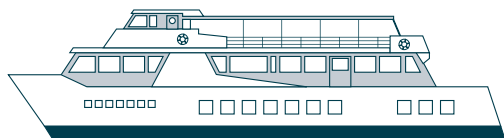




# THE STRENGTH BEHIND > SUSTAINABLE CONCRETE



# REGEN IS...

► Our Ground Granulated Blast furnace Slag (GGBS), a cement replacement, manufactured from a by-product of the iron-making industry.

Using one tonne of Regen in concrete reduces the embodied CO<sub>2</sub> by around 900kg, compared to using one tonne of Portland cement, and also increases its durability. Regen is more sustainable than other cement substitutes such as fly ash.

In the UK, GGBS is usually supplied as a separate component for concrete and is added at the concrete mixer. It can replace 70 per cent or more of the Portland cement. In British Standards, GGBS is referred to as an 'addition' and counts fully towards the cement content in concrete. Regen conforms to BS EN 15167-1 "Ground Granulated Blast furnace Slag for use in concrete, mortar and grout" and is available throughout the UK, accompanied by a full technical and logistical support package.

## The company

Regen is manufactured in the UK by Hanson Cement which acquired Civil & Marine in 2006. Hanson Cement operates under strict quality and management procedures and is proud of its ISO9001, ISO14001 and BS OHSAS 18001 accreditations. Through an Integrated Management System certified to PAS 99, the company places great emphasis on minimising its environmental impact and manufactures its products in as sustainable a manner as possible.

## Production of iron blast furnace slag

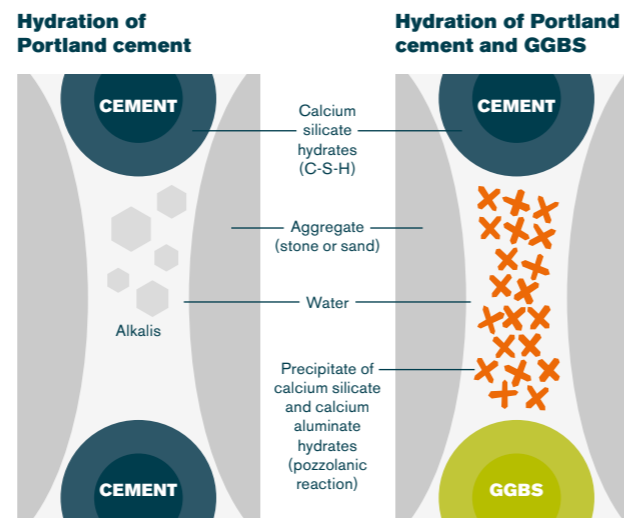
The cementitious properties of blast furnace slag were discovered in the late 19th century and it has been widely used in concrete manufacture for over 100 years.

Blast furnaces operate at temperatures up to 2,000°C and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore converts to iron, which sinks to the bottom of the furnace. The remaining materials form a slag that floats on top of the iron. The molten iron and slag are drawn off at regular intervals from the furnace. As the slag is drawn off, its chemistry is monitored as a check on the performance of the furnace. This ensures that the slag is very consistent in chemical composition. After being tapped from the furnace and separated from the iron, the slag is rapidly quenched in water. This process is known as granulation because it produces glassy granules, similar in appearance to a coarse sand. These have excellent cementitious properties.

## The hydration process

GGBS can be used as a replacement for cement because the hydration process is similar to that of Portland cement. When Portland cement reacts with water, the insoluble hydration products form close to the cement particle. The more soluble product of hydration (calcium hydroxide) precipitates as discrete crystals, surrounded by large pores. When GGBS particles are also present, both the GGBS and Portland cement hydrate.

Additionally, the GGBS reacts with the excess of calcium hydroxide to form hydrates that contribute to filling and blocking the pores. The result is a hardened cement paste, which contains greatly reduced calcium hydroxide and a refined pore structure that is less permeable. The reduction in free calcium hydroxide makes concrete chemically more stable, and the finer pore structure limits the ability of aggressive chemicals to diffuse through the concrete. Another cement addition is fly ash from coal-fired electricity-generating power stations. The hydration process for fly ash is pozzolanic, rather than cementitious.



Principal oxides					
	CaO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	Fe <sub>2</sub> O <sub>3</sub>
Regen	40%	35%	12%	10%	0.2%
Portland cement	65%	20%	5%	1%	2%



## ► THE BENEFITS OF REGEN:

### Sustainable

- Low embodied CO<sub>2</sub>
- Produces low CO<sub>2</sub> concrete
- No mineral extraction
- Reduced landfill
- Meets your criteria for sustainable construction

### Durable

- Produces more durable concrete
- Concrete made with Regen will last longer in aggressive environments

### Remarkable

- Lighter-coloured concrete – near-white
- Aesthetically pleasing
- Safer in dark areas
- A cost-effective method of making more sustainable and durable concrete

### Serviceable

- Available nationwide
- Full package of technical support available

Award-winning concrete, Stormy Castle, Gower

# REGEN IS... SUSTAINABLE

Regen is a highly sustainable cement substitute. From its low emissions production process to its use in long-life structures, concrete made using Regen provides many sustainability benefits.

With a worldwide production of 1.4 billion tonnes a year, the manufacture of CEM I Portland cement is regarded as a high-emissions industry. The use of cement replacements provides opportunities for significant reductions in energy use and CO<sub>2</sub> emissions.

The most effective alternative to Portland cement is Hanson Regen, which typically replaces 50 per cent of the Portland cement in a concrete mix. Greater proportions of up to 95 per cent can be used, with advantages in special applications.

There are environmental benefits to be gained from the use of Regen as a cement substitute in both the production process and throughout the life of the structure. In its production process, Regen:

- generates very low CO<sub>2</sub> emissions, as it is a by-product of iron-making
- produces very low emissions of the harmful gases SO<sub>x</sub> and NO<sub>x</sub>
- requires no quarrying or mineral extraction.

Comparing environmental benefits			
Environmental issue	Measured as	Impact	
		One tonne of Regen	One tonne of Portland cement
Climate change	CO <sub>2</sub> equivalent	0.07 tonnes	0.95 tonnes
Energy use	Primary energy	1,300 MJ	5,000 MJ
Mineral extraction	Weight quarried	0	1.5 tonnes
Waste disposal	Weight to tip	1 tonne saved	0.02 tonnes

**Note:** No account has been taken of the impacts of iron-making because the slag is created regardless of whether or not it can be used. Includes energy involved in the generation and distribution of electricity. The use of slag for the manufacture of GGBS saves it from potential disposal.

**Source:** Higgins D D, Sustainable concrete: How can additions contribute? Institute of Concrete Technology Annual Technical Symposium, 2006.

The increased durability of concrete manufactured using Regen further reduces a project's environmental impact by:

- reducing the amount of repair and maintenance required
- extending the service-life of concrete structures.

A comparison of the environmental impacts of Regen and Portland cement is given here (see left).

Comparison of emissions CO <sub>2</sub> kg/t		
	Portland cement	Regen
<b>Process emissions</b>	640	0
<b>Fossil fuel use</b>	100	30
<b>Generation of electricity used</b>	230	25
<b>Total</b>	970	55

**Source:** Civil & Marine 2005.

## Putting it simply...

- Producing 100m<sup>3</sup> of concrete uses **32 tonnes** of cement
- Replacing **50%** of the cement with Regen saves **12.96 tonnes** of CO<sub>2</sub>

That's equal to taking **42 cars** off the road for one year

Or equal to **41 years** of electricity usage in the average home



## CASE STUDY: SECOND SEVERN CROSSING

Long term durability in an aggressive environment was a critical factor in the design of the Second Severn Crossing. To match these requirements, over 60,000m<sup>3</sup> of Regen was used, replacing between 20% and 70% of the cement in the concrete. Over 25 years later, the concrete is showing no signs of deterioration.



# REGEN IS... DURABLE

Using Regen as a cement substitute in concrete increases its durability and resistance to deleterious reactions.

## Resistance to deleterious reactions

Sulfates occur naturally in the ground and can sometimes have a harmful effect on concrete, causing it to crack and disintegrate. The main reactions are known as ettringite and thaumasite. The use of Regen in concrete greatly increases resistance to sulfate attack. This is well recognised by codes and standards. In the latest version of the British Standard for concrete (BS 8500), the only option recommended for the most severe sulfate exposure is a concrete with a cement replacement of at least 66 per cent GGBS.

- **Ettringite** – The primary sulfate reaction that causes disruption of hardened concrete is associated with one of the minor compounds in Portland cement, tricalcium aluminate. This can combine with sulfate ions that have penetrated the concrete and form a new hydrate (ettringite), which occupies a volume greater than the original constituents. This generates high internal stresses in the concrete that can cause it to crack and disintegrate.
- **Thaumasite** – Another form of sulfate attack, called thaumasite attack, has been recognised as a problem after the discovery of its effects on some M5 motorway bridges. Thaumasite is a product, which forms at temperatures below 15°C through a reaction between cement paste hydrates, carbonate and sulfate ions. Its formation reduces the cement paste to a soft mulch, undermining the concrete's durability and stability.
- **Alkali-silica reaction (ASR)** – A reaction between the hydroxyl ions in the pore water within a concrete, and certain forms of silica which are present in some aggregates. This produces a gel which imbibes pore fluid and expands; this expansion induces internal stress of such magnitude, that it causes extensive cracking of the concrete, known as map cracking. The damage occurs in parts of the concrete structure exposed to moisture. Regen significantly reduces the risk of ASR occurring and with some reactive aggregates is the only recommended preventative measure. The resistance of Regen to ASR is a function of the reduced available alkali and the refined pore structure.

## Chloride attack

Chlorides damage concrete by breaking down the passive layer that protects steel reinforcement. This layer is formed on the surface of the steel as a result of the high alkaline environment produced by hydrating cement. Certain types of concrete are more vulnerable to attack because it is easier for the chloride ions to reach the steel reinforcement.

When CEM I Portland cement hydrates, the resultant pores are relatively large and can easily allow chloride ions to penetrate into the heart of the concrete and attack the embedded metal. The result is rapid corrosion of the steel reinforcement which can take the form of localised pitting or general corrosion.

To prevent the penetration of chloride ions, a dense concrete of very low permeability needs to be produced and this can be achieved by incorporating GGBS.

Where structures are subject to attack from chlorides from an external source, a minimum of 50 per cent GGBS should be used, with a higher proportion used in areas where high levels of chlorides will be encountered.

## Heat of hydration

The hydration of cement is an exothermic reaction. The use of Regen reduces the heat of hydration. High temperatures in concrete can generate stresses that could result in early-age thermal cracking. This cracking is known to have caused issues with some structures, so the use of Regen is recognised as an effective solution to the problem. Minimising heat of hydration to reduce thermal cracking is of critical importance in mass concrete pours. For example, Regen was used successfully in the construction of The Shard in London, the UK's largest ever continuous concrete pour.

The percentage of Regen used directly affects the heat of hydration; a replacement level of around 70 per cent is recommended for large pours. A temperature reduction of up to 40 per cent can be achieved with a 70 per cent replacement level.



## CASE STUDY: THE WALKIE TALKIE

The development at 20 Fenchurch Street in London, home to the UK's highest public park, utilised a concrete mix of 50% Regen to help it achieve a BREEAM "Excellent" rating. This significantly reduced the embodied CO<sub>2</sub> associated with the concrete.

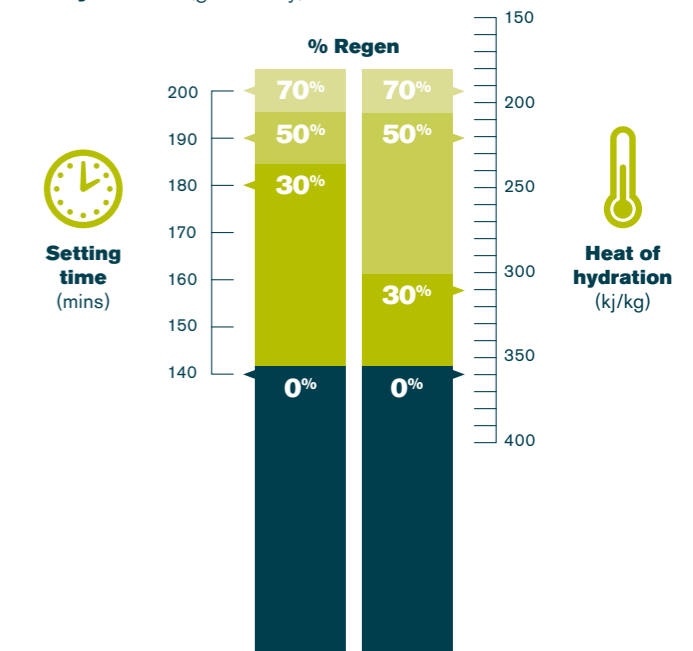
The building stands approximately 177m high, with 38 floors, including over 60,400m<sup>2</sup> of office space together with an additional allowance for retail use.

## Setting times

Concrete produced with a proportion of Regen has a slightly longer setting time than cement-only concrete. In practice, these extended setting times give greater opportunity for working the concrete, and provide more flexibility on site to compensate for any delivery delays or adverse working conditions.

Concrete with a cement content containing 50 per cent Regen will have a setting time of approximately half an hour longer than cement-only concrete, although this can be affected by the water/cement ratio and ambient temperature. We recommend carrying out tests to ensure the correct mix ratios.

## Effects of Regen on setting time and heat of hydration (guide only)



# REGEN IS... REMARKABLE



## CASE STUDY: SEA DEFENCES, BLACKPOOL

The light colour and impressive durability of Hanson Regen led to its use in the Blackpool Sea Defence project. Five headlands were created over a 3.3km stretch of seafront, using around 5,200 tonnes of Regen in 23,000m<sup>3</sup> of concrete.

The challenge was to ensure that the precast concrete sections were strong enough to protect and survive in a harsh environment, whilst remaining attractive in the popular holiday destination.

### Regen provides a superior, lighter-coloured finish than concrete made using Portland cement-only mixes.

In particular, Regen enables:

- a lighter-coloured concrete
- greater reflectivity, providing better visibility and therefore safety in dark environments
- reduced efflorescence.

Because of the near-white colour, Regen can be used as a replacement for White cement, with only a minimal difference in whiteness. However, for architectural applications where brightness is a critical factor, it is still recommended to use White cement wherever practical.

### Colour difference comparison when using Regen in concrete.



### Applications

Regen has been specified and used in many major projects, and has a wide range of applications.

Regen is ideal for use in projects where sustainability and durability are essential requirements. Example applications include:

#### Mortar

Regen can be used to replace a proportion of the cement when preparing mortars. This can be a cost-effective way to reduce the environmental burden of the structure and increase its durability. The lighter colour reduces the need for pigmentation.

#### Paving and street furniture

Paving, street furniture and other structures made with Regen have an increased service-life, reduced manufacturing costs and benefit from lightened colouring.

#### Precast concrete

The increased sustainability and durability of concrete made with Regen has made it popular for use in precast concrete structures.

#### Soil stabilisation

Stabilisation of soil with cementitious binders is widely used in road, pavement and foundation construction, to improve the engineering properties of the soil. It can increase the strength and bearing capacity, improve stability by controlling the swell-shrink caused by moisture changes, and can increase the resistance to erosion, weathering and traffic loading. Stabilisation of the existing soil is usually a much more sustainable solution than importing aggregate. Use of a lime and Regen combination offers significant advantages for soil stabilisation. The major advantage is that it can inhibit the deleterious swelling that sometimes occurs with clays containing sulfates.

#### Specialist projects

Hanson has considerable experience in advising on the best way to use Regen on projects with very specialised requirements. For example, Regen has been used for the encapsulation of radioactive material, where its lower heat of hydration and enhanced durability have been key factors. These properties have also led to Regen being used in slurry walling projects, sea defences and other structures in aggressive conditions.

# REGEN IS... SERVICEABLE

## Technical support

Hanson Cement provides strong technical support throughout the whole process of specifying and using Regen. Our team of three Technical Development Managers offer:

### CPD presentations on specifying sustainable concrete

Hanson Cement is able to provide your practice with a full Continual Professional Development (CPD) presentation on the specification and use of Regen, as well as other cement substitutes in sustainable construction. Each presentation lasts approximately one hour. A Certificate of Attendance will be issued after the event.



To request more information or to book a CPD presentation, please visit [hanson.co.uk/cpd](http://hanson.co.uk/cpd)

### Mix designs

Regen delivers its best performance when used in the correct proportions for the job. Our Technical Development Managers have experience in major projects, and can help you specify the best mix.

Please contact our Customer Services Team on **0330 123 4525** to find out more.

### On-site support

This includes temperature-match curing and advice on the best proportion of Regen to use.

Please contact your local District Sales Manager for more information.

## Ordering

Regen can be ordered by calling the Hanson Cement Order Hotline on **0330 123 4525**.

Our experienced team will be able to provide all the information you require for taking delivery of Regen. Alternatively, please specify Regen to your preferred concrete producer.

## Concrete production

Once you have specified Hanson Regen, the mix itself will generally be prepared and delivered by your concrete producer. We have great experience in working closely with concrete producers, and have a fleet of fuel-efficient vehicles dedicated to delivering Regen to them.

Our fleet reflects our environmental credentials; we ensure that our journey plans are as efficient as possible and we are proud of our policy of "never running empty."

## Specification clauses

To ensure that you use the most sustainable concrete on your project, we recommend that you use the following statements in your specifications:

### E10 mixing/casting/curing in situ concrete 101 Specification

- Concrete generally: To BS 8500-2
- Other requirements: 50% Regen GGBS to be used in all concrete, unless otherwise stated on drawings or by the engineer
- Exchange of information: Provide concrete producer with information required by BS 8500-1, clauses 4 and 5

Regen production at our Teesport plant, which reopened in 2016 following a £2 million investment.




# Hanson UK is a leading supplier of heavy building materials to the construction industry

We produce aggregates (crushed rock, sand and gravel), ready-mixed concrete, asphalt, cement and cement-related materials. We are part of the HeidelbergCement Group, which has leading global positions in aggregates, cement and concrete. Hanson UK is split into four business lines – aggregates, concrete, asphalt and contracting and cement – which together operate around 300 manufacturing sites and employ over 3,000 people. For detailed information on all areas of Hanson and our products visit [hanson.co.uk](http://hanson.co.uk)


## AGGREGATES

- Sand and gravel
- Crushed rock
- Bulk decorative aggregates
- Agricultural lime
- Rock armour
- Silica sand


## CONCRETE

- EcoPlus 
- Ready-mixed concrete
- Ready-mixed mortar
- Coloured concrete – Colourcrete
- Piling concrete – EasyPile
- Watertight concrete
- Sprayed concrete
- Reinforced concrete – Fibrecrete®


## PACKED PRODUCTS

- Cement 
- Ready-to-use mortar
- Ready-to-use concrete
- Asphalt
- Construction aggregates
- Decorative aggregates
- Sands

## BULK CEMENT

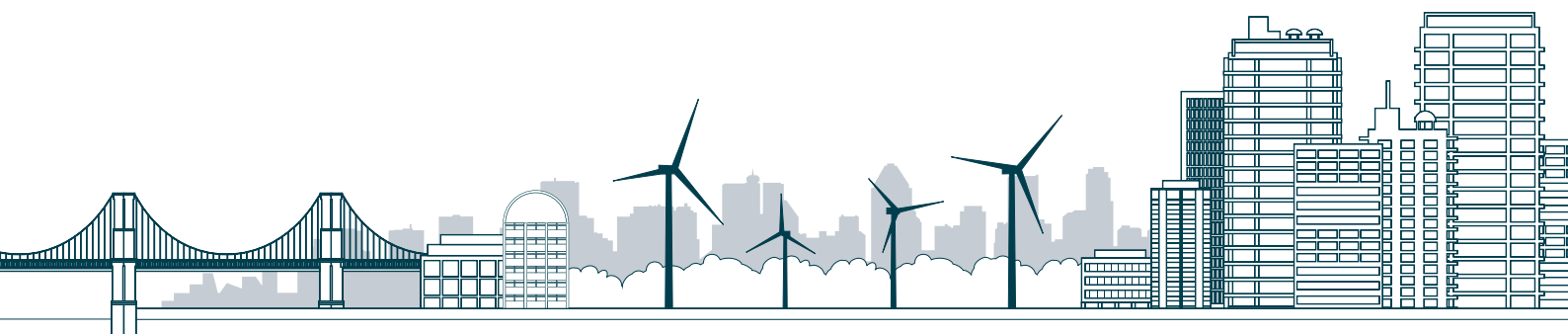
- Regen (GGBS) 
- Grey
- White

## ASPHALT

- Era® – low temperature asphalt 
- Durafalt
- Tuffgrip
- Tuffpave


## CONTRACTING

- Highway maintenance
- Road surfacing



## Hanson UK

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