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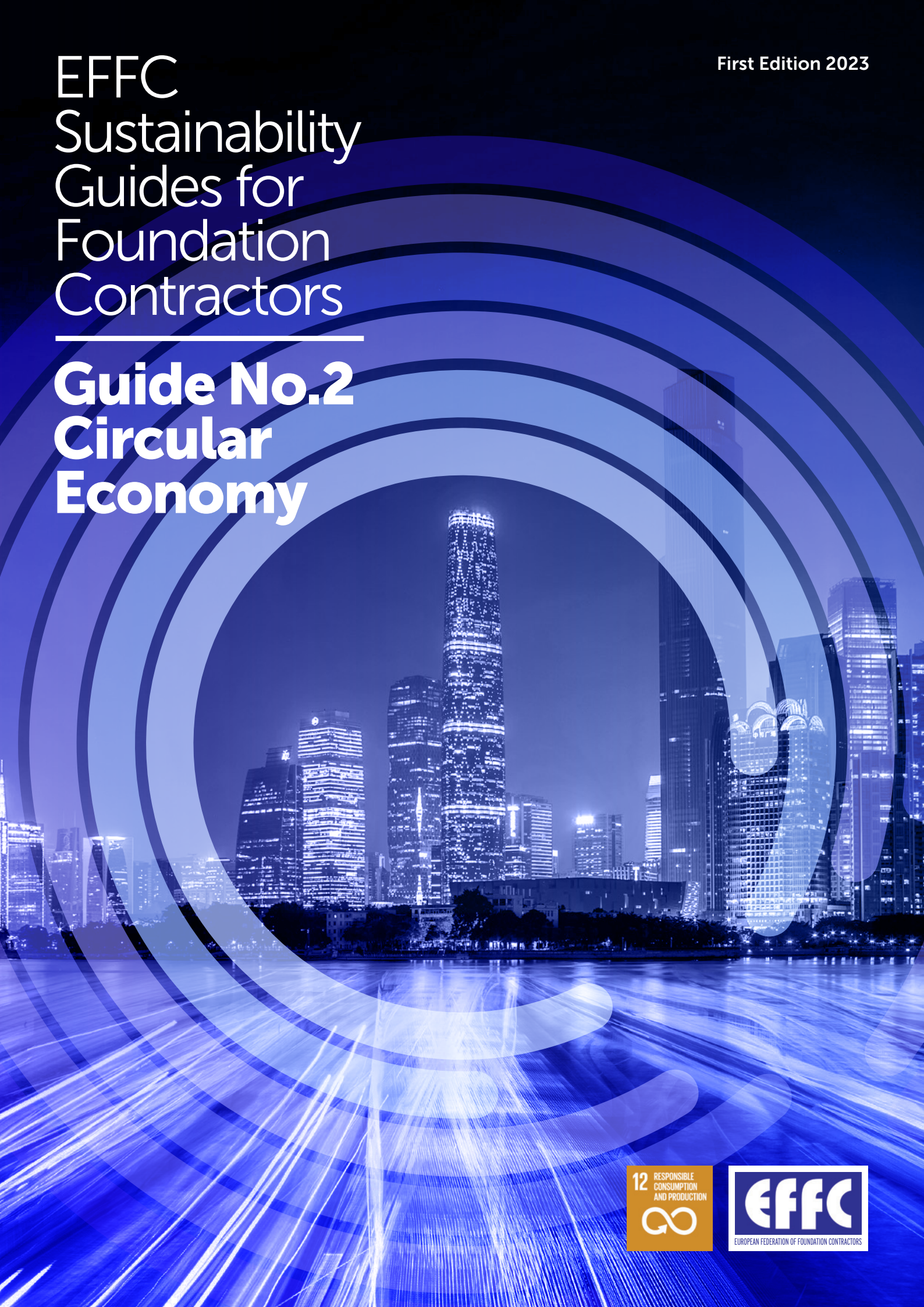
EFFC Sustainability Guides for Foundation Contractors

Guide No.2 Circular Economy



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

EFFC
EUROPEAN FEDERATION OF FOUNDATION CONTRACTORS

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EUROPEAN FEDERATION OF FOUNDATION CONTRACTORS

The European Federation of Foundation Contractors represents European geotechnical contractors across 16 countries. Our Members comprise approximately 370 companies with a combined turnover of approximately €4 billion. We collaborate to improve the standard of workmanship, technical competence, safety and innovation. We bring together experts from across Europe to produce leading guidance on critical industry topics from the safety of the machinery we use through to collaborative contracting. Our work encompasses advancing the interests of Members through engaging with the wider industry, clients and the EU. We also invite our industry partners and suppliers to participate in our activities to find common solutions to challenges for our industry.

www.effc.org.

DEEP FOUNDATIONS INSTITUTE

The Deep Foundations Institute (DFI) has joined forces with the European Federation of Foundation Contractors (EFFC) on several guidance documents such as the Guide to Tremie Concrete for Deep Foundations, the Guide to Support Fluids for Deep Foundations, and the Guide to Working Platforms.

A joint EFFC/DFI Sustainability Task Group has now been established and this Task Group will work together to develop further Sustainability Guides. This collaboration will provide perspective from other world regions.

www.dfi.org.

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1 / Introduction

Sustainability can be divided into three key pillars covering environmental, social, and economic sustainability. Within these pillars, the EFFC align sustainability initiatives with the UN Sustainable Development Goals (SDGs). There are 17 Sustainable Development Goals, which every UN country has signed up to achieving by 2030. The SDGs are global and holistic, covering all areas of sustainability. They are also used by a number of companies, including foundation contractors and other construction companies, to report on sustainability. The SDGs therefore become a common language to communicate sustainability.

A lot of work is needed to achieve these SDGs. In the foundation industry we need to adapt current standards, re-think construction projects and invest considerably in innovation if we are to meet these goals by 2030. Foundation contractors have their part to play, but they cannot do this alone. Legislators, construction clients, designers, main contractors, foundation contractors and their supply chains all must play their fair part in achieving the SDGs.

The EFFC are in the process of publishing sustainability guides for foundation contractors, for the most relevant SDGs. These guides are intended to support foundation contractors, with practical suggestions for how they can play their part in enabling the SDGs. They are not minimum requirements or sector standards, but rather practical support guides, sharing good practice.

Each guide uses a "what, why, how, measure" approach to sustainability:

- What - What is this specific Sustainable Development Goal? What impacts do foundation contractors have on this goal?
- Why - Why does this area of sustainability matter to foundation contractors? Why should they bother to improve this area of sustainability?
- How - How can foundation contractors improve their impact, and have a positive impact on this area of sustainability?
- Measure - What metrics could foundation contractors use to measure their progress and set targets in this area of sustainability?

This is the second guide in the sustainability guides series. The guide focuses on the circular economy, related to SDG 12: Responsible Consumption and Production. The first guide covers carbon reduction.

For more general advice on sustainability key terms, concepts, legislation and accreditations for foundation contractors, see the **EFFC SWG Sustainability Overview.** Updates of this guide, alongside the guides for other SDGs, can be found on the **EFFC website.**

2 / What is the circular economy?

Explained simply, the circular economy is focused on reducing raw material use, reducing waste to landfill, and extending product life. The circular economy is different to the traditional, linear economy, where primary materials are extracted from the ground, used, and then sent to landfill for disposal. Instead, the circular economy focuses on using secondary materials or components, designing for longer product lifetimes, and reducing waste at the end of a product's life *(Fig. 1)*.

Modern civilization, and improvements in living standards, can be substantially attributed to the results of engineering and construction. However, the enormous influence of the construction industry also entails a great responsibility. Whilst estimates may vary, it is unquestionable that the construction industry is responsible for much of the earth's raw material consumption as well as for much of its waste. For example, despite typically high construction waste recycling rates, construction and demolition waste accounted for approximately 25-30% of all waste generated in the European Union in 2021 (One Planet Network, 2021). The irreversible impact of extracting raw materials and dumping waste is therefore of equal importance as the energy use and societal improvements resulting from our projects.

The circular economy, and SDG 12 responsible consumption and production, are based on three principles:

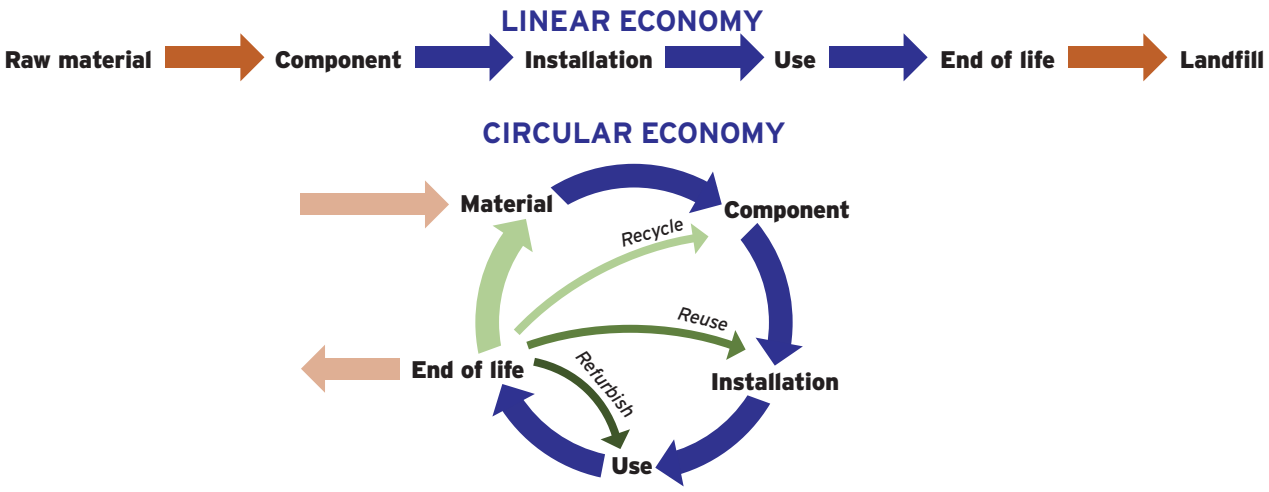
1. Eliminate waste and pollution.
2. Circulate products and materials (at their highest value)
3. Regenerate nature

All three principles are important. This guide concentrates mostly on principles 1 and 2, particularly eliminating waste, and circulating products and materials at their highest value. Remediation of contaminated land and groundwater is also an important circular economy consideration but is already covered elsewhere and so not included in this guide. Eliminating pollution and regenerating nature are intimately linked to SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land). SDG 13 is covered in **EFFC Sustainability Guide No. 1 Carbon Reduction,** whilst SDGs 14 and 15 are the intended topic of a future EFFC sustainability guide.

Important circular economy considerations, for a foundation contractor, should be reducing or even eliminating the extraction of raw materials and the landfilling of waste, in favour of the re-use of building materials. Usually, the concrete and steel that has been installed underground can hardly ever be salvaged with reasonable effort, and so circular economy considerations for deep foundations are different to, say, those for furniture or electronic goods.

The circular economy, as with all sustainable development principles, should always be considered holistically, rather than blindly optimised, potentially at the expense of other sustainability considerations. For example, clays soils can be reused as engineered fill, rather than importing virgin fill, but might require treatment with lime prior to re-use. In such a case, the carbon associated with the soil treatment should also be considered, and a holistic decision taken. Other impacts that need to be considered include energy in processing, pollution, biodiversity impact, human rights impact, water use, and adapting to local sustainability priorities.

FIGURE 1. Illustration of the difference between a traditional, linear economy, and the circular economy



3 / Why should foundation contractors contribute to the circular economy?

3.1 Overall drivers of the circular economy

There are many drivers to encourage more circular designs and operations for foundation contractors. Although there are more obvious legislative pressures, such as the EU circular economy action plan, wider drivers also help shape what companies should prioritise in terms of circularity. This is illustrated in *Figure 2*.

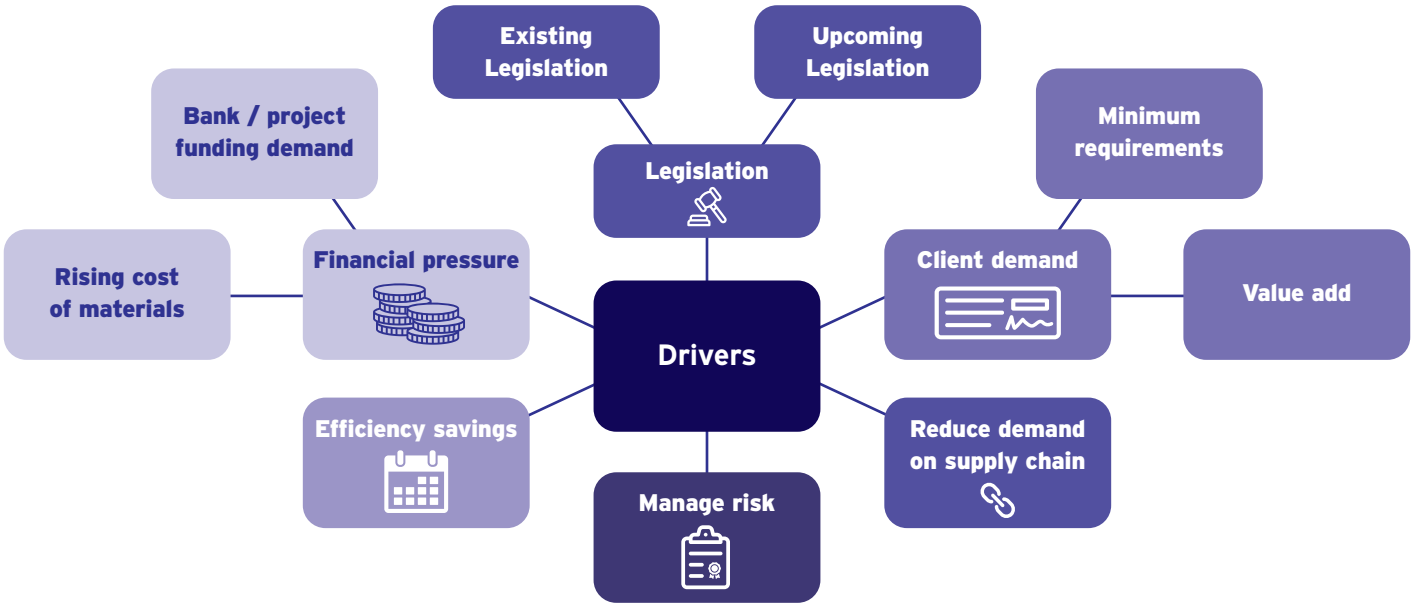
Firstly, client demand for more circular designs is growing. Foundation contractors' clients are increasingly more-sustainability conscious. Clients may set minimum requirements around waste or materials, whilst others may even factor in these principles when deciding between tenders. Some government infrastructure projects have linked bonuses to the percentage of waste that can be diverted from landfill. Covid-19 recovery funds and green funds have both been linked to circular economy principles (*see taxonomy, section 3.2*). This means that to access infrastructure and project funding, certain circular economy principles will have to be met. Likewise, as our clients require this information for access to funding and their own reporting, circular economy metrics are likely to be passed down the supply chain.

Secondly, client demand ties into the financial arguments for the circular economy. Upcoming European Union (EU) legislation, as explored in *section 3.2*, will require foundation contractors to meet circular economy standards. Foundation contractors can also expect to see more reporting requirements around material use and waste. Where these reporting requirements were once required just for large, listed companies, they are now becoming a requirement for medium-sized foundation contractors.

Thirdly, anything that can help reduce demand on raw materials or help secure secondary material supplies is useful to foundation contractors. It helps mitigate risks in our supply network, reducing demands and dependence on our supply chains and materials. Reducing material demand or securing good, local secondary materials also helps minimise the risk of hold-ups waiting for suppliers. In turn, this improves the efficiency of geotechnical projects, reducing down-time and overall time on site. Similarly, reducing construction waste reduces our disposal costs and administrative burden.

Ultimately, we live on a finite planet. With finite raw materials, we need to make better use of existing construction materials, reduce waste and extend the lifetime of our solutions. Only through this management can we ensure a sustainable future for the geotechnical sector.

FIGURE 2. Drivers of the circular economy for foundation contractors



3 / Why should foundation contractors contribute to the circular economy?

3.2. Key circular economy legislation

The circular economy is at the heart of the European Commission's Green Deal. As such, the circular economy has been introduced into a range of EU legislation. Collectively, this existing and upcoming legislation has a range of potential impacts on foundation contractors, their projects, and their supply networks. This legislation is not restricted to reporting, but could also affect the availability of recycled materials, and open up greater demand for reused foundations and ground source heat pumps.

EU Circular Economy Action Plan

Currently draft legislation, the Circular Economy Action Plan primarily focuses on:

1. The Construction Product Regulation, which includes minimum recycled content requirements for certain construction products.
2. Promoting measures to improve the durability and adaptability of built assets and developing digital logbooks for buildings.
3. Integrating life cycle assessment (calculation of the environmental impact) and carbon targets into public procurement and the EU sustainable finance framework.
4. Revising material recovery targets for construction and demolition waste.
5. Promoting initiatives to improve soil sealing, rehabilitate abandoned or contaminated brownfield sites and increase the use of excavated soils.

For more on how this plan may affect foundation contractors, see here: FIEC-CEAP-Response

EU renovation wave

The EU renovation wave focuses on improving energy efficiency and functionality in existing public and private buildings. For foundation contractors, this requires certification that foundations are suitable for re-use. The renovation wave also focuses on renewable energy sources, opening up the opportunity for ground source heat pumps. These provide opportunities for foundation contractors if they can prove their circular economy credentials to clients.

EU taxonomy directive

The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. It has been tied to Covid-19 recovery funds and may control access to sustainable finance and investment in the future. To obtain this funding / investment, companies need to prove they have a positive impact on at least one of the following six environmental objectives and do no significant harm on the others:

- Climate change mitigation (carbon reduction)
- Climate change adaptation
- Use and protection of water and marine resources
- Transitioning to a circular economy
- Pollution prevention and control
- Protection and restoration of biodiversity and ecosystems

These circular economy requirements apply to civil engineering, buildings, restoration & remediation, sewerage, and waste management.

The Platform on Sustainable Finance uses four high-level categories to define substantial contributions to the circular economy:

1. Circular design & production: design and produce products and materials with the aim of retaining long-term value and reducing waste; promoting dematerialisation by making products redundant or replacing them with a radically different product / service.
2. Circular use: life extension and optimised use of products and assets during the use phase, with the aim of retaining resource value and reducing waste to help improve usage and supporting service.
3. Circular value recovery: capture value from products and materials in the after-use phase.
4. Circular support: develop enabling digital tools and applications, education and awareness-raising programmes, and advisory services to support circular economy strategies and business models.

3 / Why should foundation contractors contribute to the circular economy?

Corporate Sustainability Reporting Directive (CSRD)

The EU CSRD is due to be introduced in 2023-2024. It extends sustainability reporting to all enterprises satisfying at least two of the following three criteria:

1. >€20+ million balance sheet
2. >€40 million net sales revenue
3. 250+ employees

The circular economy will be a mandatory reporting requirement in the CSRD proposals. The reporting requirements, being set out by the European Financial Reporting Advisory Group (EFRAG), will cover circular economy metrics, as well as risks and opportunities to the business posed by changes in material supply and waste disposal. CSRD is also expected to ask for a governance disclosure to highlight roles and responsibilities for sustainability in the company.

Waste legislation

Each country has their own waste legislation. However, almost all EU countries use a waste carriers licence scheme, to ensure waste contractors effectively manage waste and dispose of it safely. Many EU members have introduced a tax on waste going to landfill or for incineration. This aims to encourage the re-use of products and the recycling of materials. As well as encouraging foundation contractors to reduce spoil and cement waste, this also helps secure more secondary materials. Reducing waste to landfill helps create a steadier supply of these materials which can then be used in geotechnical projects. For example, crushed concrete can be used as aggregate, or pulverised fly ash (PFA) can be used in cement mixes if the standards and technical requirements allow for it.

Environmental Product Declarations

Environmental Product Declarations (EPDs) are a valuable source of information for understanding the sustainability of the materials foundation contractors use. EPDs record the life cycle environmental impacts of a product, based on EN 15804. As well as recording the carbon footprint of the product purchased, this means they capture raw material used, waste sent to landfill and other circular economy impacts. EPDs are not mandatory on all products, but some suppliers have them to respond to client requests.

4 / How can foundation contractors contribute to the circular economy?

4.1 Applying a hierarchy of principles

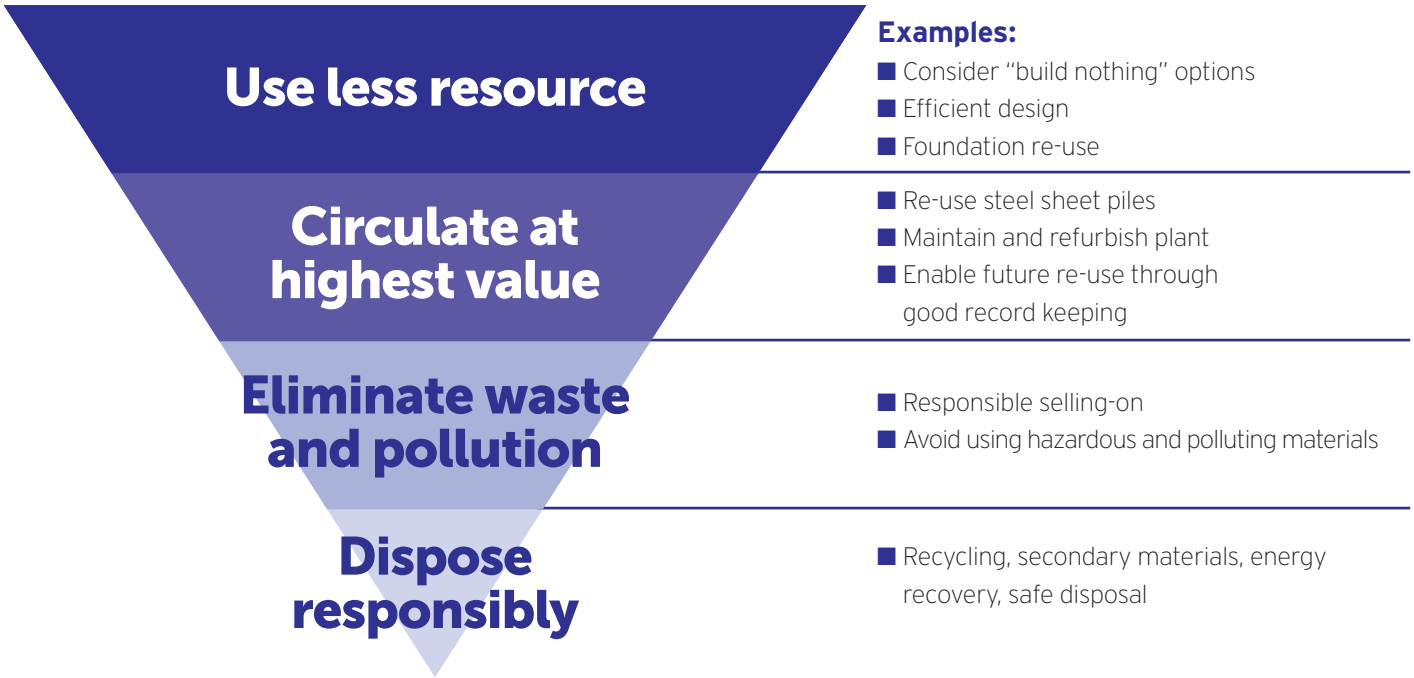
The EFFC Sustainability Working Group has compiled some good practices that can help foundation contractors work towards a circular economy. Further references are provided at the end of this guide, but here we pick out some key ways to aid the circular economy as a foundation contractor. These key ways are intended as a starting point to help direct companies towards the best use of resources. They are suggestions, and are not intended as an exhaustive list, nor as minimum standards for the geotechnical sector.

When considering which circular economy principles to prioritise it can help to work towards a hierarchy. In the context of foundation contracting, the following hierarchy is recommended:

- ***Use less resource:*** Eliminating use of virgin materials and reducing resource use overall. To avoid potential conflict with decarbonisation requirements, it may be helpful to include energy and carbon when thinking about resources.
- ***Circulate at highest value:*** best is to extend current use e.g., by maintenance, then re-using the whole product elsewhere, repairing, re-using parts, or repurposing (re-using for a different purpose)
- ***Eliminate and reduce waste and pollution:*** follow an established waste reduction hierarchy, avoid use of hazardous and polluting materials.
- ***Dispose responsibly:*** follow an established waste disposal hierarchy e.g. recycling, secondary materials, energy recovery, safe disposal

Steps higher up on the circular economy hierarchy (*Figure 3*) are likely to enable the biggest resource savings.

FIGURE 3. Circular economy hierarchy



4 / How can foundation contractors contribute to the circular economy?

Similar circular economy hierarchies exist in other guidance documents, for example the "9Rs" (www.greenofficeacademy.com) uses a broadly similar hierarchy of:

- Refuse (make the product redundant)
- Rethink (make product use more intensive)
- Reduce (the amount of material used)
- Re-use (products)
- Refurbish (products to extend their life)
- Repair (to extend useful life)
- Repurpose (amend the product or parts of it for a different use)
- Rot (dispose of via composting)
- Recycle (the constituent materials)
- Generate energy (e.g. via incineration)
- Landfill.

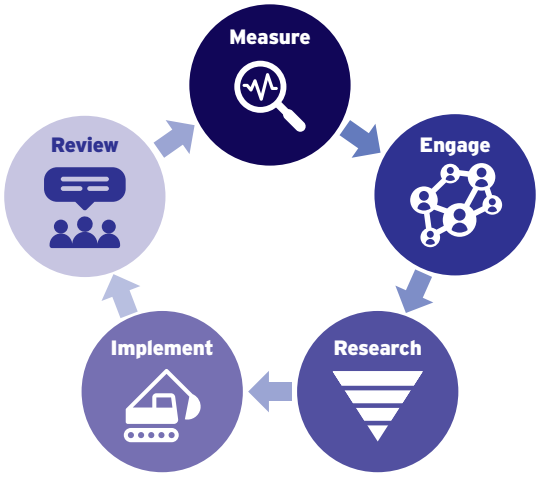
The Ellen Macarthur Foundation **butterfly diagram** can also provide a useful framework for understanding the foundation contractor's role in the circular supply chain.

4.2 The circularity improvement cycle

In order to improve the circularity of your business, it helps if you understand your current impact. This allows you to identify the areas where you could have the largest influence and where you may be able to make the fastest changes.

Before you start, define the boundaries where you will consider your circular economy impact. It may be simplest to start with your own operations and equipment, before moving on to areas which require more cooperation from others, such as influencing clients and designs (if you are able) and considering materials procurement. However, these latter areas could provide more significant circularity benefit. *Figure 4* illustrates a circularity continuous improvement process.

FIGURE 4. Circularity improvement cycle



1. **Measure** current degree of circularity in your operations. First time round, this could be collating a list of existing initiatives and ideas for improvement.
2. **Engage** representatives from your workforce, and across your supply chain, to understand how circularity could be improved in your company-wide operations, and identify project-specific opportunities.
3. **Research** feasibility, barriers and benefits of the ideas generated. Prioritise as necessary, and plan how you will implement changes.
4. **Implement** the changes you have proposed. These may be initially via pilot initiatives before being rolled out across all operations / projects.
5. **Review** successes, share lessons learnt and next steps. Repeat the cycle, seeking continuous improvement.

4 / How can foundation contractors contribute to the circular economy?

4.3 Key quick wins

- **Make meticulous records during construction, and save them.** This will enable confident future re-use. This includes, for example, the as-built geometry, the installed reinforcement, the concrete and its subsequently determined compressive strength, the encountered subsoil layers and their properties, and the records of any inspections or quality checks undertaken during construction.
- **Commission re-useable temporary works** that can be demounted and reused on other sites, with minimum sacrificial elements.
- **Optimise designs** where you have the ability to influence them, to re-use materials and elements or reduce material use.
- **Segregate waste at source** to enable better recycling. Of course, this requires an advanced recycling system in your country or at your waste management company. Especially in planning and procurement, make sure to procure easily separable materials, no composite materials, and reduce packaging.
- **Use preused steel.** Ask your steel pile / sheet pile supplier what preused piles they have available and ask the specifier to consider accepting equivalent steel classifications. Likewise, you can consider steel that is freed up on your own construction sites by dismantling it there at the end of its use.
- **Re-use demolition waste,** potentially from nearby sites, for example for working platforms.
- **Use secondary materials in concrete** such as GGBS / PFA, crushed concrete, recycled aggregate, where suitable and standards allow for it. Be aware, however, that tremie concrete is a sensitive building material that reacts significantly to even minor changes in its constituents in terms of workability and stability.

4.4 Repair / refurbish / repurpose: right now

It is already technically feasible to use reused materials and geotechnical elements in new projects, depending on the regulatory environment and quality assurance. Some examples are given below, with an outline of the technical considerations. There may also be local regulatory considerations.

- **Excavated soil.** Topsoil is particularly valuable as a growing medium and should be handled with care to avoid degradation, and a receptor identified. Granular excavated soil can be readily reused for engineered fill. Silty and clayey soils may also be re-useable but could require treatment, for instance with lime – in this case, careful consideration is required of the carbon and other sustainability implications of the treatment. Clays could also be used for clay bricks and pottery, or calcined for use as a cement replacement in concrete.
- **Temporary works.** Props and shoring can be rented and returned, formwork could be re-useable, temporary ground anchors could be extracted and recycled, soldier pile timber lagging can be reused.
- **Preused steel sheet piles and tubular piles.** Specifications should allow alternative similar steel grades. Appropriate testing of reused steel is required to demonstrate compliance, in a similar manner to new steel quality control procedures.
- **Secondary materials in concrete.** Use of ground granulated blast furnace slag (GGBS), or pulverised fuel ash (PFA) as a cement replacement for concrete is well-established common practice for cast-in situ geotechnical elements.
- **Secondary and recycled aggregates.** Chemical composition, moisture content, angularity and expected flow characteristics need to be well known in order for concrete mixes to meet the required standards. Demolition audits from nearby projects could indicate good sources of secondary materials. To avoid excessive testing, this may require a single, known, source of provenance (e.g. demolition of a specific building). More information is available in the EFFC/DFI Guide to Tremie Concrete for Deep Foundations.

4 / How can foundation contractors contribute to the circular economy?

4.5 Repair / refurbish / repurpose: enabling a circular future

Whether or not your materials, or construction elements, have already been reused / recycled, it is possible to increase the likelihood of them being successfully reused in the future. Here's how:

- **Make standardised, meticulous records** of what you construct, including geometry, materials data, any quality issues and how they were remediated. Consider what information could be useful in the future, and where / how it is best stored – this may be more than the minimum record-keeping requirements of your client or your current quality system.
- **Keep and share your construction records.** There may be client requirements to provide construction records to them and / or the local authority, in the form of BIM asset data, piling contract close-out reports and Operation and Maintenance manuals. However, these can be lost, be kept in obsolete formats, or may be routinely destroyed once warranty periods have ended. By keeping an archive of your own records, you may also be able to charge a fee for sharing data in the future.
- **Use trading and re-use platforms** to advertise materials, temporary works elements, spare parts, construction spoil etc for others to re-use. These could be internal to your company and / or external.
- **Insurance and warranties.** What steps does your company need to do to enable you to provide extended warrantees for your previous projects if they get adapted for different future use?
- **Consider material passport schemes.** The available options are evolving for keeping product / material information with the product, but could include digital passports, watermarks, QR codes, chips in foundations containing the "as built" records, EU Digital Log Book (if implemented) etc.

4.6 Site

- **Make standardised, meticulous records of what is constructed.** These records will enable future re-use of those foundations. This not only helps in providing evidence to government inspection bodies, but it also helps in identifying and assessing potential savings.
- **Re-use waste products on site.** Once a material has been designated as a waste product, it often needs to be recertified as a secondary material before it can be reused. Therefore, before it becomes designated as waste, consider secondary uses for these materials. For example, cuttings can be used as backfill, whilst crushed concrete can be used in working platforms or as aggregate. Always consider material quality and potential environmental impacts, especially if moving materials between sites.
- **Re-use temporary works from a previous site.** Whilst this requires significant coordination, reusable components, such as sheet piles, helical piles or even some precast concrete, can be moved from one construction site to another.
- **Re-use / recycle drilling fluids.** Separating solids from the drilling fluid, or allowing fluids to thicken within the designed range, can vastly reduce the volumes of drilling fluid required for a project.
- **Use filter chamber presses and centrifuges** to reduce waste volumes produced when grouting.
- **Monitor cement and fluid overconsumption** to avoid losing large volumes of primary materials.
- **Segregate site waste,** particularly where recyclable like paper bags or steel drums, to enable material recycling.
  For more on waste, see *section 4.7.*

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4.7 Waste

Wate management starts with minimising waste, followed by promoting re-use and repurposing – these are covered in other sections. Waste management in Europe is highly regulated, however there is scope to go beyond minimum requirements.

- **Conduct waste audits.** Discuss with your worksites to discover what is un-used, over consumed and what can be reused. Adapt supply logistics to avoid overconsumption and plan for un-used materials to be appropriately stored and transferred to the next project.
- **Minimise packaging** by engagement with the supply chain.
- **Conduct final destination audits** to confirm that waste leaving the worksite is being handled as intended.
- **Recycle wherever possible** having first taken measures to reduce waste.
- **Adopt energy recovery** where recycling is not possible, for example for the disposal of waste oils
- **Treat hazardous wastes** prior to disposal, complying with or exceeding local legal requirements.
- **Disposal to landfill** should be a last resort. Consider collection methods, transport mode and distance to the final destination.

4.8 Procurement

Procurement must continue to promote fair competition with equal opportunities for all bidders. The practical implementation of measures to promote the circular economy through procurement, such as those suggested below, should be carefully reviewed with this in mind.

- **Look first at materials re-use and sharing platforms** (including in-company) to see what preused things you can source, before considering procuring new.
- **Incentivise the supply chain.** Award a percentage of the tender based on the suppliers' commitment to contribute towards the circular economy, amount of packaging that becomes waste etc. Our end clients must also ensure this is transparently built into their procurement process as standard.
- **Set minimum standards.** Ensure suppliers meet minimum compliance with environmental and local and other applicable standards (ISO14001, BES 6001, EMAS, Eco lighthouse etc).
- **Ensure specifications allow (or request) reused elements and highest possible secondary content.** Adequate quality control, national acceptance and performance specification will need to be considered.
- **Review your balance of plant and asset ownership** versus leasing. Ownership places circularity directly in your control, hiring for individual projects may increase equipment utilisation. "Product as a service" leasing models also exist, where equipment, or high-wearing equipment parts remain the maintenance responsibility of the original provider, which can incentivise longer equipment life.
- **Consider repair and maintenance of equipment.** Prioritise circular economy principles when procuring equipment. Focus on the equipment efficiency, repairability, warranties, and the amount of energy and materials required to maintain it.
- **Avoid procuring hazardous materials.** During design and procurement, ensure that building materials and products are not on the Living Building Challenge Red List.

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4.9 Maintenance yards and offices

- **Store reusable parts and repair equipment.** Being able to repair and maintain your equipment is an important way to extend its life and reduce the need for new equipment. For the circular economy, this reduces the need for new resources for new equipment and avoids having to send off equipment for maintenance elsewhere.
- **Use reusable silos.** Working with local suppliers on long-term contracts to provide materials and equipment in reusable siloes, rather than single use plastic or paper packaging, helps reduce waste.
- **Waste recycling.** For waste that is unavoidable, separating and cleaning waste materials enables material recycling. Even just separating metal and wood from general waste can offer a financial saving, as well as allowing for their re-use.
- **For oils and greases, filter it or use waste to energy.** Some used lubricants and hydraulic oils can be filtered, cleaned and either recycled by specialist companies or burnt for heating / energy in a yard. Check local air quality requirements before doing this.
- **For offices** refer to existing guidance, such as the circular office guide.

4.10 Rigs and equipment

An alternative to buying a new piling rig is to refurbish an existing one. This is also advantageous from the point of view of long delivery times and high costs for completely new orders. In recent years, therefore, several large equipment manufacturers have begun to refurbish and improve the equipment they produce on behalf of their customers.

- **Purchase high-quality, repairable, upgradable, versatile and maintainable equipment.** This enables you to get the best use out of your equipment and reduces the need for wholescale replacement.
- **Consider a "product as a service" model,** particularly for high-quality, high-wearing and sophisticated components such as gearboxes, engines, rotary drives and hydraulic pumps. This incentivises longer life-times for components.
- **Use your equipment efficiently** by reviewing your balance between purchasing and hiring. This ensures all equipment is used as much as possible.
- **Repair and replace parts.** The original manufacturers may be able to support this, offering maintenance services, providing original spare parts and offering partial renewal of the factory warranty.
- **Consider equipment end-of-life.** Selling on equipment responsibly may extend the product lifetime. Factors to consider include the impact on future ability for the equipment parts to be reused, emissions compliance and likely end-of life.

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4.11 Foundation re-use (in situ)

Re-use of current foundations is becoming more commonplace to reduce the carbon footprint of a structure. Previous foundations limit space for installing new foundations, and foundation re-use saves time and money spent on installing new foundations. For successful foundation re-use, the following should be considered:

- **Record keeping.** Where good records exist of design, construction, quality and performance, confidence in foundation re-use is significantly higher. Records could be kept with piling close out reports, by local authority building control, in operation and maintenance manuals, in BIM models, in a Digital Log Book, by the original contractor and / or by the designer. Installing sensors, such as fibre optics for long-term monitoring, can also help.
- **Investigation and testing.** Site investigation may be required to confirm the position, length, reinforcement, material quality (and degradation over time), and where feasible current load-settlement behaviour. Specific foundations may be investigated, or a statistically representative sample.
- **Insurance.** Early dialogue about risk control with project insurers is recommended, as insurance arrangements may not be as straightforward as simply obtaining a warranty from a new-build contractor.
- **Cost.** Foundation re-use may significantly reduce capital cost for a project, but comes with higher design and investigation costs than a traditional new foundation solution.
- **Strengthening.** Where new foundation loads exceed the capacity of the existing foundations, additional foundations can be connected to share the load.
- **Monitoring.** During construction, instrumentation and monitoring is recommended, to check that reused foundations are behaving as expected as the new load is applied.

Further guidance is referenced at the end of this document.

4.12 Influencing the client and the design

The client and principal designer are able to consider the sustainability of the project as a whole and are responsible for ensuring the best overall outcome has been achieved. Foundation contractors may not always be able to influence their client, or the design, but if the contractual and / or project team set-up permits it, then the following can be considered:

- **Build nothing / less.** Can all or some of the desired outcomes be achieved without constructing some part of the scheme, or whilst using less materials? For example, by reducing car parking provision (often located underground), via foundation re-use, by incorporating temporary structures into the permanent works, by taking advantage of site morphology and geology, or by substituting displacement piles for replacement piles.
- **Undertaking more refined design and analysis** to minimise the number of materials required. This could be by the contractor's specific knowledge of ground conditions and constructability, by offering alternative foundation techniques, through more refined analysis methods, reducing uncertainty through increased testing or offering a more nuanced design.
- **Considering efficient structural forms,** to mutually optimise superstructure and foundations, and in the foundations themselves (e.g., hollow piles). Where component dimensions are governed by their structural capacity, using higher strength materials can reduce the total material quantity.
- **Consider temporary works impacts.** Some temporary works, such as steel bracing, are easier to re-use than others such as ground anchors. This will depend on local practice and ground conditions.
- **Use geotechnical elements for multiple functions,** such as using temporary retaining walls as the permanent outer wall to the structure and using permanent piles as temporary crane bases. This may require some modifications to the planned permanent structure to accommodate the temporary use. Other temporary geotechnical elements that could be adapted for permanent purposes include grouting, access shafts and soil nails. Retaining walls can also be used to carry vertical load, and foundation elements can be used to exchange heat with the ground.

4 / How can foundation contractors contribute to the circular economy?

- **Consider longevity and flexibility.** The nature of foundations, and the projects they are used for, means that designing for deconstruction and ease of repair may not be relevant. Therefore the best future minimum materials use comes from providing foundations that strike the right balance between future flexibility for re-use, and adequate longevity / resilience, without redundant oversizing for unlikely future scenarios.
- **Challenge the specification.** Has it precluded the use of reused materials or reused elements for a good reason, or could adequate testing and risk management enable this? Is there a requirement for detailed record keeping of the as-built structure? Are the requirements based on performance (i.e. load-settlement behaviour)? Are hazardous materials excluded?
- **Enable repair and re-use.** Encourage the client to safeguard as-built and construction records; detail to allow steel elements to be disconnected, consider access for future extraction of driven piles.

4.13 Innovation / looking to the future

Some innovations currently under development, which could enable greater circularity in the foundation construction industry are listed below.

- **Extendable, hollow piles.** Hollow piles use less materials for their load than conventional piles and can be extended for later re-use. Techniques exist for creating these piles precast and bored and cast in situ.
- **Recycled cement from crushed concrete.** Crushed concrete is already in use as aggregate, but potentially crushed concrete can be used to make recycled cement in the future.
- **Calcined excavated clay, or excavated limestone** may be used as a cement replacement.
- **Reversible ground improvement.** At present we can use ground freezing for temporary works, but future ground improvement might be reversible, for example through biological or catalytic processes.
- **Foundations as a service.** Sites in high-demand locations, such as city centres, might come with ready-installed adaptable foundations, which could be leased as part of the site lease, rather than constructing new, bespoke foundations for each new use of the site.
- **Removable foundations.** Sheet piles and some other pile types are already removable, but other pile types might in the future be able to be extracted and used elsewhere.
- **Full Life Cycle Analysis with targets for all Environmental Indicators.** At present, there is not enough information available to fully complete Life Cycle Analysis for every geotechnical project, and consensus has not been reached on the trade-offs between one Environmental Indicator and another.
- **Off-site prefabrication** to reduce material waste at production and construction. This is becoming increasingly common for wider construction but is harder to adopt in geotechnical projects. When considering adopting this, be aware that it can be both good, by reducing waste, and bad for the circular economy (for instance by increasing transport distances, or if poor durability of a single part means the whole needs to be replaced).

5 / Measurement

5.1 Possible project accreditations

There are no widely used accreditations that solely assess the impact of a project on the circular economy. However, circular economy metrics and requirements are integrated into multiple existing sustainability accreditations. These include increasing the use of secondary materials, producing less waste, diverting waste from landfill and, for some accreditations, designing for re-use or recycling. Example accreditations include:

- **BREEAM (Building Research Establishment Environmental Assessment Method):** This is a sustainability rating scheme, usually used for buildings, though can be applied for master planning and infrastructure. Alongside other sustainability impacts, buildings are scored on their re-use of materials, reduction of waste and designing for re-use.
- **CEEQUAL (Civil Engineering Environmental Quality Assessment & Award Scheme).** UK sustainability rating scheme for infrastructure projects. Much like BREEAM, this rewards projects that re-use materials and reduce waste.
- **LEED (Leadership in Energy and Environmental Design):** US Green Building Council's rating system, adopted globally.
- **DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen):** German Green Building Council certification for building sustainability and the "sustainable building site".
- **Consider your own metrics:** capturing ability to re-use foundations, raw material use, secondary materials used, waste sent to landfill. These can be compared against initial designs and estimations, to try and achieve an improvement.

5.2 Possible company accreditations

As with project accreditations, many company accreditations include circular economy metrics and disclosures, however the accreditations have not necessarily been set up specifically with the circular economy in mind, so accreditation alone may not be sufficient to enable a fully circular economy approach.

- **ISO 14001 (environmental management system):** an audited environmental management system standard, aiming to protect and improve the environment, as well as balancing it with social and economic sustainability. It ensures companies have various tools, policies and procedures in place to manage material use and waste disposal.
- **EMAS (Eco-Management and Audit Scheme):** an environmental management standard for companies, much like ISO 14001. It requires continual environmental management improvements, and EMAS audits must be carried out by government auditors for every individual entity in a company.
- **GRI (Global Reporting Initiative):** This is a company reporting standard aligned with the UN Sustainable Development Goals. It is commonly used in annual company reports and accounts. The optional environmental reporting module includes various circular economy-specific metrics for companies to disclose, including raw material use and waste to / diverted-from landfill.
- **SASB (Sustainability Accounting Standards Board):** This company reporting standard is also used in annual company reports and accounts. SASB is more focused on investor sustainability priorities, but does include a high-level requirement to detail any operational-phase energy and water efficiency into construction designs.
- **CSRD (Corporate Sustainability Reporting Directive):** Although legislation rather than an accreditation, the CSRD requirements will set out key metrics that need to be disclosed on the circular economy. For more information on the specific metrics being devised, look at the European Financial Reporting Advisory Group (EFRAG) website: Download (efrag.org)
- **Other Environmental, Social and Governance (ESG) ratings** such as EcoVadis, GRI, and SASB also include circular economy-related metrics both for the company and the supply chain.

6 / References

Arup - Circular Buildings Toolkit: https://ce-toolkit.dhub.arup.com

Butcher AP, Powell JJM and Skinner HD (eds) (2006) EP 75 Re-use of Foundations for Urban Sites. A Best Practice Handbook. BRE (Building Research Establishment), Bracknell, UK.

Chapman T, Anderson S and Windle J (2007) C653 Re-use of Foundations. CIRIA (Construction Industry Research and Information Association), London, UK.

Circular procurement | PIANOo - Dutch Public Procurement Expertise Centre: https://www.pianoo.nl/en/sustainable-public-procurement/spp-themes/circular-procurement **especially Construction and infrastructure projects | PIANOo - Dutch Public Procurement Expertise Centre:** https://www.pianoo.nl/en/sustainable-public-procurement/spp-themes/circular-procurement/getting-started/construction-and

Circular_Office_Guide_Content_Draft_v16 print.docx (bitcni.org.uk): https://www.bitcni.org.uk/wp-content/uploads/2019/01/190122-Circular-Economy-Office-Guide.pdf

https://www.circular-concrete.be: https://www.circular-concrete.be

Concrete in the circular economy: State of the Art Report with SWOT analysis. Bram Dooms, Niels Hulsbosch, Laura Kupers, Jeroen Vrijders BBRI, March 2021, v 2.0

Definition-of-the-digital-building-logbook.pdf (uceb.eu): https://uceb.eu/DATA/uceb2021/Definition-of-the-digital-building-logbook.pdf

EFFC influences FIEC response to EU Circular Economy Action Plan - EFFC: https://www.effc.org/news/effc-influences-fiec-response-to-eu-circular-economy-action-plan

EFFC/DFI Guide to Tremie Concrete for Deep Foundations 2nd Edition - EFFC: https://www.effc.org/media_corner/effc-dfi-guide-to-tremie-concrete-for-deep-foundations-2nd-edition

EFFC - Sustainability Overview Guidance: https://www.effc.org/how-we-operate/effc-sustainability-overview

Ellen MacArthur Foundation - Butterfly Diagram - Visualising the Circular Economy (ellenmacarthurfoundation.org): https://ellenmacarthurfoundation.org/circular-economy-diagram

FIEC-CEAP-Response.pdf (effc.org): https://www.effc.org/content/uploads/2020/07/FIEC-CEAP-Response.pdf

Gowler, P. et al (2023). Circular economy and reuse: guidance for designers. The Institution of Structural Engineers (istructe.org) Expected March 2023: https://www.istructe.org/resources/guidance/circular-economy

International, Living Future Institute - The Red List (living-future.org): https://living-future.org/red-list

6 / References

Niederleithinger, E., Katzenbach, R., Hillmann, S., Schallert, M., Unseld, H., and Wilmes, M., A Framework for Nondestructive Testing Used in Foundation Re-use Projects. 10th International Conference on Stress Wave Theory and Testing Methods for Deep Foundations, ASTM STP1611 (pp.238-253): https://www.astm.org/stp161120170159.html

One Planet Network - Construction Value Chain Analysis (oneplanetnetwork.org): https://www.oneplanetnetwork.org/sites/default/files/value-chain_analysis_-_construction_-_210210.pdf

Platform on Sustainable Finance (europa.eu): https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance/platform-sustainable-finance_en

SandStories.org: https://www.sandstories.org/about

Tayler, H (2020). A short guide to reusing foundations. Institution of Structural Engineers: https://www.istructe.org/journal/volumes/volume-98-(2020)/issue-11/a-short-guide-to-reusing-foundations/?gclid=EAIaIQobChMI6ubJiZDU_QIVTO7tCh2cnAIJEAAYASAAEgJ4QfD_BwE

The 9R Framework. Source: Adapted from Potting et al. (2017, p.5) | Download Scientific Diagram (researchgate.net): https://www.researchgate.net/figure/The-9R-Framework-Source-Adapted-from-Potting-et-al-2017-p5_fig1_320074659

UK Green Building Council (UKGBC) - System Enablers of a circular Economy: https://www.ukgbc.org/ukgbc-work/system-enablers-for-a-circular-economy