



Efficient use of GGBS in concrete

Informed specification can help to maximise the value of this low-carbon cementitious material, ensuring that it is used where it delivers the greatest benefit, writes Noushin Khosravi





round granulated blast furnace slag (GGBS) is a well-established constituent of concrete in the UK. This is due to its ability to enhance durability and long-term performance, and to significantly reduce embodied carbon through the partial replacement of Portland cement.

Like all construction resources, GGBS should be used efficiently, and where it can deliver the greatest technical and environmental benefit. Specifiers can achieve this by engaging with concrete suppliers early in the design process, setting clear performance and carbon objectives, and allowing flexibility in how those objectives are met.

What is GGBS?

Blast furnace slag is a co-product of the ironmaking stage of steel production. Smelting iron ore produces molten pig iron, which is used to make steel, and molten slag. Cooling this slag rapidly produces a glassy, granular material. When this granulated slag is dried and ground into a fine powder, it becomes reactive and it can be used in concrete, in combination with cement.

GGBS has been used as a supplementary cementitious material (SCM) for decades in the UK. In concrete, it brings a number of performance benefits, including:

- lower early-age temperature rise, reducing the risk of thermal cracking in large pours
- minimising the risk of damaging internal reactions, such as alkali silica reaction and delayed ettringite formation
- high resistance to chloride ingress, reducing the risk of steel reinforcement corrosion
- high resistance to attack by sulfates and other chemicals
- an attractive pale, off-white colour.





GGBS and embodied carbon

In comparison to Portland cement, the manufacturing of GGBS emits less carbon dioxide. This is partly due to reduced energy requirements, since it is a co-product of steelmaking, and partly because CO₂ is not released during its formation, unlike Portland cement production.

Calculating the cradle-to-gate embodied carbon of GGBS includes emissions from:

- the electricity used to granulate the slag at the steelworks
- transporting the slag from the steel works to the grinding site
- drying and grinding it to produce GGBS
- a proportion of the emissions associated with steelmaking, based on an economic allocation.

The most recent industry data for the embodied carbon of UK cements, contained in [MPA Fact Sheet 18](#), shows an indicative value for GGBS of 155kgCO₂e/t, compared to 840kgCO₂e/t for Portland cement (CEM I).

Supplies of GGBS

The 2024 closure of the blast furnaces at Port Talbot, the UK's largest steelworks, has prompted concern about whether there is enough GGBS to meet demand. These are unfounded: historically, some GGBS was sourced from within in the UK, but it has always been a globally traded resource and industry feedback indicates this will continue.

Getting a clear picture of global availability is challenging, due to international trade policies and varying levels of domestic use, but annual GGBS production is estimated to be within the range of 330-407 million tonnes.

The UK uses a very small proportion of this: according to the latest MPA data, approximately 2.5m tonnes of GGBS and fly ash were incorporated into UK concrete production in 2024. (The industry does not measure them separately.) This means that UK use of GGBS represents less than 0.6-0.7% of global output. As such, variations in



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At Reiach and Hall's Inverness Justice Centre, replacing 70% of the cement with GGBS saved around 360 tonnes of CO₂ compared with a traditional CEM I mix



Photo: Keith Hunter



UK demand for GGBS are not expected to have a significant influence on international supply dynamics or market stability.

If all blast furnaces are phased out in favour of less carbon-intensive methods of steel production, then GGBS production will eventually cease. But for now, it remains a valuable resource for lowering the embodied carbon of concrete. The immediate challenge is not one of scarcity, but of ensuring that GGBS is used efficiently and where it delivers the greatest benefit: technically, environmentally and economically.

Using GGBS efficiently

In combination with other cement replacements

GGBS is just one of a growing range of constituents that can be used to produce lower-carbon concretes. There is currently no direct replacement for GGBS that results in the same performance, with the same carbon reduction. But SCMs should be viewed as complementary materials. Under current standards it is possible to combine several to deliver comparable strength, durability and carbon performance, while reducing reliance on any single resource.

The use of multicomponent cements and combinations in concrete was established in the 2023 version of BS 8500, the British standard for concrete. This allows up to 65% Portland cement replacement by up to two SCMs, which means that GGBS can be combined with other materials such as limestone fines, fly ash or pozzolans such as calcined clay.

Specify using combined performance categories

BS 8500 sets out five standard specification methods: designed concretes, designated concretes, prescribed concretes, standardized prescribed concretes and proprietary concretes.



Photo: Jack Hobhouse

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At the Salvation Army HQ in south London by Tatehindle, all of the concrete contained 50% GGBS. The contractor split each floor into six pours rather than the planned four, to help maintain progress on site

Of these methods, designed concretes offer the greatest flexibility. The designer specifies the required performance and sustainability characteristics, leaving the concrete producer to decide the best way to achieve them. This allows it to supply whichever lower-carbon cements or combinations will create a concrete with the lowest possible embodied carbon for a specific application and location.

Specifiers should avoid requesting particular cement combinations, because availability varies depending on the local market and the supplier. Instead, they should use the combined performance categories (CPCs) set out in BS 8500-1. These group cement combinations according to their ability to resist sulfate and chloride attack, their durability and suitability for different exposure classes.

For detailed guidance, refer to The Concrete Centre document, [How to design concrete structures using Eurocode 2: BS 8500 for building and civil structures](#). The Concrete Centre has also published a [free, spreadsheet-based tool](#) to help specifiers identify CPCs for a particular application.

Specify using carbon rating systems

Carbon assessment and reduction should always be based on a whole-life, whole-project approach, not on a single material or performance characteristic. Typically, the biggest carbon savings can be made through early optioneering. But to ensure that design aspirations are carried through to delivery, carbon performance can be included in the concrete specification.

To facilitate low-carbon procurement, the concrete industry has developed product carbon classifications. Project teams can use static classification systems such as the GCCA Global Definitions for Low Carbon and Near Zero Concrete to set an appropriate target – from “better than average” to “market leading”. The actual concrete composition is left up to the supplier, enabling them to use the most efficient route to achieve it.



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Allies and Morrison's London College of Fashion. A 50% GGBS mix was used in the foundations and between 30-40% in the superstructure, where setting times were more critical to the programme



Photo: Simon Menges

The latest version of the National Structural Concrete Specification (NSCS) also provides guidance on specifying carbon targets in a way that encourages innovation in mix design and avoids overreliance on any single constituent.

What not to do: setting minimum or maximum GGBS content

As well as not specifying particular constituents or combinations, designers should not prescribe minimum or maximum GGBS content.

This is because setting a minimum GGBS content risks driving up its use where it will offer limited benefit, and could conflict with other project requirements. Limiting the maximum GGBS content, meanwhile, can hinder the supplier in providing the optimal concrete to deliver the required performance, and may result in a higher embodied carbon.

From a technical perspective, GGBS typically delivers performance benefits at replacement levels of around 35-55%, so restrictions outside of this range are likely to result in an inefficient use of the material. At low levels of replacement, other SCMs such as fly ash, calcined clay or silica fume provide better durability. Multicomponent cements incorporating up to 20% limestone fines can be extremely effective for achieving a specified carbon performance.

Collaboration is key

As with all concrete, the final specification should be developed collaboratively between the specifier, contractor and concrete producer, with consideration given to construction programme, placement and curing conditions, long-term performance requirements and sustainability.

By focusing on performance, and specifying carbon outcomes rather than material proportions, designers and specifiers can ensure that GGBS continues to deliver the maximum benefit technically, environmentally and economically, now and in the future. ■

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Photo: Kilian O'Sullivan

ABOVE

At the Ray Dolby Centre in Cambridge by Jestico + Whiles, 50% GGBS concrete was used in the slabs and 70% GGBS in the substructure