Fibo Intercon

Sustainable Construction - Methods and Benefits

fibo intercon

The Environmental Impact of Concrete

The life cycle of concrete, from cement manufacturing to a concrete structure's demolition.

19 Page feature on sustainable construction, and how to transition into a more sustainable method of development?

CONTENTS

FIBO INTERCON

THE ENVIRONMENTAL IMPACT OF

CONCRETE

By Bob Evans

To look at the environmental impact of concrete, let's look at the life cycle of concrete from cement manufacturing to a concrete structure's demolition.

1) Cement is made from limestone, shales, silica and iron oxide quarried from the ground.

2) The quarried material is then crushed and mixed to the correct proportions to manufacture cement

3) The mixed quarried material is then preheated to 900° C using heat from the central heating process that follows preheating.

4) Once preheated to 900° C the materials then go through a rotating kiln where the temperature goes up to 1500° C

5) During the heating process, the limestone turns into a clinker. The clinker is then cooled and ground down to a refined power. We call this power ordinary portland cement.

6) The cement is bagged or delivered to the concrete plant in bulk deliveries

7) Construction sites and ready-mix companies make concrete from the cement by adding sand, aggregate and water.

8) While the concrete is curing, it absorbs carbon dioxide from the atmosphere.

9) When a structure becomes redundant, it is demolished

10) the demolished concrete is either taken to a landfill or, in more recent times, is recycled into a road-base or reused as an aggregate to make new concrete.

Energy Used In The Concrete Life Cycle

Energy is used to fule transport, machinery, plant the kilns during the manufacturing process to make cement and concrete, right through to demolition and transporting the demolished concrete to landfill or reuse as aggregate or road fill. The fuel for energy has mostly been fossil fuels, but the industry is moving away from fossil fuels to alternatives over the last twenty years.

Carbon Savings Used In The Concrete Life Cycle

When concrete cures, it creates carbonates that absorb carbon dioxide from the atmosphere.

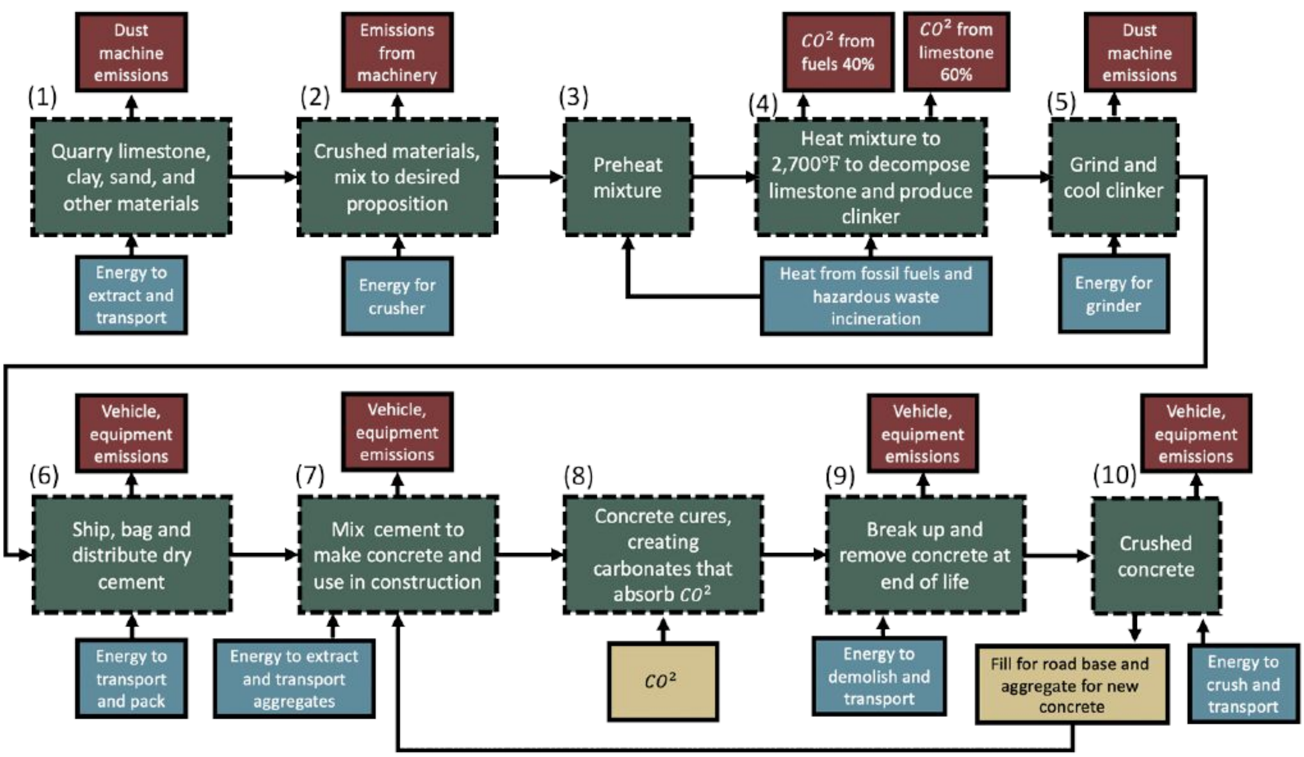
When concrete reaches the end of its life, it can be recycled and become part of the circular economy by being reused as aggregate to make new concrete or be used as a road foundation fill.

Environmental Emissions In The Concrete Life Cycle

The emissions from the concrete life cycle include:

- Dust from quarrying
- Dust from manufacturing cement
- Smoke, chemicals, carbon dioxide, and other hazardous chemicals from burning fuels

The Environmental Impact of Concrete



SUSTAINABILITY TIP #1

It’s clear that concrete and its high levels of carbon dioxide emissions can be very toxic and hazardous to both fauna and flora.

It’s upon us to take up the challenge and help minimize this pollution by ensuring we use and develop Eco-friendly alternatives.

WHY GO GREEN AND SUSTAINABLE?

Every major country on the planet is interested in carbo reduction, even if the bigger picture is still unsure, with scientists arguing with politicians.

One way or another, carbon reduction is now part of our lives, culture and businesses.

This article has been designed to give you the information you need to understand carbon reduction in concrete.

On page 6, is there a picture overview of why we should be working harder to achieve greater sustainability than we do today.

Climate change

Two and a half billion years ago, the atmosphere on the planet consisted of nitrogen, carbon dioxide and water vapour. As the planet cooled, the water vapour became our oceans, and the first life forms to evolve were microbes that could survive in this primordial atmosphere.

During this time, plants developed the ability to photosynthesize, creating glucose and oxygen from carbon dioxide and water in the presence of light from the Sun.

Twenty million years ago, the concentration of carbon dioxide reduced to below 300 molecules in every one million molecules of air.

The carbon is stored in forests that became coal and other fossil fuels.

Today, our problem is releasing this carbon into the atmosphere faster than our natural resources can convert it into oxygen. The net effect is that the plant is warming up again, which will eventually cause life on earth to become very different.

Mineral Resource Extraction

Although some resources like clay and stone are very abundant, other minerals and metals are not that abundant, and one day we will have used them up. For example, copper, once readily available, is now becoming very difficult to obtain. The largest mines are in China where they are under state control.

Our succeeding populations will not have the resources available to them we have enjoyed over the past few hundred years.

We need to reduce our dependency on mined and quarried resources if we want to provide a sustainable future.

Using the circular economy and using our resources more efficiently from reducing resource usage should be designed to go forward.

Human Toxicity

Over the past one hundred years, we have created thousands of dangerous products for humans and the environment.

Many chemicals are used in the construction industry, for example, Formaldehyde.

A lot of chemicals and substances have been examined, but the majority of the 140,000 involved are yet to be assessed and classified.

We should select products that are not harmful to humans and the environment when design construction projects.

Ecotoxicity to Freshwater and Land

Our land and water have been polluted over the years and, with legislation, have been cleaned up. In third world countries, this is not the case, and water pollution kills thousands of people each year.

In recent years plastic production is becoming one of our major concerns where we now see it in our seas and oceans, killing many sea creatures.

Industrial processes should be cleaned up, and we should stop allowing plastics to enter the seas and oceans

Fossil Fuel Depletion

For over fifty years, it has been said we will run out of oil in ten years. Today they say it will run out in ten to twenty years. One day it will run out.

Oil has been thought of as a way for economic growth. We should think of oil as a resource that will run out one day and plan for it.

We should be using alternative products that are sustainable than relying on plastic made from oil products.

Waste Disposal

As we know, landfill sites are becoming very rare in most countries.

Recycling is the new norm to reduce landfill and to use the circular economy to reuse our resources. The circular economy works by using recycled material to make new products.

For example, glass can be crushed and reused to make new glass. Aluminum can be reused to make new aluminum products.

Stratospheric Ozone Depletion
(Thinning of and holes occurring in the ozone layer)

The ozone layer in the stratosphere protects us from UV light. UV light causes skin cancers, cataracts and damage plants and plankton.

The ozone layer shrinks about 4% per decade. One day our future populations are going live differently than we do today.

Ozone depletion is caused by chemicals that destroy it called CFCs, HCFCs, HBFCs, halon, methyl bromide and bromochloromethane. These gases are more potent than carbon dioxide in depleting the ozone.

Many of these gases have been banned over the years to help slow down the ozone layer's shrinkage, but more work needs to be done.

Water Extraction

Climate change is changing our weather patterns. We may think we have enough water, but we are getting longer spells of dry weather. Rain is falling in different parts of the country, and we are having flash and heavy rainfall that flow off the land without being retained.

We need to use less water in our homes and industries by looking at new ways to use and store water. Rainwater harvesting is a straightforward method.

We need to slow down the heavy rainfalls using leaky dams on hills, where we can.

Acidification ('acid rain')

The burning of fossil fuels causes acid rain.

The chemical reaction is Sulphur Dioxide (SO_2) and nitrogen oxide (NOX) react with water, oxygen, carbon dioxide and sunlight to form sulphuric acid (H_2SO_4).

Acid rain in the past has caused problems in forests, filling many trees.

With the reduction of coal-fired power stations and the installation of chimney filters that take out the offending chemicals at the source, the problem is now far less than it was.

Unfortunately, we cannot say the same for some developing countries such as China and India.

Acid rain can also cause problems in rivers and streams to cause low levels of oxygen.

Nuclear Waste

Nuclear power stations usually act as the foundation of power supply in many countries. Nuclear power reduces the use of fossil fuel burning to create energy but comes with a price.

The price of nuclear power is nuclear waste that does not decay for thousands of years.

CEMENT MANUFACTURING

PEOPLE GET CONFUSED BETWEEN CEMENT AND CONCRETE.

Cement is a fine grey powder that is used to make concrete.Cement is also an ingredient in the mortar that masons use to lay brick and stone walls.

The manufacturing process of making cement begins at the limestone quarry. The limestone near the surface has a high content of the mineral silica iron and aluminum oxide. Deeper down, the limestone is purer, containing less of those minerals and more calcium carbonate.

The cement manufacturing plant uses both types of rock, altering the proportions to make different cement types.

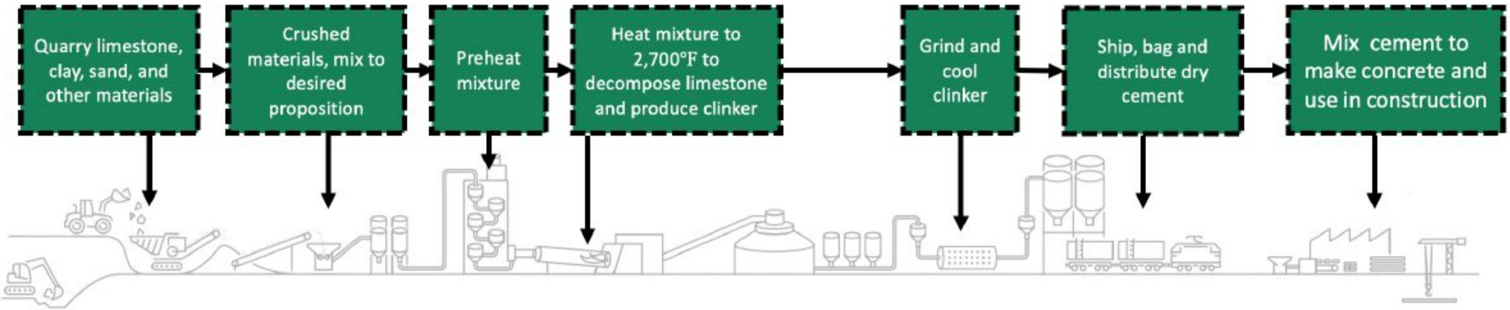
Quarry workers drill holes in the rock wall in which they lay explosives. For safety, the workers have to position themselves behind the blast area, maintaining a distance of at least 50 metres.

After blasting loaders move in, they load the limestone rocks in 50-tonne capacity dump trucks. The trucks then transport the limestone rock to the cement plant.

At the cement plant, the rock is put into the primary crusher. At this stage, the rocks can be quite big, some as big as a car. The primary crusher reduces them to about the size of footballs.

A conveyor then transports the rocks to the secondary crusher; it reduces them further about golf ball size. Rock high in calcium carbonate and rock low in calcium carbonate is crushed separately.

The stone types are now mixed. The ratio varies according to the type of cement being made. The mixing plant is called a tripper and makes piles of the required proportions, and this is called the raw mix.



A reclaimer machine loads the raw mix into a grinding machine called a roller mill. Other minerals such as silica and iron are added. In some cement, types require aluminum oxide.

The roller mill mixes and grinds the ingredients uniformly, producing a dry rock powder called the raw meal.

The raw meal goes into a preheater. The temperature is 80 degrees celsius upon entering, and within 40 seconds, it increases to 900 degrees celsius. The preheat begins the process of bonding the minerals together.

The preheater removes 95% of the carbon dioxide from the limestone and, with a chemical reaction, isolates the lime, which is the most important element in cement.

From the preheater, the powder moves into a rotary kiln. The rotary kiln is a cylindrical furnace. The kiln is set at an angle allowing the raw meal to move from the top to the bottom. The temperature reaches 1700 degrees celsius. As the powder comes to the 1500 degree mark, it fuses into pieces about marble size; these pieces are now called clinker.

The clinker is cooled down as it leaves the kiln to about 70 degrees celsius. It's essential to cool the clinker quickly as it affects the quality of the finished cement.

The last stage of cement making is called finish grinding. Gypsum is added to the clinker. The amount varies with the type of cement being made. Gypsum delays the cement setting time. It is vital that concrete has a setting time delay so it can be transported and placed before the initial set.

The grinder machine is called a ball Mill because it contains metal balls, about 150 tonnes of them in the largest mill. The metal balls and clinger rotate in the mill, the rotation with the metal balls, then grind the clinker into a fine powder. The fine power is called ordinary portland cement. The cement is then bagged or stored in large silos for bulk delivered to the concrete batching plant.

CEMENT REPLACEMENT

BY BOB EVANS

Cement manufacturing uses a great deal of energy, and a lot of carbon dioxide is released into the atmosphere from the limestone during the heating process in manufacturing.

THERE ARE QUITE A FEW CEMENT SUBSTITUTES THAT CAN BE USED. MANY OF THEM ARE UNPRACTICAL, BUT THE ONES THAT ARE IN GENERAL USE ARE:

- **GGBS - Ground Granulated Blast-furnace Slag**
- **PFA - Pulverised Fuel Ash**
- **Silica Fume**

GGBS

GGBS is a by-product from the production of iron and steel. Iron and steel come from iron ore that is mined. The iron ore is heated in a blast furnace that melts the rock, releasing the iron. The iron is heavier than the rock, and the molten rock that we now call molten slag floats up to the surface.

The molten slag is scraped off from the top of the furnace and is quelched in water, and ground down into a fine powder. The fine powder is GGBS and is chemically similar to ordinary portland cement (OPC).

GGBS hydrates as OPC when mixed with water.

GGBS is normally mixed with OPC in a ratio suited to the design mix requirements, for example, strength and setting times. Common mixing ratios include :

OPC 60% GGBS 40%
OPC 30% GGBS 70%
OPC 10% GGBS 90%

GGBS concrete cures a lot slower than OPC and generates less heat. The generation of less heat is an advantage in large mass pours as the concrete does not expand and crack to the same extent as OPC.

The OPC 30% GGBS 70% mix will sett slower and generate less heat than the OPC 60% GGBS 40% mix.

Because GGBS is a by-product of steel production, it reduced the carbon footprint of the concrete.

850 kg of carbon is saved for every tonne of OPC substituted using GGBS.

PFA

Pulverized fuel ash comes from coal-burning power stations.

Coal is pulverized into powder and then used as fuel. The ash that is left over is PFA.

PVA cannot be used as cement alone as it needs water and lime from OPC to hydrate as part of the primary chemical reaction. The PFA/OPC rations are normally:

OPC 80% PFA 20%
OPC 60% PFA 40%

As PFA is a by-product of coal-fired power stations, it will not be available for cement replacement when the power stations become obsolete from Government's overall carbon reduction programs.

850 kg of carbon is saved for every tonne of OPC substituted using PFA.

Silica Fume

Silica fume is a very fine powder with particle sizes similar to smoke. Silica fume is a by-product of silicon manufacturing.

Silica fume is used in smaller ratios than GGBS and PFA, typically OPC 90% Silica Fume 10%.

Silica fume is a more specialist cement substitute used when high strength concrete is required in aggressive environments and is more expensive.

CARBON REDUCED

CONCRETE MIXES

The major cement manufactures have developed low carbon concrete mixes using GGBS (ground granulated blast furnace slag) as the primary low carbon option. The main reasons GGBS is more sustainable and more economical than other cement replacements.

Thirty-two tonnes of cement go into making 100m3 of concrete to produce a standard concrete mix.

Replacing 50% of the OPC cement with GGBS cement saves 13.5 tonnes of carbon.

Replacing one tone of OPC with GGBS saves 850 kg of embodied carbon.

The benefits of using GGBS are:

- No limestone extraction to make cement
- Lower carbon emission from making OPC
- Reduced landfill as GGBS is a waste by-product of iron production.
- More sustainable that PFA (Pulviried fly ash)
- More GGBS can be used than PFA 70% compared to 30%
- Meets sustainability requirements in the construction sector
- Low CO2 concrete
- More durable even in aggressive environments
- Fewer shrinkage cracks due to low heat generation
- Slower setting time giving more time to place

To compare all replacement cement types with OPC

The table below compares cement replacement types with OPC. The specification of the CEM types is a British standard but will be similar in all standards.

The table below gives an example of carbon saving for several typical concrete mixes using GGBS and PFA. The cement replacement for the table used 50% GGBS and 30% PFA.

	C25/30 Mix Tonnes Carbon/100m3	C32/40 Mix Tonnes Carbon/100m3	C40/50 Mix Tonnes Carbon/100m3
Standard CEM1 Mix	27.0	31.6	36.6
PVA Mix	21.8	26.6	31.6
GGBS Mix	15.6	18.6	25.6
PVA Saving	19.2%	15.8%	13.7%
GGBS Saving	42.2%	41.1%	30.0%

Building made from recycled concrete

As you can see, the stronger the concrete mix, the more cement used and more carbon.

You can also see GGBS delivers more significant carbon saving than PFA. Greater carbon savings can be achieved using high GGBS within the concrete mix. 70% GGBS to 30% OPC is typical.

Recommendations

Our recommendation to produce low carbon concrete is to design your own.

It is essential to do this using the sand and aggregates you use in your location with GGBS and OPC's blends.

Produce trial mixes with GGBS/OPC ratios of 40%, 50%, 60% and 70%. for the types of concrete you want to produce or sell. First, you could use prescribed mixes for C10, C15, C20, C25, C30, C35, C40.

Test for setting times
Test 7, 14, 21, 28 day strengths

After you have experimented and are achieving the results you are looking for, you can then set the mixes up in your Fibo Intercon batching plant and sell low carbon concrete.

We recommend you use the support of a qualified concrete technician, and you continually test your batches for quality assurance.

AGGREGATES IN CONCRETE

Aggregate represents between 60 to 80% of the concrete mix. Traditionally aggregates have been natural stone, gravel and sand. Today with natural resources, sustainability and reduced carbon being at the front of decision-making, alternatives are being sourced.

Aggregates give the concrete its compressive strength. The stronger the aggregate, the stronger the concrete. For example, concrete made from crushed brick will be far weaker than concrete made from granite aggregate.

Aggregates for a particular mix are selected for their strength, shape, durability, workability and if they can give a good finish to the concrete.

Aggregates are divided into two parts, coarse and fine.

Coarse aggregates are normally between 5mm to 40mm, and fine aggregates are normally less than 9mm. Normally coarse aggregates are 20mm, and fine aggregates are coarse sand.

It is essential to grade the aggregates to ensure a dense mix. The fine aggregates should fill in the gaps between coarse aggregates. Part of designing a concrete mix is to grade fine and coarse aggregates into a ratio that gives the greatest density.

Common aggregates:

Quarried stone and sand

A number of rock types can be used for concrete production. The type of rock will depend on location. Limestone and granite are common concrete rock types, for example. The rock is quarried and crushed, and screened into several particle sizes from 40mm to dust.

Aggregate production from quarries typically uses explosives to break out the rock from the face.

Gravel

Gravel is broken rock that has been transported from glacial, rivers and the sea. They tend to be rounded from the action of the transport.

Deposits of gravel can be found from old river beds to glacial deposits. In some cases, the gravel is below the water table and is extracted using pumps leaving ponds and lakes behind.

Sand

Sand is the breakdown of rock over time and can be found in the sea and deposits from millions of years of the earth moving. For example, there are sand deposits in the UK when the land was a desert, and the country plates have moved from the equator to where the UK is today.

Glass Aggregate

Glass can be used as an aggregate by crushing it to a suitable size, normally 6 to 9mm. Glass can also be ground down to a powder and used to add to the cement as it has pozzolanic properties.

Recycled Concrete

Recycled concrete from structure demolition is a good source of aggregate and supports the circular economy. Old concrete is crushed into aggregate.

Caution is required when using recycled concrete as aggregate as it has higher absorption and a lower mass than quarried stone. These attributes produce concrete that may creep and have higher drying and shrinkage rates than concrete made from quarried stone.

The chloride content within recycled concrete may not be known. This is also a concern, and it is recommended that it is not used in reinforced structural concrete.

Marine aggregate

Extracting gravel and sand from the sea is very common. The sand and gravel are either dredged using buckets or sucked up using pumps. The gravel and sand are then washed to remove chlorides before use as aggregate.

CIRCULAR ECONOMY

WHAT IS A CIRCULAR ECONOMY?

An economy where products and materials are used, then recycled and used again. The purpose is to save natural resources, reduce carbon emissions and become a more sustainable economy.

Concrete and the circular economy

There are a few ways that concrete production can take advantage of circular economy thinking.

Old Building into New Buildings
Recycled glass can be crushed and made into aggregate.
The waste by-product from iron making made into cement
The waste by-product from coal-fired power stations made into cement.

Old Building into New Buildings
When a building becomes obsolete and demolished to make space for a new building, the structure's materials can be recycled and reused. The materials that can be recycled include:

Timber beams and joists reused after detailing or burnt as fuel.
Masonry recycled into road fill.
Concrete is crushed into aggregates and used to build the new structure.
Sanitary and ceramics crushed and used as aggregate and pipe bedding.

Recycled glass can be crushed and made into aggregate.

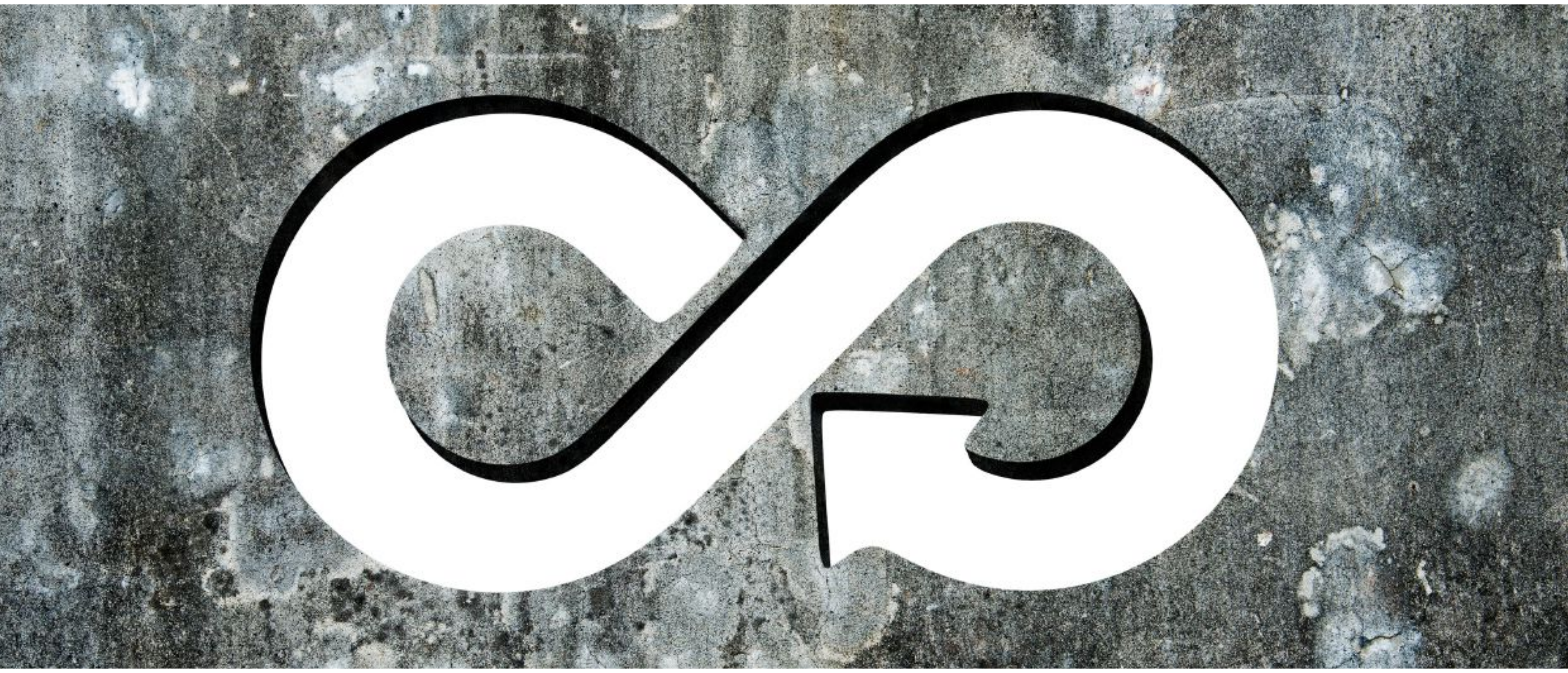
Glass can be used as an aggregate by crushing it to a suitable size, normally 6 to 9mm. Glass can also be ground down to a powder and used to add to the cement as it has pozzolanic properties.

The waste by-product from iron making made into cement

The waste by-product from making iron and steel is GGBS (ground granulated blast furnace slag). Steel is made from iron ore. The iron is removed from the iron ore by heating it to a molten state. The iron sinks to the bottom and the rock floats to the top of the cauldron. The molten rock is a blast furnace slag. The slag is cooled and ground to make cement.

The waste by-product from coal-fired power stations made into cement.

Coal is crushed or pulverized into coal dust before used. The pulverized coal dust is then used as fuel to generate electricity in coal-fired power stations. After combustion, the ash left over is called PFA (pulverized fuel ash and is used as a replacement cement.



CARBON REDUCED CONCRETE BATCHING PLANT

FIBO INTERCON HAS DEVELOPED SEVERAL SOLUTIONS TO REDUCE THE CARBON FOOTPRINT WHEN PRODUCING CONCRETE FOR CONSTRUCTION.

MATERIAL INPUTS:

Alternative cement replacement

Using GGBS and PFA cement instead of OPC cement can save 20% to 40%. For example, a C25/30 mix on concrete using OPC cement generates 27 tonnes of carbon compared to the same mix using GGBS that only generates. 15 tonnes of carbon.

Use of recycled aggregates

There are lots of recycled materials that can be used as alternative aggregates. They include:

Demolished concrete building crushed into concrete aggregate.

Recycled concrete has higher absorption and is lighter than quarried stone. Recycled concrete will produce concrete with higher drying, creep and shrinkage. The Chloride content of recycled concrete will be unknown, and this is also a concern. It is recommended that recycled concrete is not used for structural and reinforced concrete use. It can be used for blinding, road braces, plain foundations.

Road sweepings and gully waste

99.7 % of road sweeping and gully waste can be used as an alternative aggregate saving landfill. The aggregate can be used as road fill, pipe bedding and concrete aggregate.

Recycled Glass

Crushed recycled glass can be used as an aggregate to make concrete. When the glass is crushed or ground down to a fine powder, it can also be used as a Type 2 pozzolanic addition to the cement mix. There are British and EU standards for the use of glass in concrete.

PLANT INPUTS:

Use two or three cement silos.

Fibo Intercon can supply you with a batching plant with two or three cement silos to blent GGBS with OPC to gives you these savings.

Buy a F2200 Fibo Intercon batching plant as it has four aggregate bins and is ideal for mixing recycled aggregates with natural aggregates to design alternative concrete mixes for various usage.

Reuse waste concrete aggregates by treating them through a concrete washout plant

Reuse cement contaminated water by treating it through a water management system.

LOGISTICAL INPUTS:

Reduce transport miles

Producing concrete close to the site and cement, sand and crushed stone will reduce the transport miles. By locating the supply chain and the construction site using GPS, we can calculate the transport carbon footprint. By careful logistical planning, you can save a lot of carbon miles. Request a carbon footprint calculation from Fibo Intercon. We have software that can give you carbon saving using Fibo Intercon batching plant.

RECYCLE

RECYCLING PLANT RC1800

A green solution with reliability and good economy

This mobile recycling plant is designed to reuse up to 90% of the excavated material from underground utility networks and road works.

The integrated separator crushes and sorts the excavated material.

The recycling plant is an extremely flexible solution. It is ideal for working in urban environments and places with limited space. It is also quick and easy to set up and prepare for production.

Fibo Intercon

YOUR PARTNER IN CONCRETE SOLUTIONS

Many years' experience in the industry has made Fibo Intercon a leading supplier to the global concrete industry. We manufacture and deliver both mobile, semi-mobile and stationary concrete batching plants as well as production equipment and complete concrete systems.

In our production, we only use state-of-the-art technologies and methods to ensure our customers the best quality, efficiency, and reliability.

Over the years, we have been developing and delivering high-quality solutions to customers all over the world. The products delivered have ranged from standard batching plants to unique customized solutions, and our batching plants have been used for both small and large-scale building projects.

Fibo Intercon strives to provide quick and competent service. We have, therefore, developed our own representative network in several countries, and our service technicians are ready to go to your place and help you with the installation and servicing of your batching plants and with the training of your employees.ere.

High quality concrete solutions