is higher than the minimum required for strength, and to allow the use of wash-water admixtures. However, these options require consideration on a case-by-case basis due to the composition of different admixtures.

Responsible sourcing of steel

ResponsibleSteel is a not-for-profit organisation that is the steel industry's first global multi-stakeholder

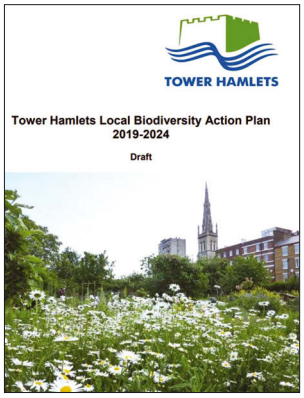
FIGURE 4: Biodiversity checklist from Responsible Property Management Toolkit[5]

BBP

CANARY WHARF BAP

Canary Wharf was one of the first developers to create a Biodiversity Action Plan (BAP) in 2004

TOWER HAMLETS LOCAL BAP



NETWORK RAIL BAP

standard and certification initiative. The Responsible Steel Standard (www.responsiblesteel.org/standard/) aims to support the responsible sourcing and production of steel, by tackling the economic, social and environmental issues associated with steel production and procurement. The process aims to align with the ISEAL – a global membership organisation for ambitious, collaborative and transparent sustainability systems – Codes of Good Practice (www.isealalliance.org).

Within the standard, Principle 11–Biodiversity states: 'ResponsibleSteel certified sites protect and conserve biodiversity' and further explains what needs to be demonstrated for different habitats within the area of influence of the site to ensure that biodiversity is being protected and conserved. A certified company is also required to create a Biodiversity Risks and Impacts Assessment as well as a Biodiversity Management Plan.

Recent guidance from the IStructE[10] suggests that the following wording is included within your specification:

A minimum of [50%] by mass of the structural steel used on the project shall be from steel products that meet one or more of the following criteria:

- *ResponsibleSteelTM Certified Steel, or steel meeting an equivalent international standard*

Responsible sourcing of timber

The Forest Stewardship Council (FSC; https://fsc.org/en) was established in 1993 to provide a worldwide certification scheme for the sustainable management of forests, and there are now over 1600 Forest Management certificates and 38 000 Chain of Custody certificates globally.

FSC-certified forests (typically referred to as Forest Management Units) need to abide by a set of 10 principles of sustainable forest management. Specifically related to biodiversity, the FSC states that they 'shall maintain, conserve and/or restore ecosystem services' (Principle 6) and 'maintain and/or enhance the high conservation value' (Principle 9) of the Forest Management Unit under their certification.

If FSC-certified timber is specified for all permanent works, temporary works and formwork timber, then it is highly likely that the above principles will be followed. If the UK *National Structural Timber Specification*[11] is being followed, FSC-certified timber can be specified under Sections 5.1.1–Procurement and 5.1.5–Certification and CE Marking.

Note that if formwork timber is being reused from a previous site, this is preferable to newly sourced FSC timber.

Top three things to do:

- Reuse existing material wherever possible.
- Ensure there are appropriate responsible-sourcing clauses within your material specification.
- Engage with contractors early to ensure responsible sourcing sits appropriately alongside other project drivers.

Construction phase impacts

Site management and the construction of a project is the responsibility of the main contractor, and as such they should be in charge of impacts that their activities have on biodiversity and habitats both on site and off site. In the UK, the Considerate Constructors Scheme (CCS; www.ccscheme.org.uk/) is a not-for-profit, independent organisation founded to raise standards in the construction industry. Contractors who are part of this scheme need to follow the Code of Considerate Practice, which states that contractors should 'protect and enhance the environment', including 'ecology, the landscape, wildlife, vegetation and water courses'.

IStructE members who regularly visit site and/or have a site engineer role can also play their part by proactively collaborating with ecologists to ensure that the main contractor is aware of and acting on the requirements of the Ecological Impact Assessment and supporting information, such as a Biodiversity Action Plan, as well as other documents such as the Design and Access Statement and Code of Construction Practice. By understanding what is required on site by these documents and other relevant information, a structural engineer can be an important part of mitigating the impact of construction activity on nature.

Top three things to do:

- Ensure that the contractor is part of the CCS.
- Ensure that the contractor is aware of the Ecological Impact Assessment, the Design and Access Statement and Code of Construction Practice.
- Collaborate with ecologists to understand the requirements of these documents and engage with the contractor and wider team where they are not being implemented.

Conclusions

The biodiversity emergency is now, but it can be difficult for a structural engineer to understand their sphere of influence. We hope that our approach within this article and the key actions in each section have demonstrated where you can make positive change throughout the project cycle and in the various roles we fulfil. We hope that this is the start of a wider conversation on the biodiversity crisis.

BOX 1. Key points for reuse of typical structural materials

TIMBER

- Visual grading surveys can often tell the grade of the timber if it is unknown. BM TRADA provides Q-Mark visual strength grading certification to the timber and construction industry.
- Reuse of timber elements from deconstructed buildings may be possible. However, it may be distorted during its life, and in the case of hardwoods such as oak, the timber will be dry and harder to work with.
- **Guidance:** Davies I. (2016) *Sustainable construction timber: Sourcing and specifying local timber*, Edinburgh: Forestry Commission

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CONCRETE

- **Concrete blocks** can be recycled if deconstructed appropriately, load tested, and cleaned of mortar and other contaminants. However, the cost uplift for labour required for cleaning and testing blocks vs. buying new blocks is difficult to justify with clients that do not have a strong incentive to do so.
- **Aggregates** typically make up 50–75% of a concrete's mix by volume, and so recycled aggregates are an impactful option to increase the reuse of concrete.
- **Guidance:** Concrete Centre (2020) *Specifying sustainable concrete: Understanding the role of constituent materials*, London: MPA The Concrete Centre

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STEEL

- Only 1% of steel structural elements are sent to scrap because of steel's intrinsic value.
- However, a majority of the steel reclaimed is recycled into new components rather than reused.
- Reclaimed steel that was subject to fatigue (e.g. bridges) or extreme loads such as fire and impact is not suitable for reuse.
- Steel elements should be tested in accordance with BS EN 1090-2 within the UK; and a buckling resistance should be verified using

$$\gamma_{M0} = 1.15\gamma_{M1}$$

- **Guidance:** Brown D.G., Pimentel R.J. and Sansom M.R. (2019) P427: *Structural steel reuse. Assessment, testing and design principles*, Ascot: Steel Construction Institute

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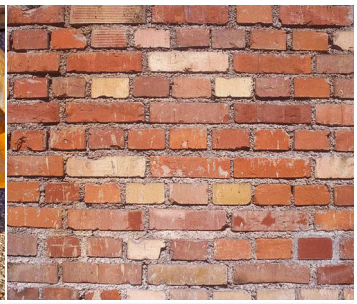

CLAY BRICKS

- Reusing bricks salvaged from cladding and/or structural walls has a financial incentive as reclaimed bricks can retain their value.
- Unfortunately, there are currently no standard guidelines nor codes of practice that give rigour to the processes required to reclaim bricks and test them, and, consequently, there is little certainty on the durability and strength of the bricks reclaimed.
- However, bricks taken from external walling can be treated as frost resistant, and load tests can be undertaken if the bricks are to be used structurally.
- **Guidance:** Brick Development Association (2014) *BDA comment on the use of Reclaimed Clay Bricks*, London: BDA

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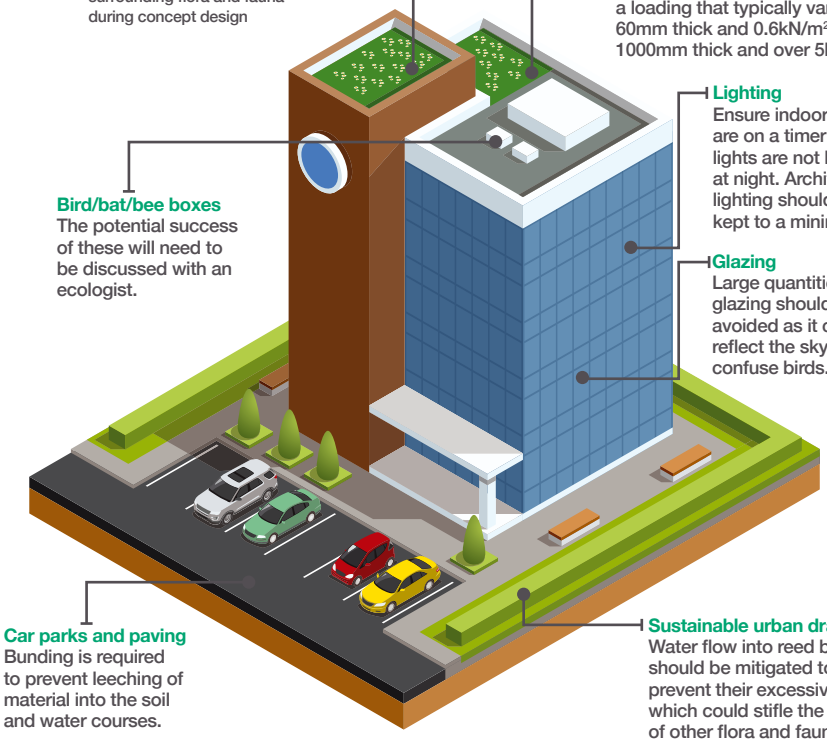
FIGURE 5: Ways to enhance surrounding flora and fauna during concept design



FURTHER READING

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10) Institution of Structural Engineers (2021) *Making your steel specification more sustainable* [Online] Available at: www.istructe.org/resources/guidance/making-your-steel-specification-more-sustainable/ (Accessed: July 2021)

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