Think Concrete, Go Precast

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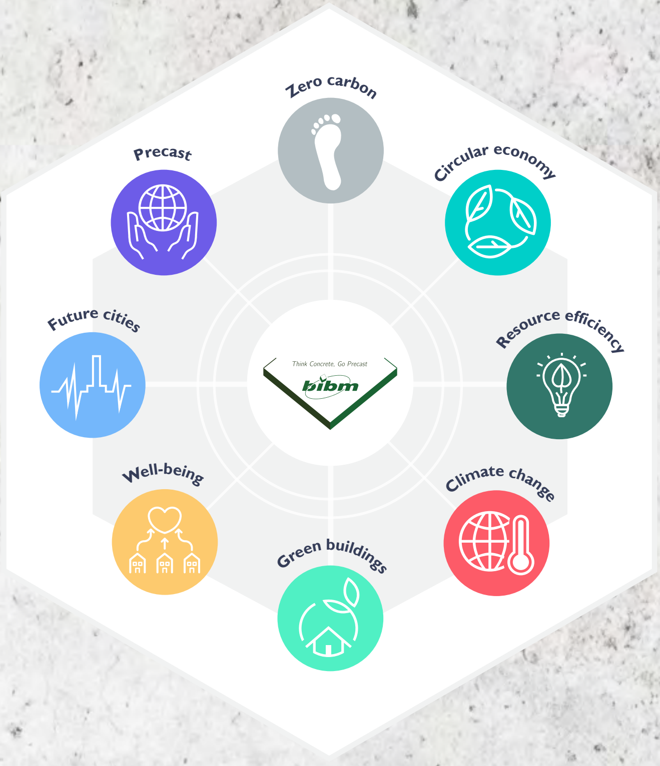
The Little GREEN BOOK of Concrete

Sustainable construction with precast concrete


Zero carbon
Circular economy
Resource efficiency
Climate change
Green buildings
Well-being
Future cities
Precast
Think Concrete, Go Precast
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Why this book?

There is increasing demand for construction options that will contribute to achieving sustainable development. This little book provides all stakeholders - the architect, the designer, the engineer, the client, the financier, the insurer and the environmentalist - with a summary guide to the sustainability credentials of precast concrete. It explains how the precast industry is becoming more resource efficient and environmentally aware, and how its products can contribute to achieving greener construction. We hope you enjoy reading about how sustainable construction can be achieved with precast concrete. If you wish to know more, please visit:

www.bibm.eu
or contact us: **info@bibm.eu**

The 2021 edition of the Little Green Book of Concrete is the updated version of the edition published by the British Precast Concrete Federation in 2008.

BIBM warmly thanks British Precast for agreeing on working on a common European version for this update.

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"In a world which is changing rapidly, our industry has to face upcoming challenges. Providing sustainable buildings, with particular attention to climate change mitigation and adaptation, is the way forward. With this book we want to provide not only the sustainable advantages of precast concrete, but also the engagement of the industry to provide more sustainable, circular and decarbonised solutions for the built environment".

Bart van Melick
President of the Federation of the European Precast Concrete Industry (BIBM)

Why precast concrete?

For the purposes of this current version of the Little Green Book of Concrete, "precast" includes all factory-made concrete products, from smaller modular items such as concrete blocks, paving and roof tiles, through to larger standard products such as pipeline systems, piles and precast floor beams, as well as bespoke units such as cladding panels and structural units designed and manufactured to specific architectural and engineering requirements.

This amazing portfolio of products serves the daily needs of society and supports economic growth. Together this provides places and spaces to live, work and enjoy life:

- Houses and residential buildings;
- Commercial, educational and healthcare facilities;
- Communication and transportation infrastructure;
- Drainage and sanitation systems;
- Energy supply systems;
- Shelter and protection against the forces of nature.

As well as these functions, precast concrete products have very positive inbuilt sustainability advantages. In use, such products help to combat some of the direct effects of climate change such as hotter summers, high winds and flash floods.

Chapter 1

On the way to zero carbon

Achieving carbon neutrality is an urgent challenge, but also a promising opportunity to build a better future for the next generation. The precast concrete sector is on its way to cut CO_2 emissions, especially where the life cycle emissions of buildings and structures can be reduced by the intelligent use of concrete. The sector's progress towards carbon neutrality, the net result of zero emissions, is vital towards achieving a sustainable Europe that works for all.

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1.1 Minimises embodied CO_2...

Embodied CO_2 (the emissions associated with the manufacturing and disposal of construction products) is becoming a decisive factor for achieving net zero-carbon buildings. This is driven by the transition towards low-, zero- and positive-energy buildings, where embodied and operational energy and CO_2 will be of the same order of magnitude.

Building with precast concrete means that you need less cement, less reinforcement and less materials for the same performance.

As an example, precast floor slabs show a 35% to 50% weight saving compared to an in-situ floor. For a 6,000 m² building, this results in an embodied energy saving of 184 tonnes of carbon, the equivalent of 60 years of CO_2 emissions from one car, primarily from the reduction in cement.

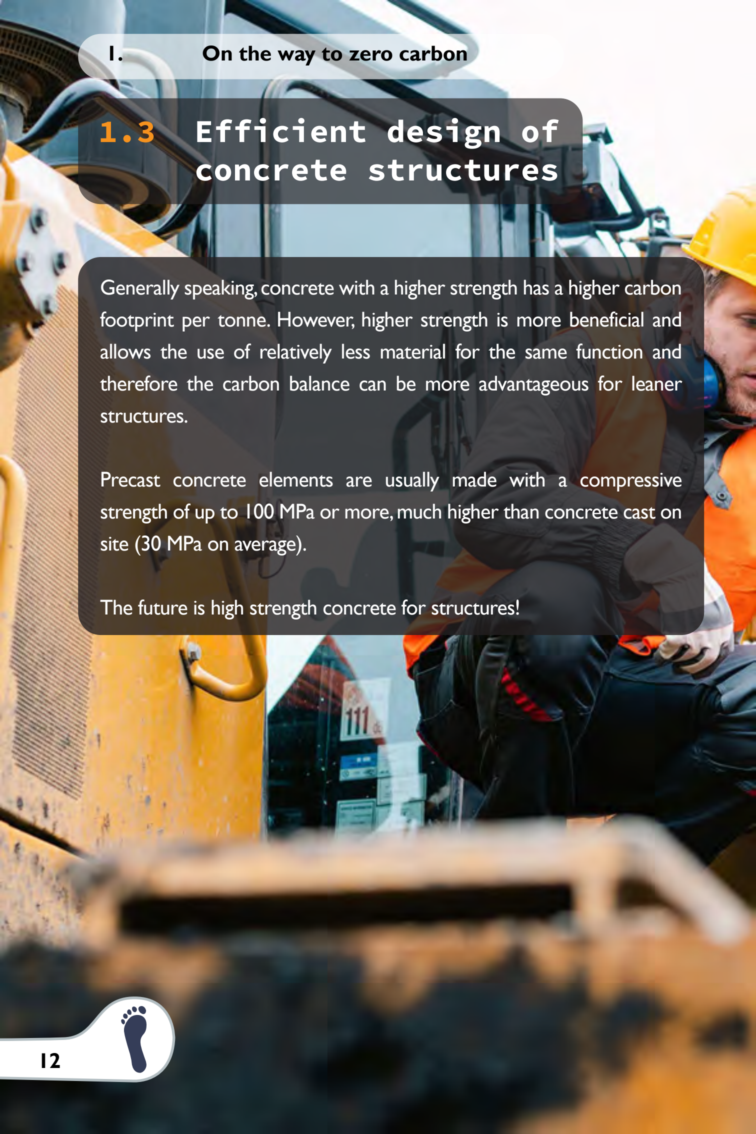
1.2 ...and operational energy

Concrete is renowned for its intrinsic ability to store and release thermal energy and regulate indoor temperatures, known as thermal mass.

In residential buildings energy gains are up to 9%, whereas in office buildings the gains can be as high as 15% when compared to a lightweight structure.

That is not all: thermal mass can be "activated" with a properly designed heating and cooling system. European studies of buildings using this technology show an outstanding 66% reduction in operational energy.

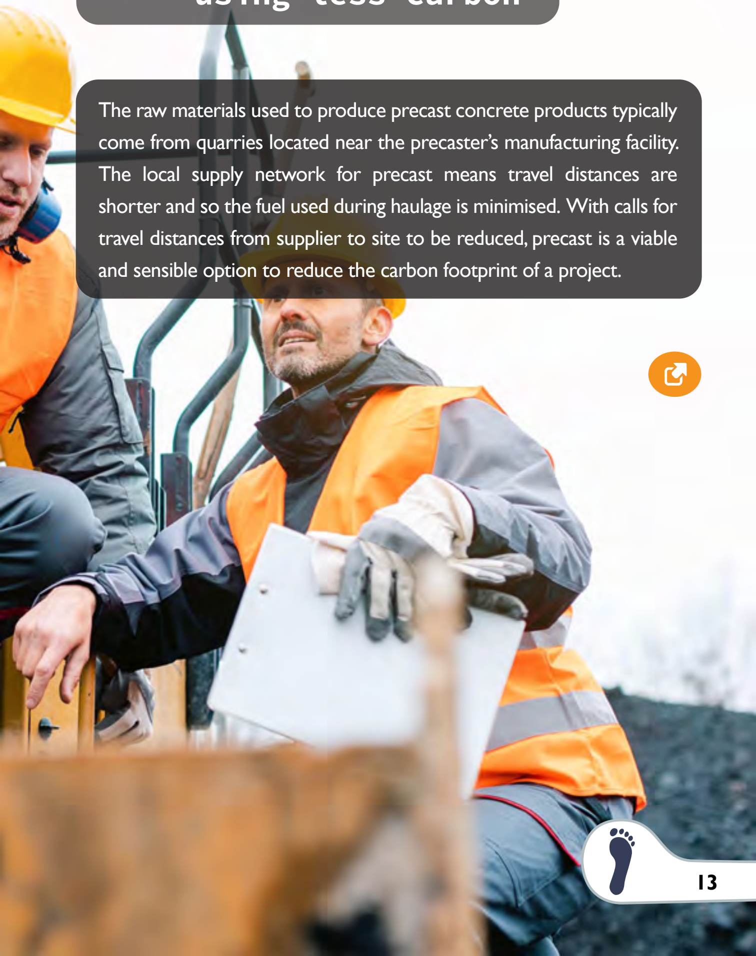
1.3 Efficient design of concrete structures



Generally speaking, concrete with a higher strength has a higher carbon footprint per tonne. However, higher strength is more beneficial and allows the use of relatively less material for the same function and therefore the carbon balance can be more advantageous for leaner structures.

Precast concrete elements are usually made with a compressive strength of up to 100 MPa or more, much higher than concrete cast on site (30 MPa on average).

The future is high strength concrete for structures!



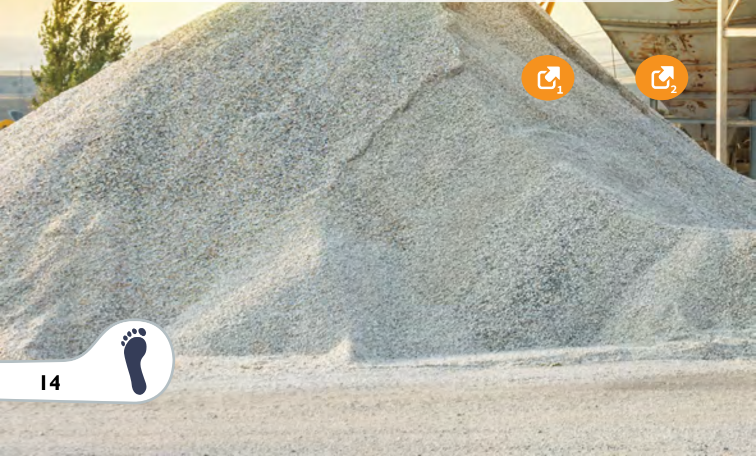
1.4 Being closer means using less carbon

The raw materials used to produce precast concrete products typically come from quarries located near the precaster's manufacturing facility. The local supply network for precast means travel distances are shorter and so the fuel used during haulage is minimised. With calls for travel distances from supplier to site to be reduced, precast is a viable and sensible option to reduce the carbon footprint of a project.

1.5 Uses cementitious materials from a responsible industry...

Between 1990 and 2018 CO_2 emissions from cement manufacturing were reduced by 19,2%, directly improving the carbon footprint of concrete.

The precast industry works hard to improve the efficiency of cement use by maximising hydration and by optimising cement content to reduce embodied CO_2. Other binders with much lower embodied CO_2 than portland cement can be used; today the use of other cementitious materials such as ground granulated blast furnace slag and pulverised fuel ash is a common practice.



1.6 ...which is reducing its carbon emissions

Although making cement in a kiln requires a great deal of heat energy, the amount of non-renewable fossil fuels used to produce this heat is being reduced and replaced with alternative waste derived fuels. Over 40% of thermal energy used to supply the clinker making process comes from waste and biomass. Energy efficiency in cement kilns varies between 70% to 80% depending on the raw materials moisture content.

The great majority of precast concrete mixes are made up of low carbon footprint sand, gravel or crushed rock, meaning that the carbon content of cement is diluted many times over. The embodied carbon of 1 tonne of concrete is around one tenth than that of a tonne of cement. The confusion between cement and concrete carbon footprints is the major source of misinformation about the beneficial sustainability characteristics of concrete. Using less cement in concrete even by using existing technology is improving its environmental impact.

1.7 Uses alternative binders

Today's precast products incorporate materials such as blast furnace slag (GGBS) from the steel industry and fuel ash (PFA) from coal-fired power stations that might otherwise go to waste. As a rule of thumb:

- Substituting 50% of cement with GGBS = 40% less CO_2;
- Substituting 30% of cement with PFA = 20% less CO_2.

These materials can improve the environmental performance of concrete and it is now possible to specify products with over 70% replacement material. Materials like microsilica, glass, limestone powder and china clay waste can also replace Portland cement or primary aggregates.

1 2 3

1.8 Achieving low-carbon concrete mix

Precast concrete manufacturers reduce the need for cement by modifying concrete composition, i.e. acting on other parameters than the cement used.

By using special admixtures, it is possible to reduce the need for cement whilst maintaining the strength and durability characteristics. Alternative binders like novel cements and geopolymers can be used in a controlled manufacturing environment. Precast manufacturers also optimise their mix design to reduce the need for cement.

1.9 A range of alternative reinforcements

Today steel is the common method of providing reinforcement in concrete, due to its high tensile strength.

The precast industry also invests in the application of alternative reinforcing materials like fibres, textiles and carbon in order to reduce environmental impacts linked to reinforcement. Non-corrosive reinforcement can also produce slimmer elements. For example, steel fibres are currently used in pipe manufacturing and textile reinforcement for cladding elements.

1.10 CO_2 offset

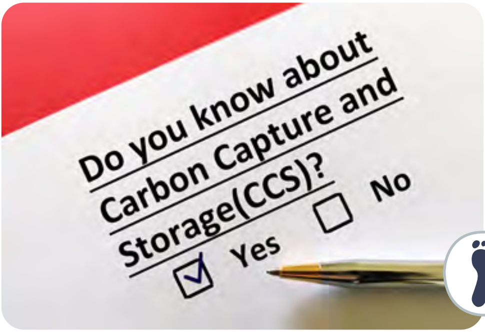
Carbon emissions can be drastically reduced by applying the principles set out previously. To reach net-zero carbon by 2050, it will be necessary to employ carbon capture and storage with any remaining carbon offset.

One possible route to offset them is with carbon sinks like natural forests. It has been demonstrated that increasing unexploited forest surface area and allowing natural growth is the best way to create an efficient carbon sink in a net zero-carbon economy. Thanks to the limited land use for manufacturing concrete, it is possible to use this natural route to zero carbon.

1.11 Capturing and storing CO_2 to make useful products

Once the emissions from the production of cement are reduced to a minimum, it is necessary to capture the remainder to achieve net zero emissions. By employing carbon capture (CC) the emitted carbon is either stored (S) or can be used (U). Technologies are being developed for both applications.

In terms of use, captured carbon can be reinjected into precast concrete products or used for curing. The carbon reacts with calcium compounds in concrete and produces solid calcium carbonates in a binding matrix. Captured carbon can also be used for manufacturing lightweight aggregates.



1.12 A vital carbon sink

The absorption of CO_2 into concrete has long been known, but only recently has this been identified as a potential carbon sink.

During its lifetime precast concrete will effectively re-absorb on its surface an average of 25% of the carbon dioxide that was used to create it in the first place.

Crushed concrete materials can take up CO_2 relatively fast. The amount of carbon uptake is even greater when stockpiles of crushed concrete are left exposed to the air before reuse.


CO_2

Chapter 2

Regional circular economy

The current paradigm of a linear economic model (make-use-dispose) is coming to an end and its place will be taken by the circular economy model (reduce-reuse-recycle). Adopting circular economy principles in the construction industry can lead the way to sustainable construction and a zero-waste society. Precast concrete elements are durable, can be designed for re-use or recycled as aggregate at end of life - a circular economy at play!

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2.1 Durable

Concrete buildings and structures from a long time ago are still in use today. Some concrete structures cast more than 2000 years ago still exist.

A service life of more than one hundred years can be achieved when necessary, especially for critical infrastructure. The Channel tunnel, for example, was designed to last 120 years. Swedish authorities are considering a design life of 100 to 150 years for sustainable drainage and, in their study, they identified concrete as a suitable solution.

Precast manufacturers can offer guidance on designing for durability. Precast concrete goes on increasing in strength for hundreds of years after it is cast. Whats more, it can be relied upon to perform consistently year after year with minimum maintenance.

2.2 Flexible for life

Keeping a structure in place ("in the loop") for a long period requires two characteristics: durability (long service life) and flexibility (ability to adapt to changing needs).

Precast structures combine the durability of concrete with the possibility to design and build edifices with little to no internal vertical elements like columns. The transformation of the internal spaces becomes much easier, making it possible to adapt to changing needs and even new uses.

2.3 Easy to maintain and replace

Precast concrete paving units have proven durability and long-term skid resistance.

Pavement elements can be temporarily lifted for maintenance or inspection purposes and then replaced.

For example, paving units for pedestrian or cycling lanes can be taken up for maintenance of underground systems (wastewater, electricity) and replaced without breaking the upper layer.

2.4 Easy to repair

Despite all the best intentions on a construction site, sometimes minor dents, damage or soiling can occur, which can compromise the appearance of neatly installed concrete units.

The excellent surface finish of precast makes cleaning and repairs easy – most manufacturers offer extensive guidance on how best to undertake these tasks.

2.5 Stays in the construction loop

Although precast can be designed for reuse, structures from the past constitute a large stream of the demolition waste and therefore of recyclable material. For this reason, addressing reinforced concrete's end of life (EoL), it is essential to divert the demolition waste from landfills.

Recycling is done by separating concrete from steel and other materials (e.g. insulation in concrete panels). Concrete can be easily processed for re-use as aggregates for both bound (new concrete elements) or unbound (geotechnical works) applications.

2.6 At the end, it can be relocated...

Many precast products such as paving units, retaining wall and safety barriers are relocatable.

Precast structures can be designed for disassembly. This proves very useful when a temporary structure (a building or a bridge) can be further re-used in another location. At the end of the life of a structure, precast units can be re-used in their entirety. For example, floor slabs can be reclaimed as whole elements. These could then be re-installed in the same building, or even transported a short distance and used in a comparable structure.

Now, with a greater number of products incorporating technical information on a bar code or microchip, designers can be more confident about re-using precast products, such as floors, columns and frame elements.

2.7 ...or recycled

As with many concrete products, precast is easy to crush and recycle as aggregate – almost 100% of concrete buildings can be recycled, no matter how heavily reinforced.

The use of recycled concrete aggregate is a clear and obvious example of the circular economy in action and has benefits that include reducing the use of new natural resources.

2.8 Keeps materials in the loop

Keeping materials in the loop is a pillar of the circular economy and the demand from specifiers for products with a higher recycled content is growing steadily.

Besides the fact that concrete is fully recyclable, many precast products now contain recycled aggregates including coming from crushed concrete (urban mining).

Some precast elements (blocks, paving units) use up to 97% reclaimed material in their manufacture.

Several research projects (SeRaMCo, VEEP) have been carried out to ensure the long-term performance of such products.

2.9 Uses by-products from other industries

In many cases precast products incorporate materials such as blast furnace slag (GGBS) from the steel industry and fuel ash (PFA) from coal-fired power stations that might otherwise be lost and go to landfill.

This is not only reducing the carbon footprint of concrete, but it diverts a considerable amount of materials otherwise destined for landfill.

2.10 Uses recycled steel for reinforcement

Reinforcing steel is made from steel scrap and uses around 10% of global total recycled steel. At the end of a precast element's life the reinforcement can be recovered for recycling again. Most of the rebar used in precast concrete products therefore scores highly in terms of recycled content.

Sometimes galvanised or stainless steel reinforcement is used in weather critical precast products - such as cladding - where enhanced durability and long life justifies its selection. This does not harm the recycling process of the steel reinforcement.

2.11 Uses regional raw materials from local suppliers

Most of the needs for precast products can be met locally, so with precast there is simply no need to import materials from thousands of kilometers away. In most European countries, the average transport distance for aggregates is below 30 km and for cement below 150 km. This reduces the impacts linked to transportation, but it also contributes to the economical development of the region.

2.12 Locally available products...

The average transport distance for precast concrete elements in most European countries is less than 100 km. This is confirmed in a study on the UK market from the Concrete Centre.

There are indeed more than 8,000 production plants spread all over Europe, able to deliver locally in all regions.

2.13 ...which arrive by sustainable transportation

Precast concrete products are predominantly sourced domestically. Distribution of products tends to be well-coordinated; wherever possible, return load planning by hauliers ensures that delivery vehicles are not empty. This prevents fuel waste and reduces road congestion.

Modern fuel-efficient vehicles are used when transporting precast elements, and driver training aimed at improving fuel efficiency is now commonplace.

The large nature of precast elements means that significant parts of the building can be brought to site with each delivery. Materials for formwork, scaffolding etc. are not required at the site, reducing the transport movements dramatically.

The amount of energy consumed during the transport of precast elements is about 0.00114 MJ/kg/km. This represents 5% to 10% of the total energy consumption during manufacturing of precast concrete elements.

2.14 When closing the loop, think small...

Even small amounts of scrap or waste in the process can be recycled: cement, slurry and process water are recycled and off-cuts are often crushed and reused.

Nothing is lost in a well-managed precast concrete factory.

2.15 ...then think big!

Closed-loop recycling systems are integrated in modern precast concrete factories. Residual concrete is automatically conveyed back to a central recycling plant where aggregates are cleaned and added to stock, or crushed with dry concrete waste. These systems virtually eliminate all waste, which is great news for the environment.

2.16 No need for extensive packaging

Most of the time, precast concrete elements do not need any packaging.

When packaging is necessary to protect the aesthetic of the product, this is handled in a sustainable way.

For plastic packaging, efforts have been made to reduce use to a minimum. Its collection on site is further streamlined for 100% recycling.

2.17 Avoids expensive environmental disposal costs

Making better use of natural resources makes good business and environmental sense. Landfilling taxation penalises poor use of materials, so contractors who waste more, will pay more. Using ready-made precast products prevents waste disposal costs being incurred due to site mixing, so extra costs do not have to be passed on to the customer and resource efficiency is maximised.

2.18 Close to zero waste at construction site

Elimination of waste through the efficient use of resources is fundamental for a state of zero waste. Using precast is a highly effective strategy to eliminate waste from wet concrete, formwork and other sources on site.

Even if excess material is created at the building site, it can be segregated, collected and broken up to create aggregate.

Precast manufacturers take responsibility for the removal of packaging (e.g. plastic sheets) and transport materials (e.g. pallets) from the construction site.

This keeps the site tidy, ensures that any waste is recycled and helps site managers to meet their environmental commitments, for example to ISO 14001.

Chapter 3

Resource efficiency

By using fewer natural resources in a more sustainable manner, we can boost the economy while minimising environmental impacts. Better infrastructure planning can be a major driver of the transition towards a sustainable economy. Offering material efficiency at each stage of development is crucial to achieving resource efficiency in the building sector.

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3.1 HSC for slim construction saves resources for each building

High Strength Concrete (HSC) for slim construction saves resources for each building. Manufacturing HSC involves making optimal use of the basic ingredients that constitute normal strength concrete. In practice, this means that for the same final function you need less materials.

The use of HSC in high-rise buildings allows for increasingly intricate design and architectural art. There is the possibility of using HSC in wider areas in the future. It could also be a reliable option for safe construction in seismic areas.

3.2 Can have a high recycled content

The use of secondary materials (coming from both recycled concrete and sometimes other industries) reduces the need for primary materials. The use of recycled aggregates from concrete demolition is increasing, contributing to the circularity of the industry.

Furthermore, many producers (i.e. paving elements ones) use their own waste (faulty products, concrete waste) to process it and reintroduce in a new production cycle, minimizing the embodied energy of the transport of waste. Therefore, the final balance of waste could reach the absolute zero.

3.3 Uses regional raw materials

Precast concrete uses either natural, locally available materials (aggregates from rocks or river gravels, limestone and water) or quality recycled materials, which are mainly inorganic. This means they require minimal processing to render them suitable for use, which results in concrete having a relatively low embodied energy value, unlike highly processed materials, such as plastics.

3.4 Little need to import

With precast, there is simply no need to import materials from thousands of kilometres away. Concrete is mainly manufactured close to the final user. This reduces the adverse impacts of transportation. Local sourcing supports regional economies and employment.

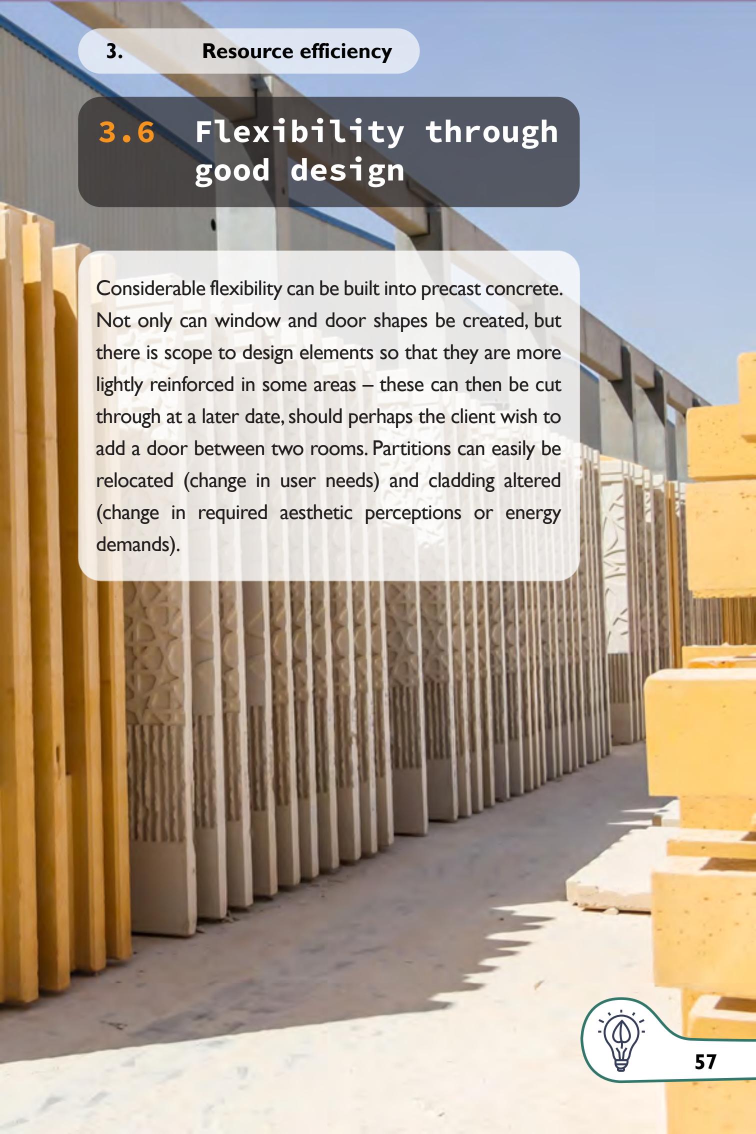
Shipping resources or products from far away countries such as Russia, Canada and Brasil, can have a huge impact on the final environmental profile. It is estimated that between 2007 and 2012 the shipping sector emitted about 1,000 Mt CO_2 per year, about 3.1% of annual global CO_2 emissions. Additionally, carbon pollution from ships could increase by up to 50% by 2050 if left unchecked.

3.5 Long lifespans

Long service life means less need for resources.

On one hand, it is important to design and produce better products that use less resources.

On the other hand, having a long lifespan and being re-usable and recyclable is also key for resource efficiency. Precast concrete has all the qualities to be considered as a sustainable material for the current and future society.



3.6 Flexibility through good design

Considerable flexibility can be built into precast concrete. Not only can window and door shapes be created, but there is scope to design elements so that they are more lightly reinforced in some areas – these can then be cut through at a later date, should perhaps the client wish to add a door between two rooms. Partitions can easily be relocated (change in user needs) and cladding altered (change in required aesthetic perceptions or energy demands).

3.7 Reduces the need of cement

The cement that goes into precast concrete is vital to both its durability and appearance and its basic components are widely available.

Optimisation through precasting reduces the cement required for the same function as cast in-situ, thanks to the factory-controlled process. This also applies to other binders.

3.8 Can have positive effects on increasing biodiversity

More than 99% of relevant quarries have a biodiversity action plan. Quarry restoration provides a major opportunity to protect and enhance biodiversity. The mineral extraction industry has a long legacy of high-quality restoration and makes a significant contribution to the wildlife, including many rare and threatened species. Many plant species also live in quarries, attracted by the low-nutrient habitats that result when soils are removed.

3.9 An efficient factory environment...

Precast is produced in factories under strictly controlled conditions which means excellent resource efficiency for materials, labour, energy and processes. Today's precast factories are clean and productive, and use computer-controlled processes for batching, mixing and casting. Major efficiency programmes are also helping reduce factories' energy consumption and water used in production.

3.10 ...with long-lasting moulds

Moulds for precast concrete are usually made from steel and can be used several times; they can be stored to allow later replication, whether additional units are required one day, one week or one year later.

This means much less manufacturing waste goes to landfill.

3.11 Conserves water resources in the factory...

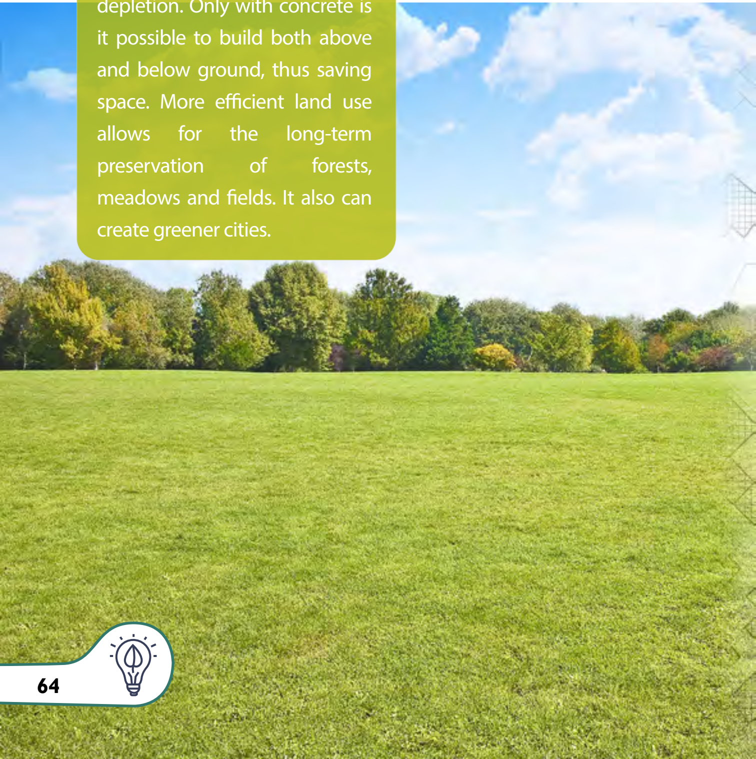
Although water is a widely available resource and is currently in plentiful supply, it is important to manage its consumption. Water recycling and conservation is a common feature in precast factories. For example, tanks, ponds and lagoons are used to store rainwater, which is used in the factory to minimise mains water consumption, saving thousands of cubic metres per annum. A large proportion of precast factories have on-site water treatment plants to recycle their used process water.

3.12 ...and on site

Precast concrete arrives on site ready for installation and usually requires no further treatment or additions. Executing all the necessary finishing tasks in the precast factory allows process water to be more easily controlled, recycled and re-used.

3.13 Efficient land use on site...

Concrete is the building material that protects green spaces from further construction and soil depletion. Only with concrete is it possible to build both above and below ground, thus saving space. More efficient land use allows for the long-term preservation of forests, meadows and fields. It also can create greener cities.



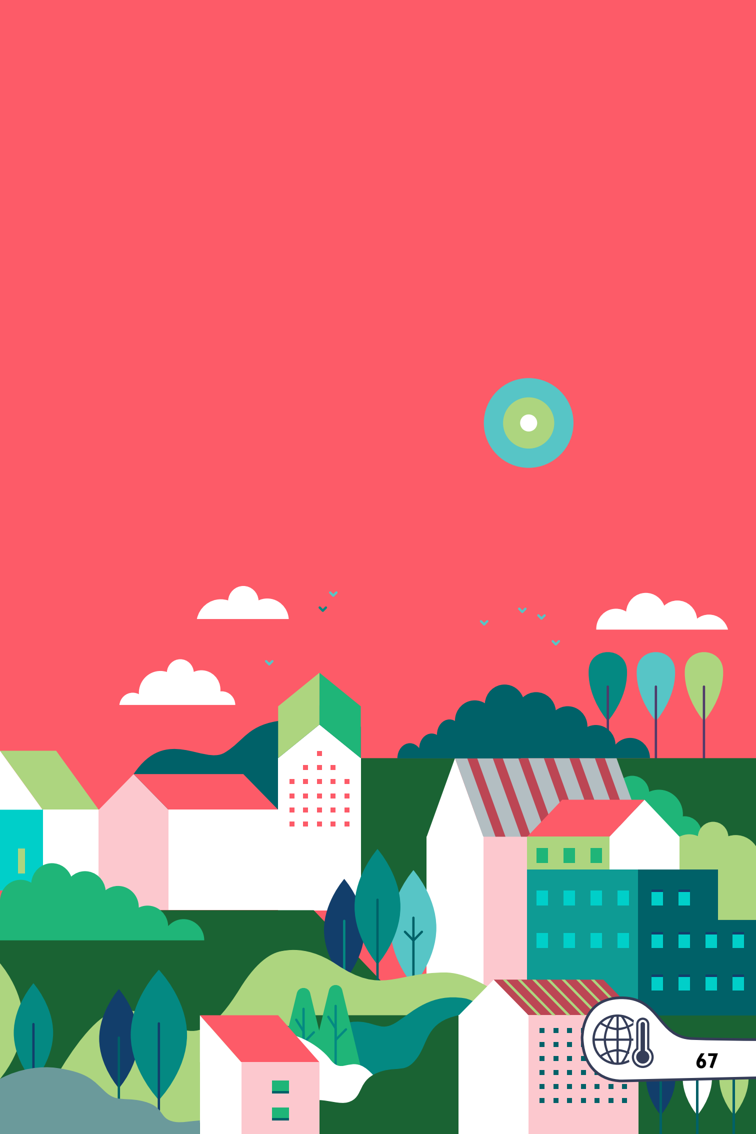
3.14 ...and in the extraction

The largely vertical nature of mineral extraction means that the land surface needed for producing concrete is smaller than other materials like timber. Increasingly efficient extraction technologies, such as horizontal drilling and hydraulic fracturing, are raising resource productivity and thus reducing land use.

Chapter 4
Adaptation to climate change

Climate change is one of the major environmental challenges facing our planet today. That is why the ability to cope and adapt to the changing environment is very much needed in both the short and long-term.

Precast concrete is a strong material that can withstand all possible natural catastrophes which may occur more frequently in European regions, such as floods, wildfires or droughts.



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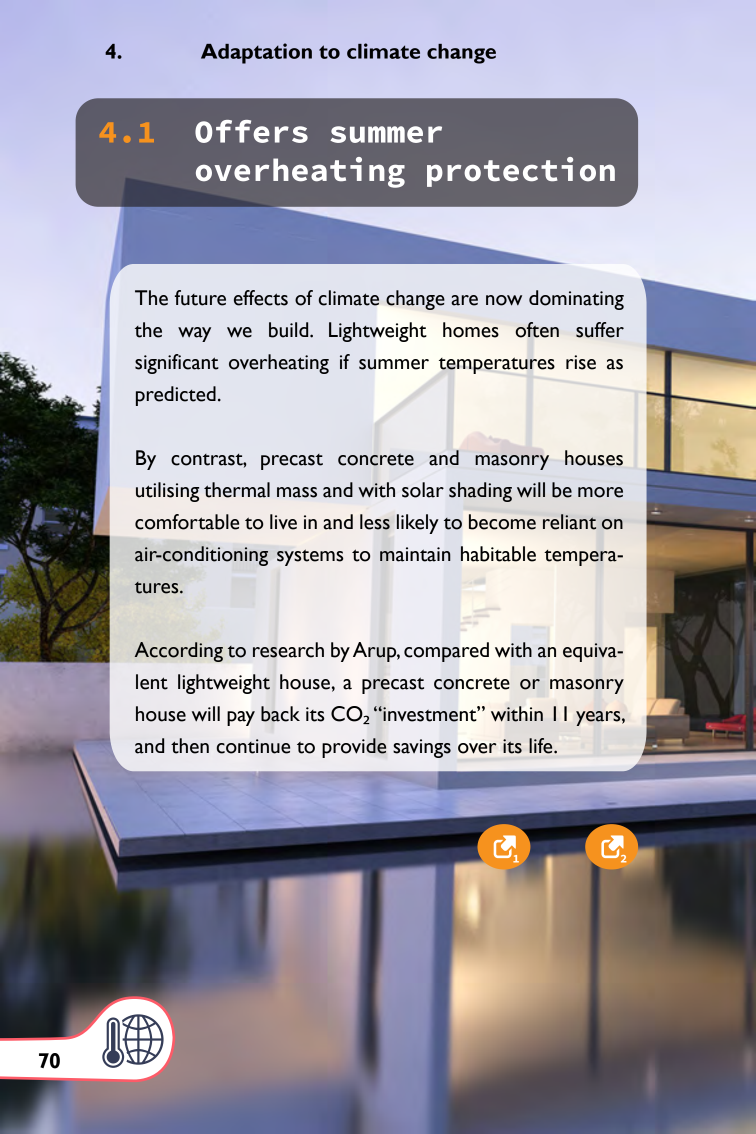
4.1 Offers summer overheating protection



The future effects of climate change are now dominating the way we build. Lightweight homes often suffer significant overheating if summer temperatures rise as predicted.

By contrast, precast concrete and masonry houses utilising thermal mass and with solar shading will be more comfortable to live in and less likely to become reliant on air-conditioning systems to maintain habitable temperatures.

According to research by Arup, compared with an equivalent lightweight house, a precast concrete or masonry house will pay back its CO_2 "investment" within 11 years, and then continue to provide savings over its life.

4.2 Activated thermal mass

Thermal mass is a powerful tool for the efficient heating and cooling of buildings. Energy cost and decarbonisation policies drive the need to find new and innovative ways to heat and cool modern buildings.

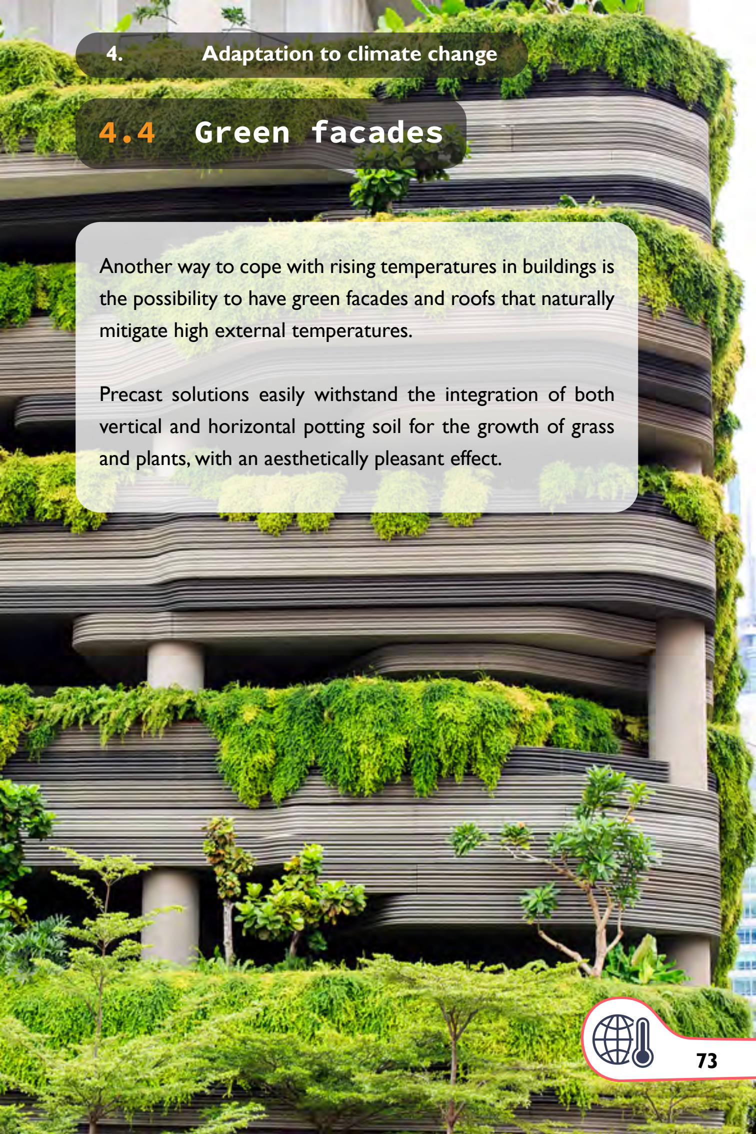
Thermally Activated Building Structures (TABS) is an innovative temperature control system engineered to meet these goals. TABS combines the advantages of radiant cooling and heating with the thermal storage of concrete ceilings and floors. It does this by running hot or cold water for low temperature heating and high temperature cooling through pipes within the slab.

4.3 Reflection of light

Concrete is not only grey, it can be made in every possible colour. The enhanced reflectivity of white concrete can be used to conserve energy and meet criteria for sustainable construction. Light coloured concrete absorbs less heat and reflects more light/energy than dark coloured materials, therefore maintaining a low surface temperature.

Paving with concrete elements which are lighter than asphalt will also play a beneficial role in reducing heat absorption and release and hence also in reducing heat stress in cities.

4.4 Green facades



Another way to cope with rising temperatures in buildings is the possibility to have green facades and roofs that naturally mitigate high external temperatures.

Precast solutions easily withstand the integration of both vertical and horizontal potting soil for the growth of grass and plants, with an aesthetically pleasant effect.

4.5 Weatherproof

Besides increasing temperatures, future construction will also have to withstand a changing and more aggressive climate. Flooding and extreme events are becoming more frequent.

The strength of precast solutions, together with their robustness and resilience, can ensure that buildings and infrastructure are better protected from these events.

4.6 Less susceptible to external conditions

Extreme events due to climate change are not only more frequent, but also more unpredictable and severe. Concrete structures are far less susceptible to external events than other construction solutions.

Once a structure is designed to withstand the required load, the contribution of external forces (wind, snow, etc...) is marginal. Simply put, safety is embedded within concrete structures.

4.7 Robust and resilient

Should such events affect a concrete structure, its durability and robustness allow it to recover its initial function in a shorter time than other materials, thus avoiding critical disruptions. Easy repair after a fire and resistance to humidity are examples of concrete's ability to restore its original functionality after exposure to potential damage.

4.8 Protection from forest fires...

Increasing temperature not only creates overheating problems, it also increases the chances of forest fires and their intensity.

Concrete is the best construction material when considering fire resistance. Not only it does not burn nor melt, but can be easily repaired after the devastation.

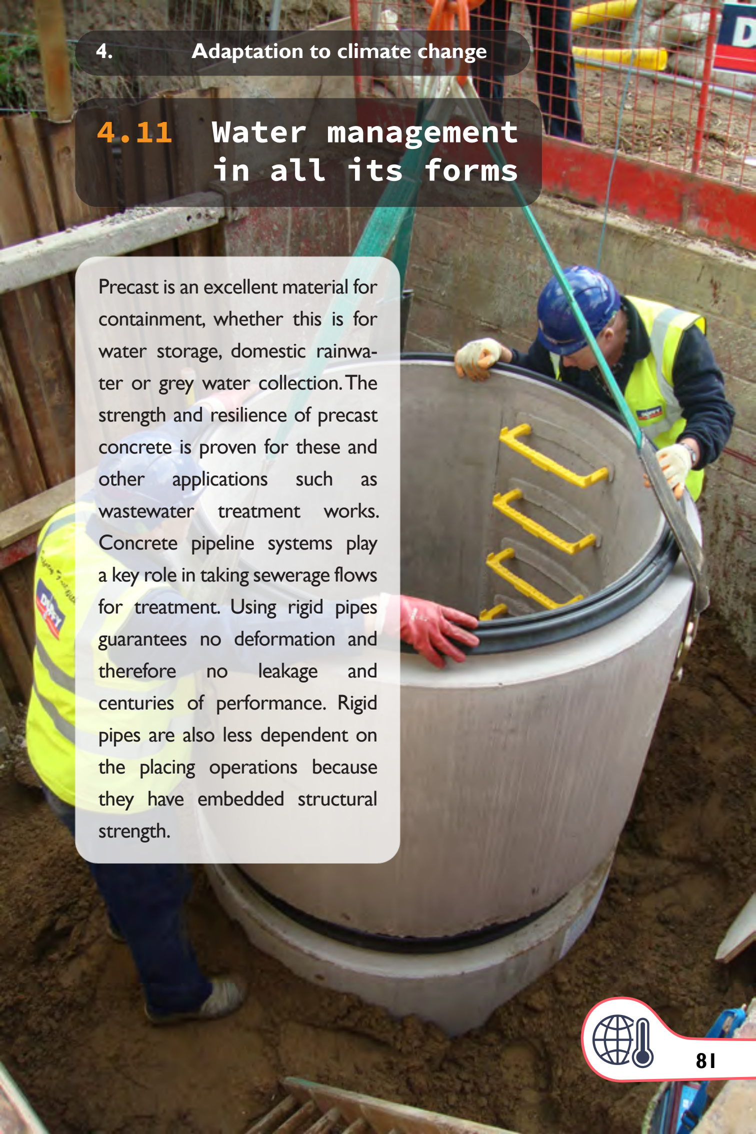
4.9 ...and blazes

Structures made of combustible or deformable materials are more vulnerable to fire, which can result in structural damage and a risk to life. In comparison, precast concrete can withstand high temperatures. Concrete can usually resist heat without collapsing for a minimum of 2–6 hours enabling sufficient time for rescue operations in cases of fire. Everything that is surrounded by concrete, including steel reinforcement, remains stable for sufficient time to allow the building to be structurally safe during evacuation.

4.10 Rockslides and avalanches

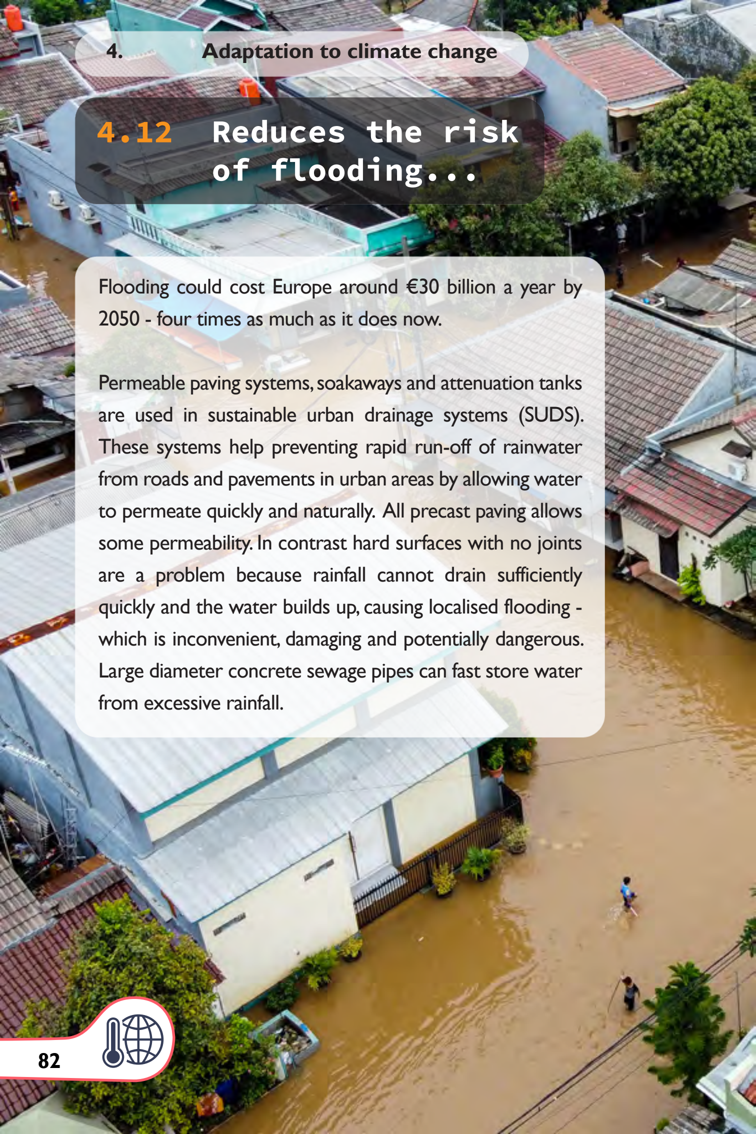
The impact of a rockslide or an avalanche can be disastrous, including loss of life and property. Retaining walls made of precast concrete provide an impenetrable barrier against rockslides and avalanches. The strength of concrete can contribute to the safety of people when these accidents occur.

4.11 Water management in all its forms



Precast is an excellent material for containment, whether this is for water storage, domestic rainwater or grey water collection. The strength and resilience of precast concrete is proven for these and other applications such as wastewater treatment works. Concrete pipeline systems play a key role in taking sewerage flows for treatment. Using rigid pipes guarantees no deformation and therefore no leakage and centuries of performance. Rigid pipes are also less dependent on the placing operations because they have embedded structural strength.

4.12 Reduces the risk of flooding...



Flooding could cost Europe around €30 billion a year by 2050 - four times as much as it does now.

Permeable paving systems, soakaways and attenuation tanks are used in sustainable urban drainage systems (SUDS). These systems help preventing rapid run-off of rainwater from roads and pavements in urban areas by allowing water to permeate quickly and naturally. All precast paving allows some permeability. In contrast hard surfaces with no joints are a problem because rainfall cannot drain sufficiently quickly and the water builds up, causing localised flooding - which is inconvenient, damaging and potentially dangerous. Large diameter concrete sewage pipes can fast store water from excessive rainfall.

4.13 ...and eases the clear-up

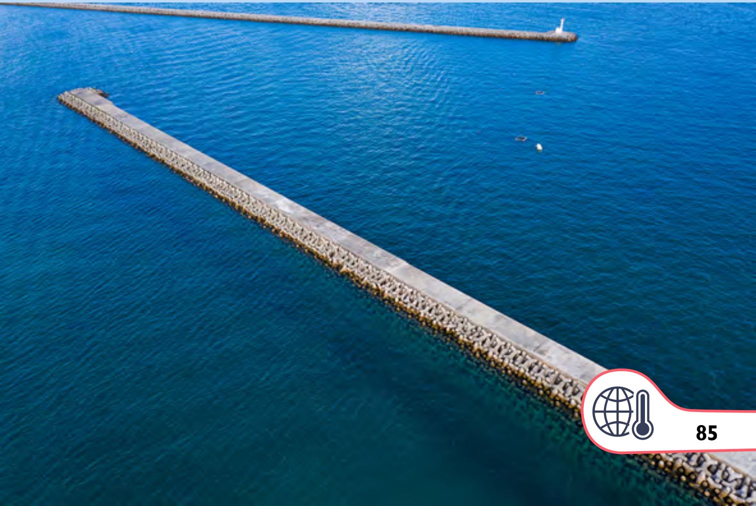
Compared to other materials, concrete resists water damage very well as it does not rot nor absorb water. The structure is therefore easy to clear-up and can quickly recover its function. This can be a difficult time for people struggling to come to terms with the devastation that floods can bring, so precast brings a welcome respite whether the flooding is a frequent or an occasional event.

4.14 Ground water management

Permeable paving and clean water sewage pipes allow the collection and infiltration of rainwater to replenish groundwater. It can also be used for some industrial or agricultural applications. Precast concrete tanks can be used to store water when managing the ground water level. Precast concrete systems can be designed specifically for this purpose, saving huge amounts of tap water.

4.15 Rising sea levels

Precast concrete sea defence walls, revetment walls, sea outfalls, tetrapods, tribars and dolos can help coastal cities adapt to rising sea levels caused by global warming. The outstanding durability and aesthetic quality of factory-produced elements make the material particularly suited to construction in tidal and flood prone areas. The use of similar precast elements can also be used to create breakwaters and artificial reefs out at sea.



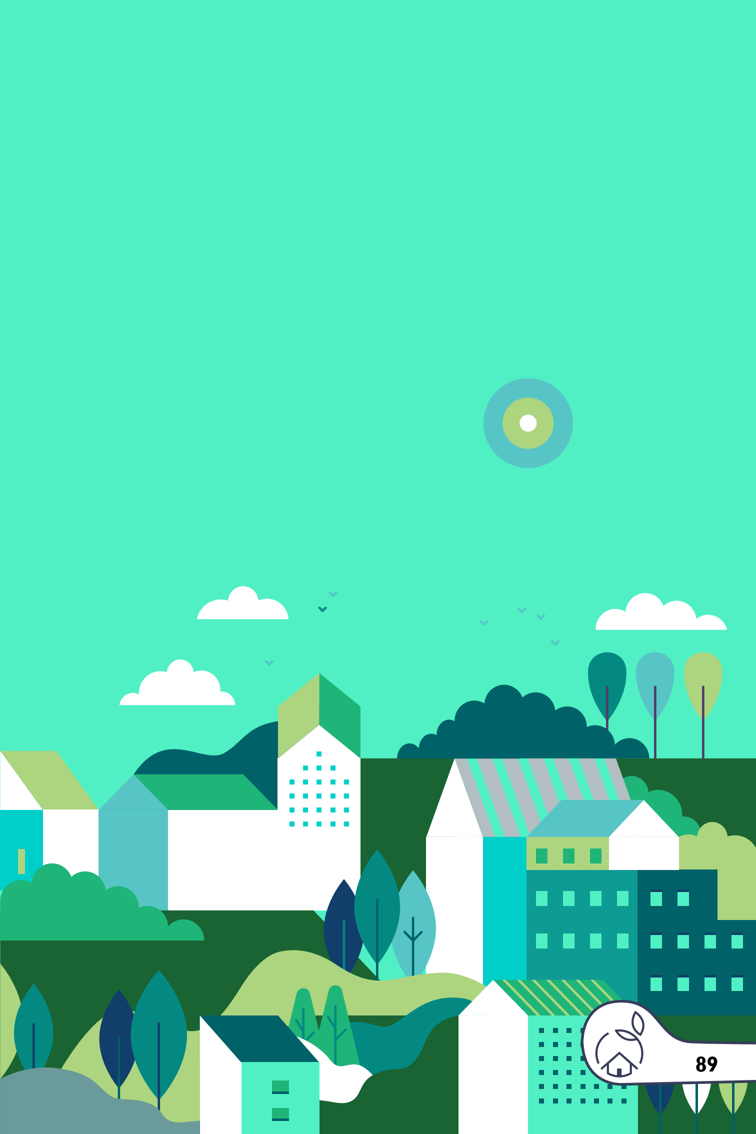
4.16 Overflow of rivers and lakes

It must be ensured that we keep control of sudden rises in the level of rivers or lakes. Mobile barriers made of precast concrete can easily be dispatched to affected areas, protect against the flood and then be relocated to where there is an evolving need. Precast concrete flood-mats and barriers can protect adjacent property and livelihoods.

Chapter 5

Achieving green building with precast

Today, green building design deals with aspects that go beyond the technical properties of a building and considers its long-term impacts on the society and the environment. Precast concrete can play a major role in green construction, through creating more energy efficient and low-emission buildings. It can create a structure that is environmentally responsible and resource-efficient throughout its life cycle. Thanks to its thermal mass, precast concrete reduces the losses of energy to the outside, creating a fully high-performance building.



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5.1 Sustainable choice

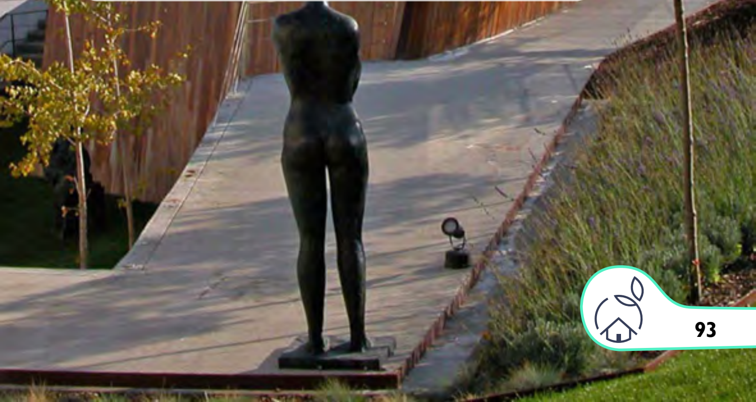
A ‘green’ building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can add value to the local environment. Green buildings preserve precious natural resources and improve our quality of life.

When considering the whole picture, precast concrete is the solution of choice. Not only does it reduce negative impacts on the environment (using less water, energy, natural resources) but it also creates a durable and affordable local asset.

5.2 Reduces embodied and operational energy

Embodied and operational energy are of equal importance in modern buildings. Reducing both is possible with precast concrete. By optimising concrete structures, as is the norm with precast, embodied carbon can be reduced whilst fulfilling the same function.

Over 60 years, a concrete and masonry home emits up to 15 tonnes less CO_2 than a lightweight alternative, thus providing a better long term solution. Research by Currie and Brown on commercial buildings show that, over a 30-year period, concrete structures are more cost-efficient than steel because they require less energy to heat and cool.



5.3 Thermal mass will ease summer overheating

A green building should be designed to withstand not only the present, but also future climatic conditions. Increasing temperatures will affect the energy-demanding cooling needs of buildings.

If we want to keep indoor temperatures pleasant, the use of products with high thermal mass like concrete are the best solution because they flatten the temperature peak. In contrast, lightweight homes with large windows may suffer significant overheating if summer temperatures rise as predicted.

5.4 Passive thermal mass

Concrete can store thermal energy like a battery.

This results in cooler rooms for living and working during summer and warmer ones during winter.

This effect also addresses day/night temperature shifts.

5.5 Active thermal mass

Activating thermal mass means that energy is stored in concrete and used for heating or cooling. This important characteristic of precast concrete can be seen in its application as a medium for heating or cooling, whether via air or fluids. The hollow cores in precast floors can be used or pipes can be cast into slabs to form cooling systems that use up to 50% less energy than air conditioning.

Precast piles are also available with built-in ground source heat exchange systems.

5.6 Integration with renewables

Renewable energy is the fastest-growing energy source in Europe. Precast is the perfect match for integrating renewable energy sources into a building. It can easily withstand the weight of solar panels on roofs or walls. Alternatively, these panels can be integrated into the precast structure during casting.

5.7 Uses the building as battery for renewable energy

The 'buildings as battery' concept (BaB) is one route to achieve net zero energy, creating a sustainable, livable, and efficient houses.

Precast concrete elements can provide a good option for renewable energy storage while reducing peak hour consumption. Integration with grid management can potentially save 25% of CO_2 emissions and 50% in peak electricity for a total saving of 300 € per year.

5.8 Heat radiation instead of convection

Heating by heat-radiation is much more effective and provides more comfortable spaces than traditional convection heating.

The air in the room is not heated, but the heat comfort is provided by the radiation effect, thus reducing the energy consumption for the same effect.

Concrete surfaces radiate effectively, protecting the heating or cooling system within and allowing room space to be used without the cost and hindrance of radiators or ducting.

5.9 Green roofs

Green roofs are gaining popularity and can be perfectly integrated with precast concrete solutions. They provide a wonderful added value to a building in terms of sustainability, ecological footprint and energy use. An area of growth in green building is the use of a vegetative layer to cool city streets, cut heating and air conditioning costs, reduce water and air pollution, whilst providing local food and encouraging biodiversity. Green roofs have also been proven to help reduce the urban heat island effect.

However, this layer of vegetation is quite heavy, especially if it designed for rain retention, and only concrete can support such an additional load.

5.10 Vertical farming

Vertical farming is a form of controlled environment agriculture (CEA) - an ambitious concept in which entire buildings could be dedicated to large-scale farming. It offers the possibility of greater sustainability for urban areas by producing crops on multiple levels using indoor farming techniques. Precast concrete elements can help to bring modern farming closer to urban centres and higher structures for increased productivity.

5.11 Urban gardening

Growing plants in an urban environment may have a positive impact on the economy, the environment, food security and even societal progress and well-being. Precast concrete elements can be used in urban horticulture when arranging vertical gardens, roof gardens or building-integrated agriculture (BIA).

5.12 Durability for generations

Thinking long term is a must for today's green buildings; they need to be used for generations, whilst minimising maintenance and operational costs.

No material other than concrete can provide a long service life of 100 years or more. If any maintenance is required, it is very easy and affordable because concrete does not need protective layers (which preserve the material or protect against fire) to be regularly refurbished.

5.13 Weatherproof material...

Precast concrete is resistant to rain penetration and wind-blown debris – only concrete and masonry walls can provide this protection. In a study of exterior wall systems, Texas Tech University's Wind Engineering Research Centre found that only concrete wall systems were proven to withstand 100% of all recorded hurricane-force winds, and over 99% of tornado-force winds. Besides it protects against the debris that is flying around in hurricanes and tornados.

Concrete can also withstand many winters of freeze-thaw cycles, unlike other materials that can deteriorate quickly with such regular exposure to climatic changes. In damp, exposed, or harsh environments, other materials struggle to match the performance of concrete.

5.14 ...and construction

A heavy concrete structure will be less affected by the increasing loads linked to external events (snow, wind) than a lightweight one. Heavy winds will also inflict much less damage on concrete structures than on other materials.

The structural advantages of concrete also benefit infrastructure: in the case of flooding, erosion of the upper layer of the road will likely leave a concrete pipe in place, whereas a plastic pipe will float away.

5.15 Design for disassembly

Designing a concrete building for easy disassembly (DfD) could enable the reuse of its component parts in other construction projects, reducing use of raw materials and lowering waste during construction, renovation and demolition. It is possible through the application of DfD criteria on precast concrete elements to change the linear life-cycle model to a circular one. This shift to a circular model has the potential to reduce the environmental impact of construction by reducing material taken to landfill.

5.16 Contribution to ratings

More and more homes and business premises in the EU are being built to exacting sustainability schemes, such as BREEAM, LEED or DGNB. Specifiers therefore need to be confident about the products they select.

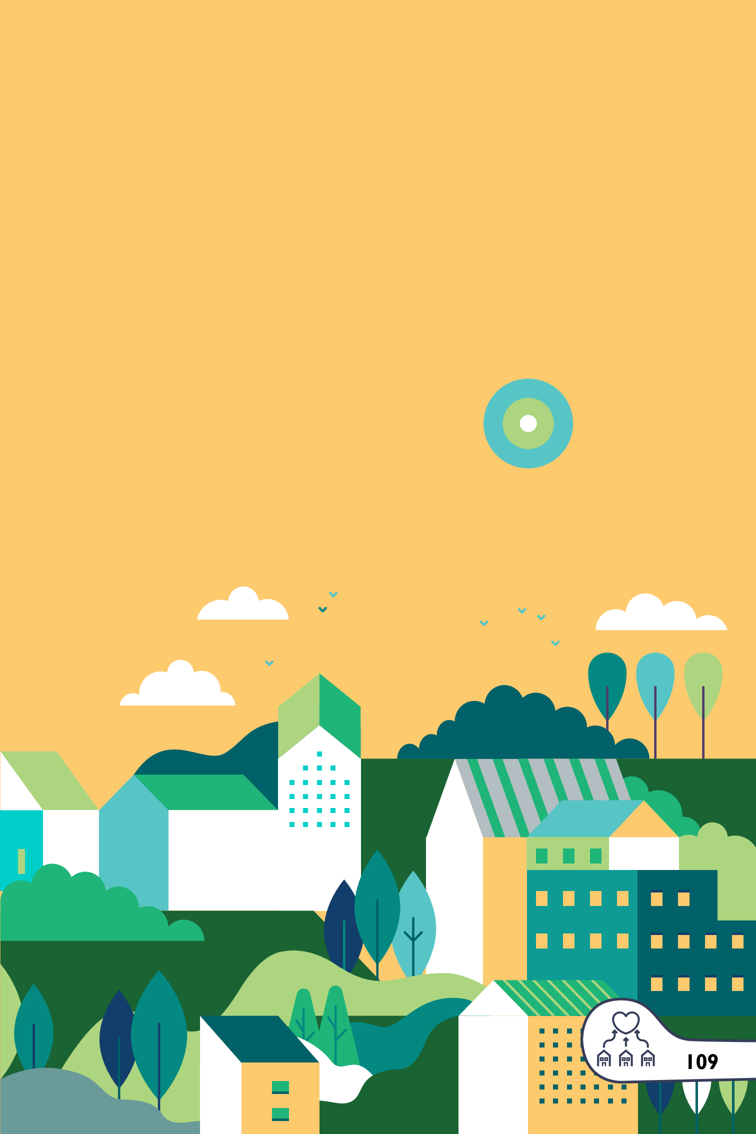
Using precast structures improves the scores linked to:

- energy efficiency;
- indoor air environment;
- acoustic performances;
- thermal comfort;
- absence of harmful substances;
- responsible sourcing of materials;
- positive impacts to the local economy;
- reusability and recyclability;
- water management.

Chapter 6

Human well-being

As humans, we spend most of our time in buildings and we are surrounded by concrete. The new sustainability trend in construction takes a holistic design approach with a focus on healthy and comfortable architecture. It is also important to create a safe and healthy working environment and urban space.



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6.1 Helps creating healthy indoor environments

Home is a place where people should feel secure and relaxed. It must be healthy, thermally and acoustically comfortable and safe.

Building with precast can enhance human well-being thanks to the inherent properties of concrete, which acts as a barrier between the internal and the external environment.

6.2 Precast is emission free

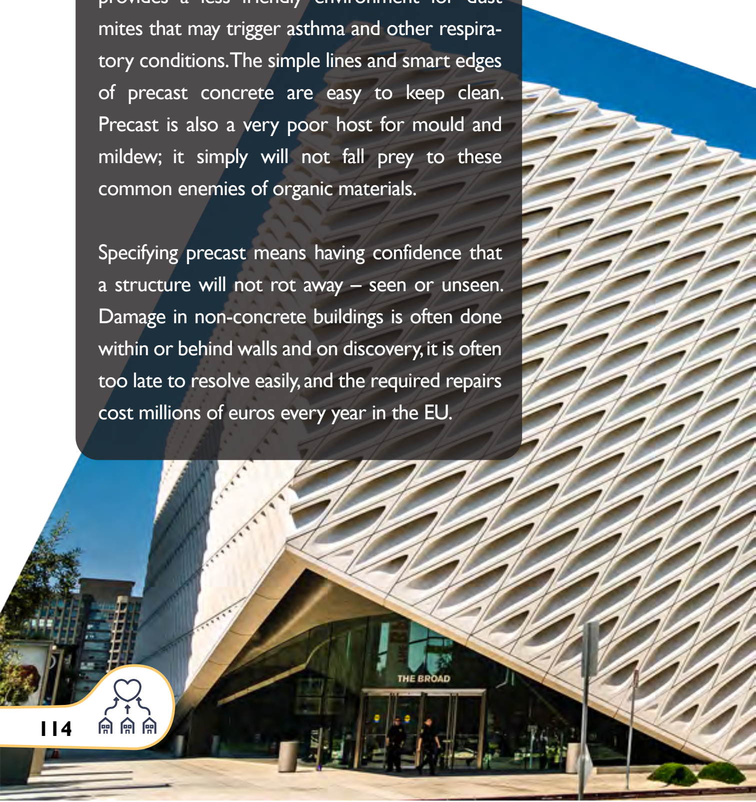
In its daily use, precast concrete doesn't emit or give off any gases, toxic compounds or volatile organic compounds.

This means allergy sufferers can breathe easy because precast does not contribute to the symptoms of 'sick building syndrome'. A concrete house is also advised to Chronic Obstructive Pulmonary Disease (COPD) patients.

6.3 Avoids mildew...

Precast for housing reduces diurnal temperature ranges meaning less internal condensation; this provides a less friendly environment for dust mites that may trigger asthma and other respiratory conditions. The simple lines and smart edges of precast concrete are easy to keep clean. Precast is also a very poor host for mould and mildew; it simply will not fall prey to these common enemies of organic materials.

Specifying precast means having confidence that a structure will not rot away – seen or unseen. Damage in non-concrete buildings is often done within or behind walls and on discovery, it is often too late to resolve easily, and the required repairs cost millions of euros every year in the EU.



6.4 ...and attacks from insects and rodents

In its daily use, precast concrete doesn't emit or give off any gases, toxic compounds or volatile organic compounds.

This means allergy sufferers can breathe easy because precast does not contribute to the symptoms of 'sick building syndrome'. A concrete house is also advised to Chronic Obstructive Pulmonary Disease (COPD) patients.

6.5 Does not leach

Precast does not leach out any harmful chemicals. When precast concrete is used to store or transport potentially harmful fluids, these will be contained securely although seeking specialist advice is always recommended when dealing with harmful chemicals.

Precast concrete pipes have been subjected to extensive testing in this respect. European studies have confirmed the importance of concrete pipeline systems in ensuring safe transportation networks for sewage effluent.

6.6 Can be self-cleaning

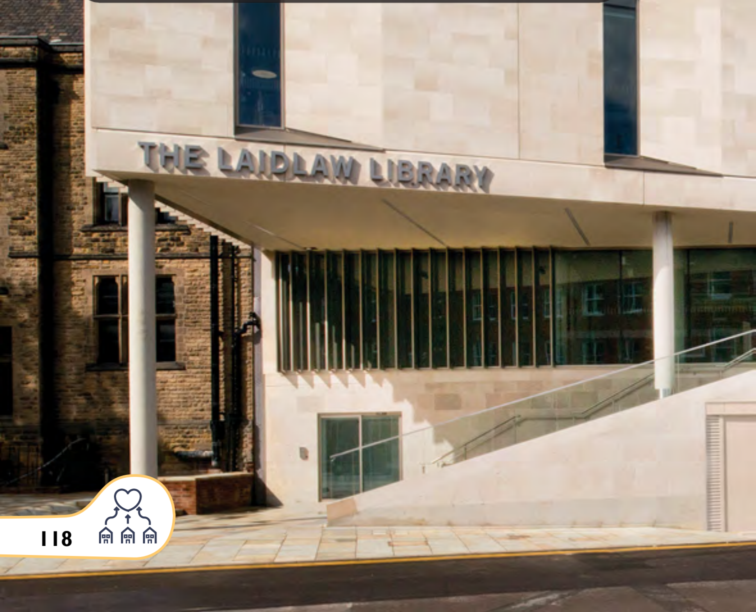
The optional inclusion of additional compounds in the concrete mix does not only lead to the production of white precast concrete but also helps to keep the finished product clean. The additions achieve this by capturing dirt particles which are then washed away by rainfall.

Clean buildings look more attractive and support physical and mental health.

6.7 Quiet...

As a dense material, precast elements in a building make for a peaceful lifestyle. It is the mass of concrete which helps to dampen noise, whether this arises from people talking, playing music or doing DIY activities.

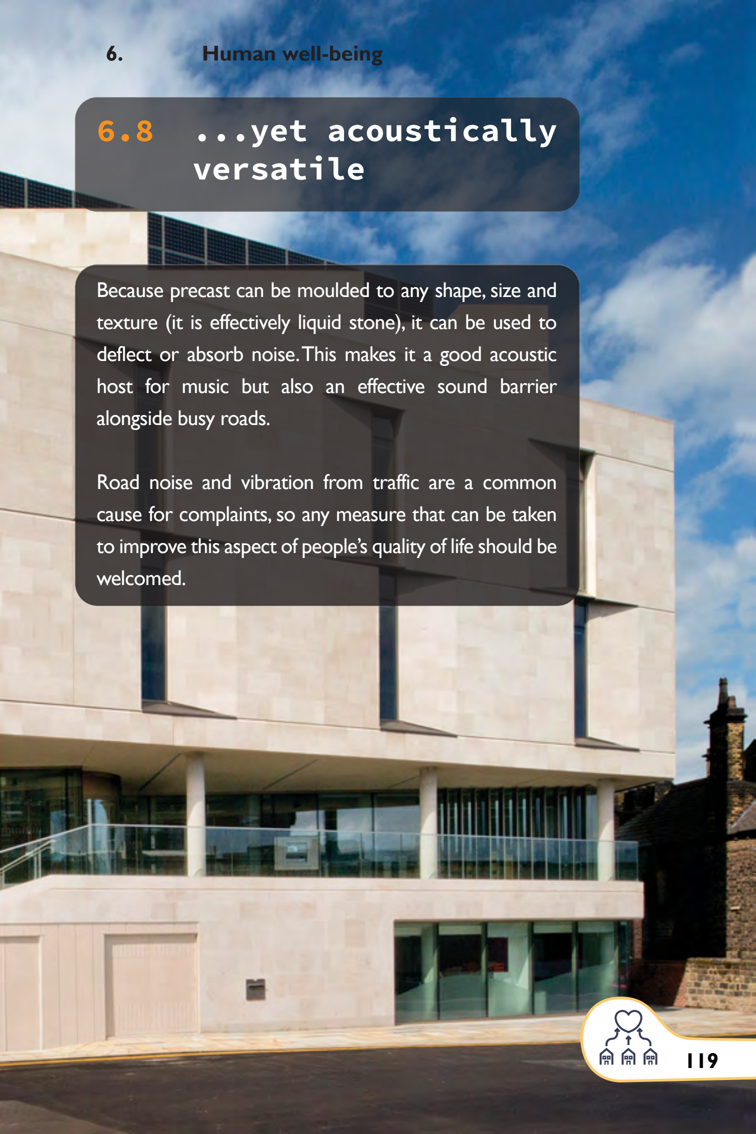
Privacy and effective sound reduction are thus ensured, which is why precast walls and floors are an excellent choice in schools and multiple occupancy dwellings.



6.8 ...yet acoustically versatile

Because precast can be moulded to any shape, size and texture (it is effectively liquid stone), it can be used to deflect or absorb noise. This makes it a good acoustic host for music but also an effective sound barrier alongside busy roads.

Road noise and vibration from traffic are a common cause for complaints, so any measure that can be taken to improve this aspect of people's quality of life should be welcomed.



6.9 Protects against fire...

Precast is fireproof. It does not catch fire or burn. It protects against the spread of fire between rooms or properties – fewer fire-related deaths are recorded proportionately in concrete buildings. In fire tests, concrete performs consistently well, typically needing very little remedial treatment following exposure to the high temperatures of a fire. In most cases, some minor patching and a new coat of paint may be all that is required to make good.

Studies in Sweden have indicated that a major fire is more than 10 times less likely to develop in houses built from concrete or masonry. Furthermore, a study from the Vienna University of Technology has also found a clear link between construction materials and fire safety – there are about three times fewer fire victims in countries which build mainly in concrete, masonry and stone.

6.10 ...with no need for potentially harmful protective layers

Just like many other concrete and masonry materials, precast concrete does not melt in high temperatures. This means that there is no need for protective paints or special insulation – and finishes can be viewed just as the designer intended. Concrete will not drip molten particles in a fire, helping protect human life by providing safe escape routes and preventing fire spread. Concrete will also not create toxic fumes in a fire.

6.11 Offers a safe haven...

In a large building, concrete structures are often used for stair cores (escape routes) and can form a protective area around designated places of safety.

The structural strength and dense nature of precast concrete makes it an ideal choice for safe or panic rooms in houses.

6.12 ...and keeps buildings secure

Tackling the fear of crime and disorder is a major issue within social sustainability and security also has a massive impact on people's livelihoods.

Whether for homes, businesses or increasingly for prisons, precast is secure against break-ins and break-outs; it cannot easily be cut open and is extremely resistant to impact.

6.13 Absorbs impacts and offers blast protection

Precast concrete can resist massive impacts. There is a growing need for the built environment to be more resilient to the threat of flooding and fire. In extreme applications, blast protection from explosions may also be a necessary design criterion. Sufficiently reinforced and thickened precast units can perform a critical role here.

Many high-profile infrastructure projects and government buildings feature precast concrete products because of their robustness and resilience. Some have unfortunately been put to the test, and have proved impenetrable under attack.

6.14 Acts as an aid to visually impaired people...

It is common to see textured or profiled paving slabs near pedestrian crossings. Tactile paving helps visually impaired people to recognise changes in level and direction, as well as dangers from passing traffic or other hazards.

By making our towns and cities more useable and attractive to all, we can better facilitate social inclusion and accessibility.

6.15 ...and to others

The same techniques of casting-in textures can be used to increase the skid resistance of the surface of a precast concrete product. This can be particularly useful in busy paved areas, steps and ramps where, for example in winter, icy patches could cause slips and falls.

Precast concrete wheelchair ramps are commonly used because they are convenient and quick to install.

6.16 Built for generations

Precast concrete homes can be passed from parents to children with the confidence, leaving a real legacy for future generations. By adhering to the principles of 'lifetime homes', successive generations can be accommodated in the same properties without recourse to major changes or relocation.

Not only do precast homes have a long lifespan, but parts of buildings (bathroom pods, new rooms, garages) can be prefabricated for inclusion.

6.17 Resistance to aggressive environments

Precast concrete is gaining special importance due to its ability to resist severe environmental conditions such as marine environments, harsh environments (high & elevated temperature), regions with high humidity or sulphate rich environments.

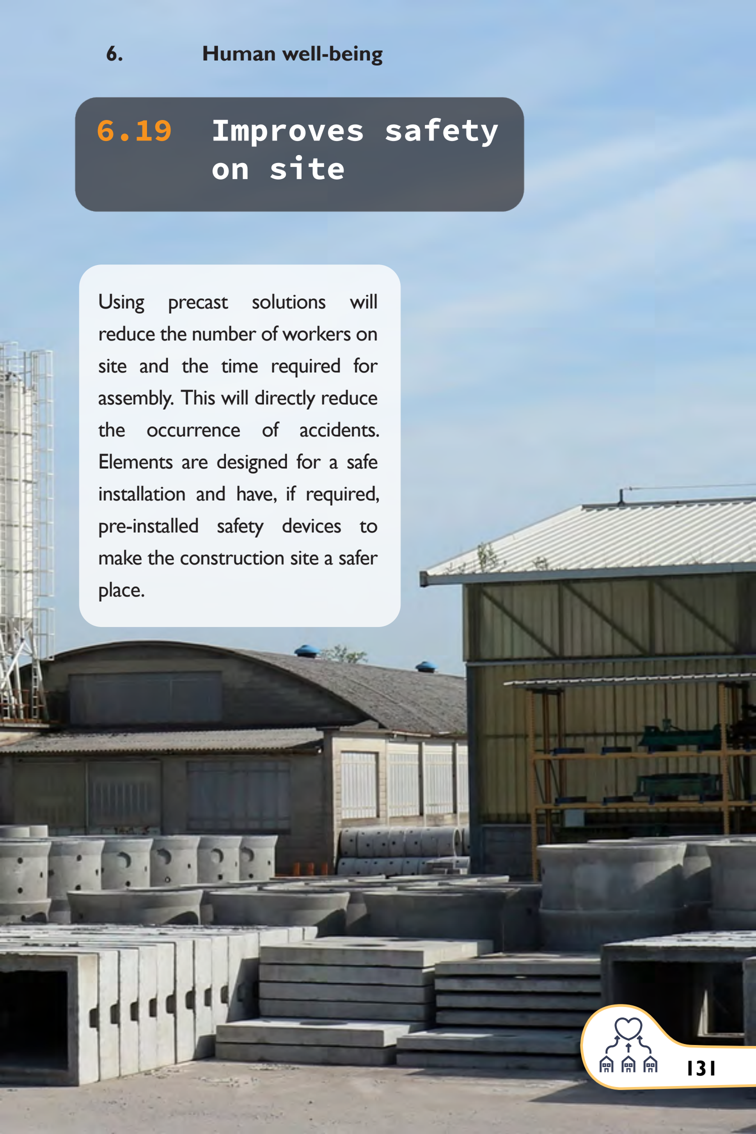
For vehicle hard-standing, aircraft standing aprons and other paved areas, concrete paving blocks are an ideal choice because they are resistant to fuel and oil spills. Their use makes sense economically and environmentally because pavement repairs are localised, using less materials and causing less disruption.

6.18 Workers conditions are better in a factory

Precast workers can benefit from a safe, industrialised environment that they become familiar with, reducing the risk of accidents.

Precast can be installed during harsh weather conditions where in-situ construction may be delayed because it is manufactured ahead of time in a protected factory environment.

6.19 Improves safety on site



Using precast solutions will reduce the number of workers on site and the time required for assembly. This will directly reduce the occurrence of accidents. Elements are designed for a safe installation and have, if required, pre-installed safety devices to make the construction site a safer place.

6.20 Provides an instant work platform...

Precast structures and in particular floors and staircases provide an early, secure and broad platform from which subsequent site activities can be undertaken.

This solid footing helps speed up construction and gives managers confidence that operatives can go about their work safely – allowing safe access and egress, even in an emergency.

6.21 ...and safety for neighbouring properties

The fast installation of precast concrete elements is a major advantage of this construction solution, which in turn has the effect of lowering disturbance to neighbours during assembly.

The quick and easy installation of precast products makes for much less noise from the construction site because there is not the need to vibrate concrete. This is of great benefit to those inhabiting or working in adjoining properties; life is quieter and therefore much more tolerable during the construction period.

In addition, a precast site will emit virtually no dust – lessening the likelihood of problems with dirt and poor air quality, the most common causes for complaint amongst construction's neighbours.

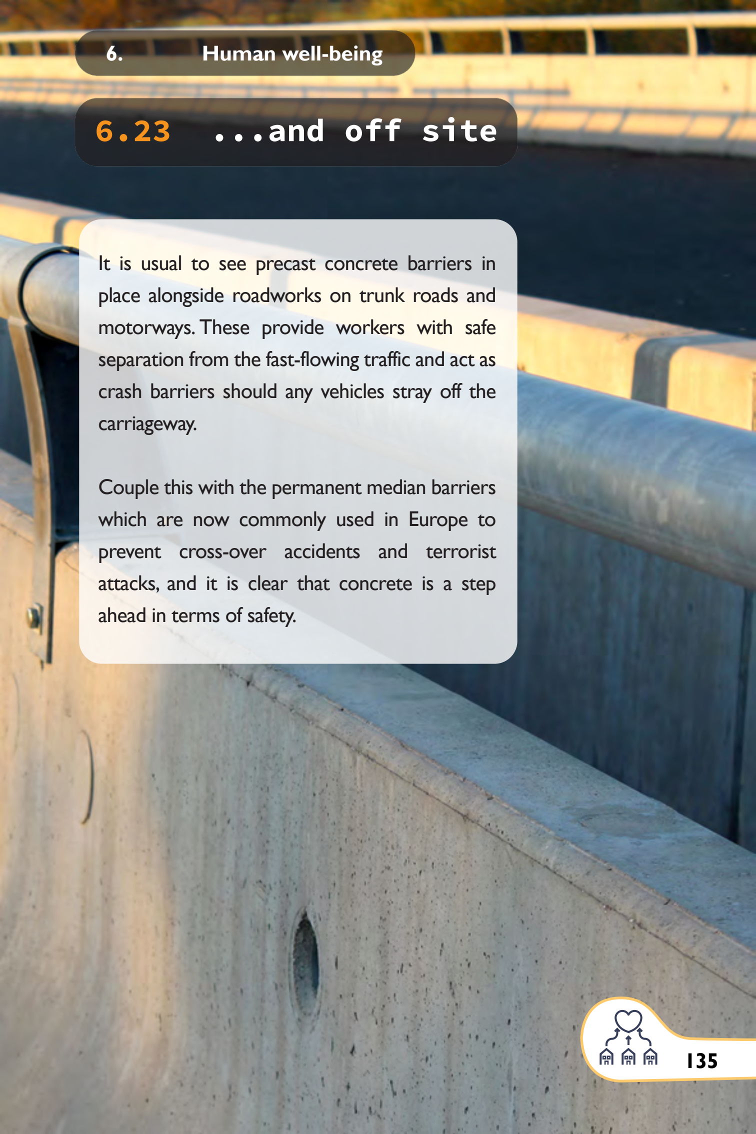
A hub near to the construction site will secure just in time delivery and less disturbance during rush hours.

6.22 Protects the workforce on...

By placing solid precast barriers between pedestrian walkways and traffic routes on a construction site, managers can be more confident that their site is a safer place to move around for site workers and visitors alike.

Concrete barriers save lives by absorbing the impact from vehicles.

6.23 ...and off site



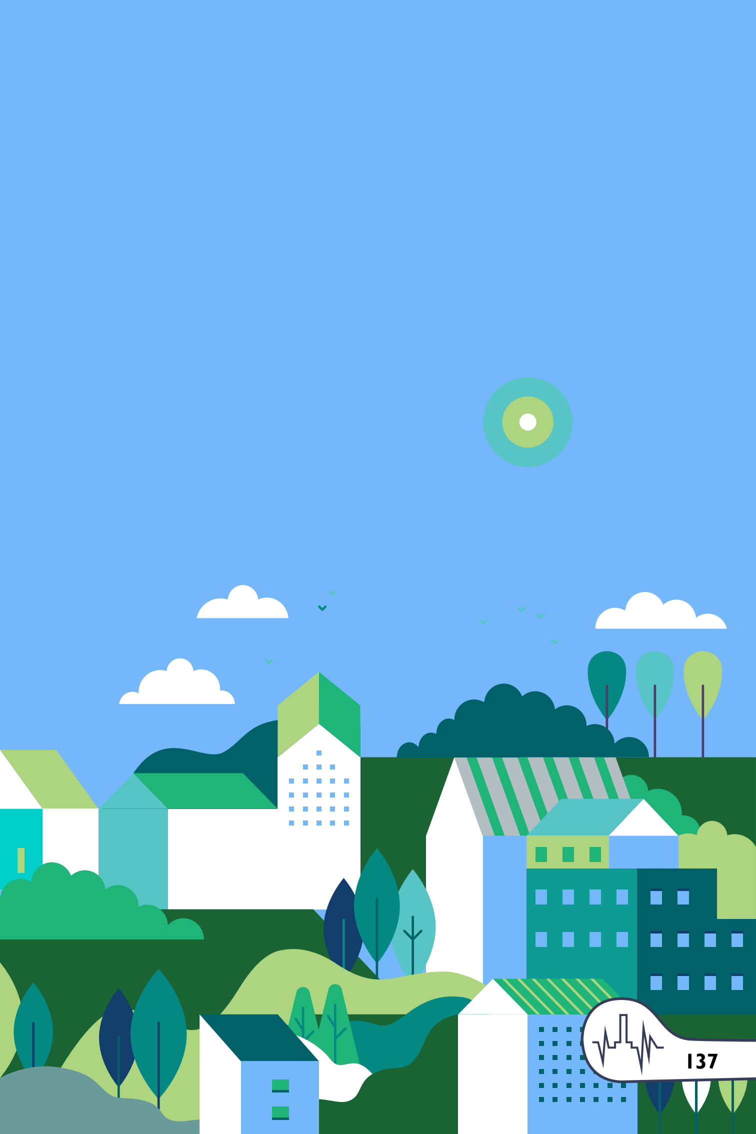
It is usual to see precast concrete barriers in place alongside roadworks on trunk roads and motorways. These provide workers with safe separation from the fast-flowing traffic and act as crash barriers should any vehicles stray off the carriageway.

Couple this with the permanent median barriers which are now commonly used in Europe to prevent cross-over accidents and terrorist attacks, and it is clear that concrete is a step ahead in terms of safety.

Chapter 7

Future cities and buildings

Precast concrete buildings can be designed to create unique modern spaces that are efficient, affordable and in line with stylish city architecture. Modern city infrastructure must be resilient and adaptable to changing an environment. During the design, manufacture, and build process, precast concrete manufacturers are taking into account individual needs in order to create a healthy built environment.



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7.1 Efficient land use above the ground...

Efficient land use is the key challenge for most cities. Combining free and green spaces with vertical development is the vision for sustainable and liveable cities. Precast concrete offers opportunities to develop multi-floor yet aesthetic solutions.

Integration of commercial and residential spaces in the same building is also a challenge that can be addressed with precast structures, thanks to their flexibility. Roof tops made of precast can host additional space for urban gardening or leisure activities.

Precast concrete responds well to this important aspect of social sustainability in its flexibility, modularity and effective use of space. Entire buildings, including houses can be precast or only part of them (lift shafts, stairs, balconies).

7.2 ...and below

The space beneath a building can host several services (parking, storage, etc...) saving space above ground. Basements can reduce heating and cooling costs as it is a form of earth sheltering. If the height of the house is limited by city planning, basements can save up to 27% of land required to build the same volume of living space in a house with two stories above ground.

Infrastructure developed underground can also save space and avoid disturbances. Tunnels, metro stations and other infrastructure can be effectively built with precast. Today, for basement walls insulation is obligatory for most rooms, so living and working space of high value are created. Modern design with bigger light wells means that daylight can be utilised more efficiently. So in a single family home you can increase the valuable floor space by a third through the addition of a basement.

Precast concrete basements can provide easily adaptable extra space for playrooms, utility rooms or even home offices – removing the need for commuting. That same house is automatically up to 10% more energy efficient as 1/3 of its volume is below ground.

7.3 Embracing circular economy

Future cities need to fully embrace the principles of a circular economy. Buildings that are designed today need to be built to last, be able to adapt to changing user needs, be demountable and finally recyclable.

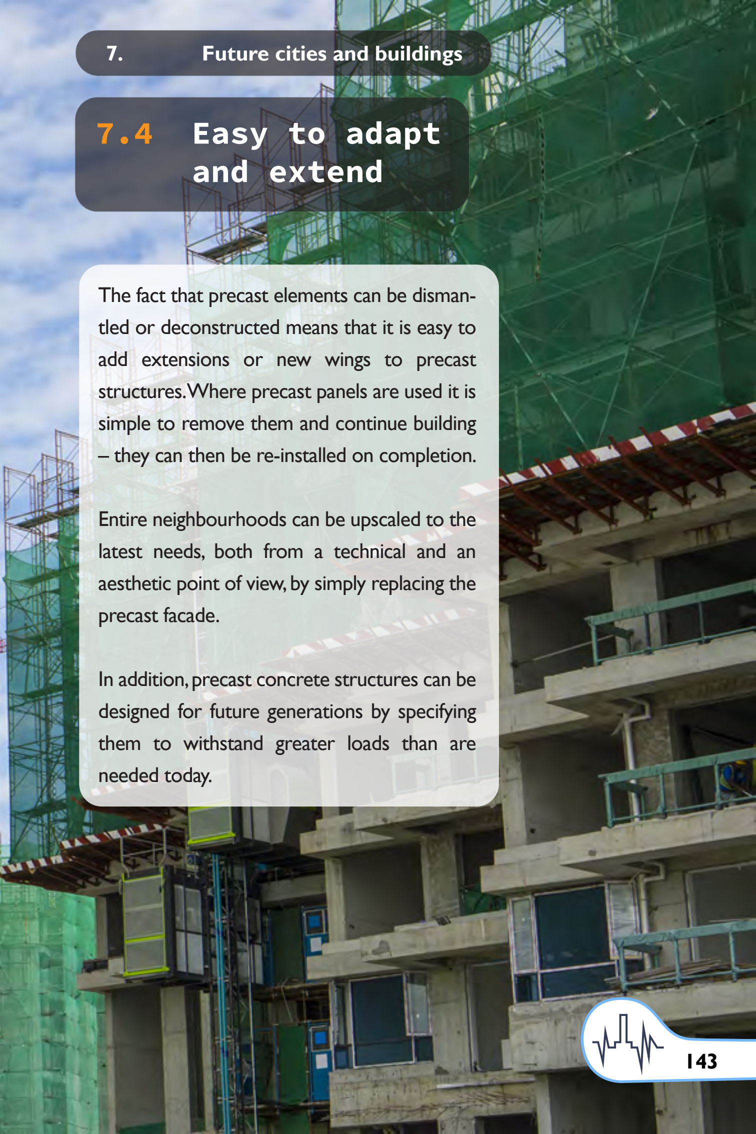
Only precast solutions can offer these four aspects in one single product, providing cities with the necessary flexibility to adapt to changing needs whilst minimising their impacts. Considerable flexibility can be built into precast concrete. Thanks to its generally longer spans and bigger open spaces, the initial purpose of a building can easily be adapted to the changing needs of the user.

7.4 Easy to adapt and extend

The fact that precast elements can be dismantled or deconstructed means that it is easy to add extensions or new wings to precast structures. Where precast panels are used it is simple to remove them and continue building – they can then be re-installed on completion.

Entire neighbourhoods can be upscaled to the latest needs, both from a technical and an aesthetic point of view, by simply replacing the precast facade.

In addition, precast concrete structures can be designed for future generations by specifying them to withstand greater loads than are needed today.



7.5 Infrastructures for living needs and connecting people

Future cities are not only buildings. Citizens need outdoor places and spaces to live and meet. These can be perfectly arranged with precast concrete solutions.

Commuting needs can be facilitated through the use of precast solution, be it for personal (e.g. bike lanes) or public (above or below the ground) transportation.

Underground precast pipe systems further allows for a sustainable management of waste and rain water.

7.6 Essential for sustainable transport systems

Clean, greener options for travelling to work, school or home are being built throughout Europe, and precast concrete is at the heart of many schemes.

Guided bus lanes and track beds, and bridges for light rail or tram systems commonly include precast elements because they are long-lasting, durable, robust and can also have a very attractive surface finish or solar panels.

7.7 Can reduce traffic fumes

Future cities are not only buildings. Citizens need outdoor places and spaces to live and meet. These can be perfectly arranged with precast concrete solutions.

Commuting needs can be facilitated through the use of precast solution, be it for personal (e.g. bike lanes) or public (above or below the ground) transportation.

7.8 Efficient water management systems

Water is, and will be, a very important resource to be sustainably managed today and in the future. Precast is an excellent material for containment, whether this is for water storage, domestic rainwater or grey water collection.

Concrete pipeline systems play a key role in taking sewage flows for treatment. Using rigid pipes guarantees no deformation and therefore no leakage, as well as centuries of performance. Rigid pipes are also less dependent on the placing operations because they have embedded structural strength.

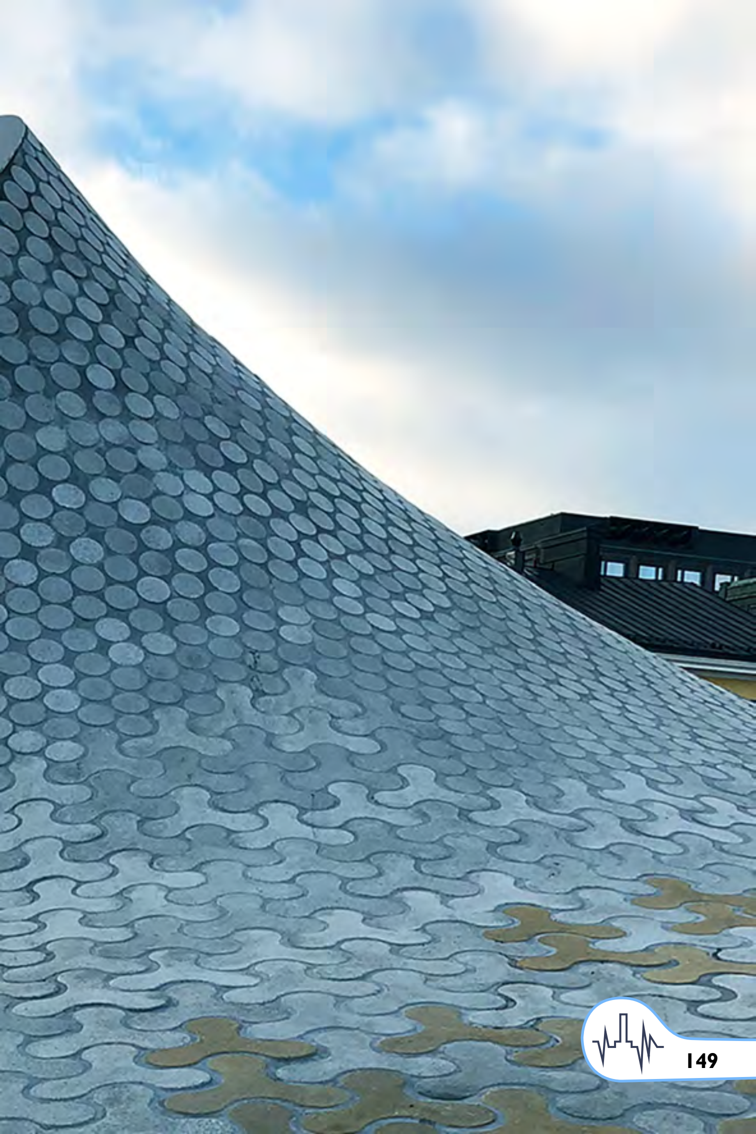
A parallel system separating rainwater from wastewater can easily be installed using precast concrete elements in order to use the former for ground water replenishment, industrial and agricultural applications. Systems composed of permeable paving and pipes can deal with intensive rain and flood. In case of extreme dry weather and drought, precast tanks and pipes can distribute excess water accumulated during wetter periods.

7.9 Perfect for outdoor leisure facilities

Everywhere you look you will see innovations in hard landscaping and street furniture constructed using precast concrete.

Precast concrete units can be easily used to form Parkour, bike and skatepark facilities. Boardwalks, ramps and bike paths made of precast have a smooth and durable riding and walking surface. Precast concrete benches can provide an area of rest for large outdoor living spaces.

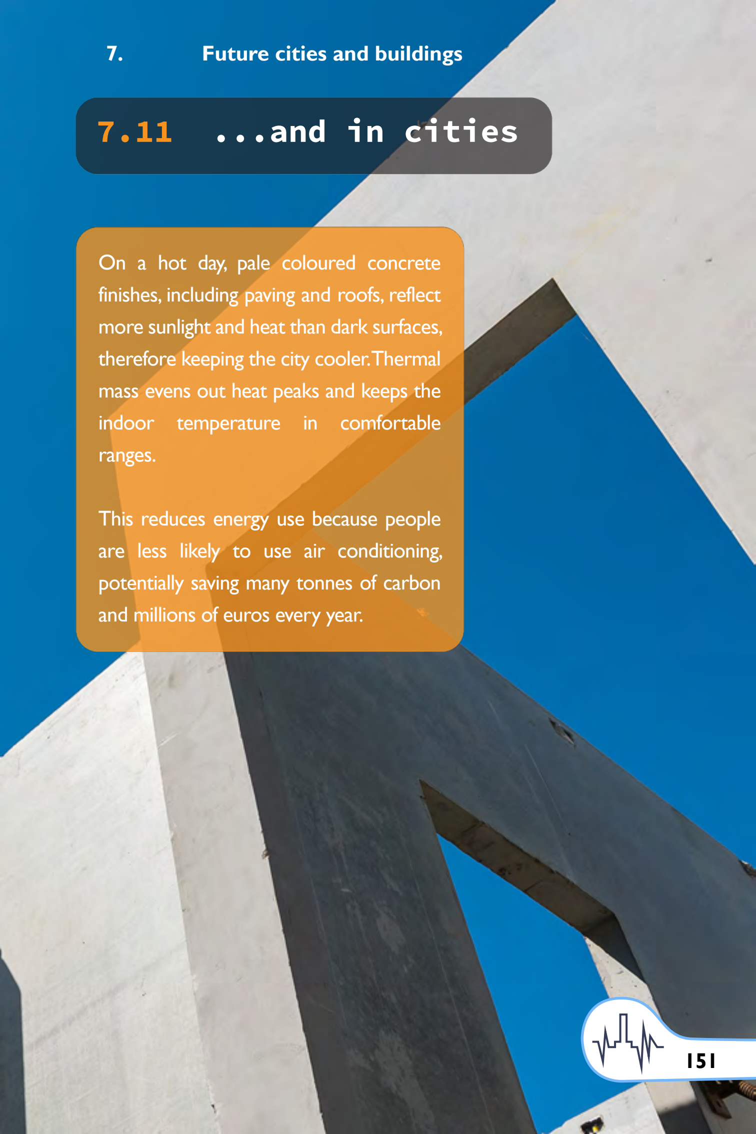
Large planters, planted bridge abutments and living walls help to make places greener and more pleasant.



7.10 Saves energy in buildings...

Using the thermal storage capacity of concrete in combination with renewable energy and heat pumps can also reduce the use of fossil fuels for heating purposes.

A very effective approach to increase the energy efficiency of buildings is the intelligent use of load-bearing components made of concrete for storing thermal energy. Pipe systems are installed into large-scale components made of concrete, such as storey ceilings, to transport a heat carrier, which can be used to control the temperature in adjacent rooms. In the building industry, this system is known as "thermal component activation".



7.11 ...and in cities

On a hot day, pale coloured concrete finishes, including paving and roofs, reflect more sunlight and heat than dark surfaces, therefore keeping the city cooler. Thermal mass evens out heat peaks and keeps the indoor temperature in comfortable ranges.

This reduces energy use because people are less likely to use air conditioning, potentially saving many tonnes of carbon and millions of euros every year.

7.12 Clean energy from wind turbines

Future cities will rely on renewable energy, including solar and wind. Precast concrete is often used for very high wind turbines – its high levels of weather resistance and inherent stiffness help provide a stable and resilient structure.

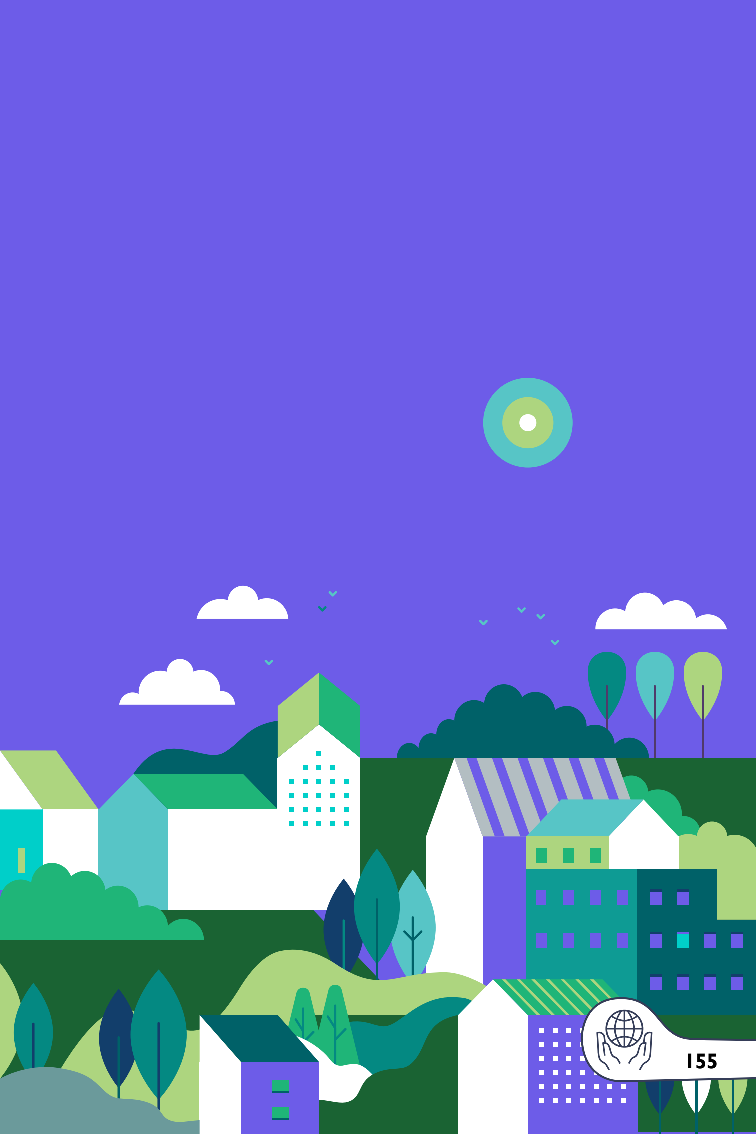
Wind turbines are often placed in the harshest environments, so it is important to use a structural material that does not rust or decay.

7.13 Minimises reliance on fossil fuels

Even on a domestic scale, precast products support the drive to use renewable technologies. Photovoltaic cells can easily be integrated with concrete. There are several examples of concrete tiles, facade panels and even bicycle paths that produce solar energy with this technology.

Chapter 8
Precast, construction of the future

Precast concrete is rapidly becoming one of the dominant ways to build the modern world. By coupling the excellent properties of concrete as material with an industrialised manufacturing environment, precast is the perfect choice for a fast and efficient solution in construction. The versatility and flexibility of concrete means that it is a suitable material for a wide range of applications in the built environment for today and tomorrow.



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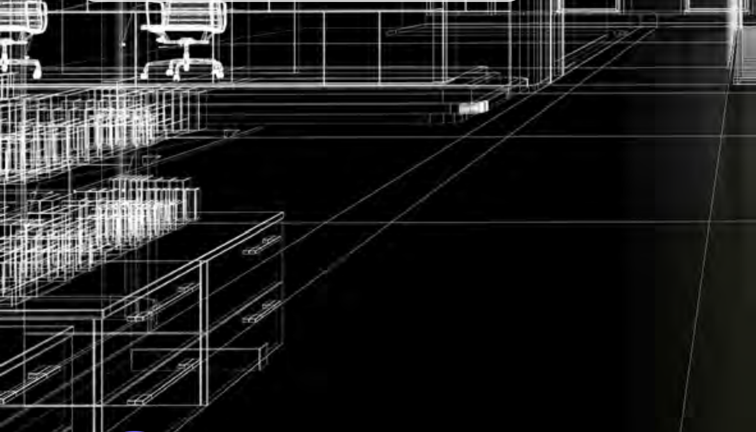
8.1 The key actor in the digital transformation of the construction sector

The construction sector will undergo a digital transformation in the years to come. Thanks to the benefits of an industrial environment coupled with the flexibility of concrete, precast solutions can be the "missing link" between the digital world and the construction sector.



8.2 BIM

The BIM methodology is object-oriented. So is the precast concrete industry! BIM and precast go together like a horse and carriage. Precasters encourage their clients to adopt the BIM approach and to become part of the digital building process. With BIM and precast concrete you get the maximum out of your 3D design, you construct faster and you avoid mistakes. Since the BIM database is feeding our machines and we apply strict quality procedures, you can rely on the fact that what you see is what you get.

8.3 Future proof solutions

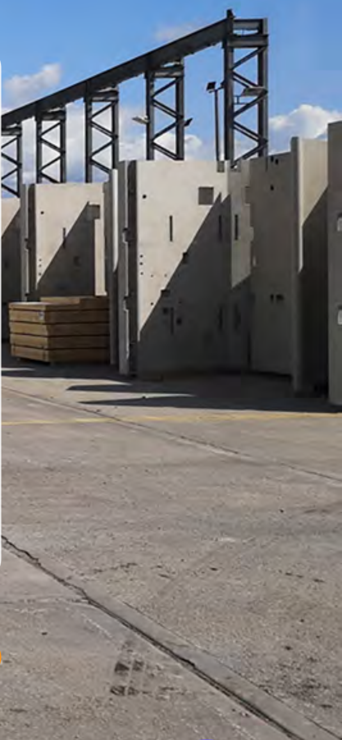
Throughout this whole publication, the compatibility of precast concrete with future users' needs has been highlighted.

Thanks to their flexibility and resilience, well-designed precast structures can adapt to the changing needs of the user and the altering external conditions.

8.4 Multiplier effect of 2.8 – strengthening the local economy

Through the use of precast concrete, you strengthen the local community. The raw materials used in the manufacture of precast concrete are usually local materials. The companies provide local employment and contribute to local social security.

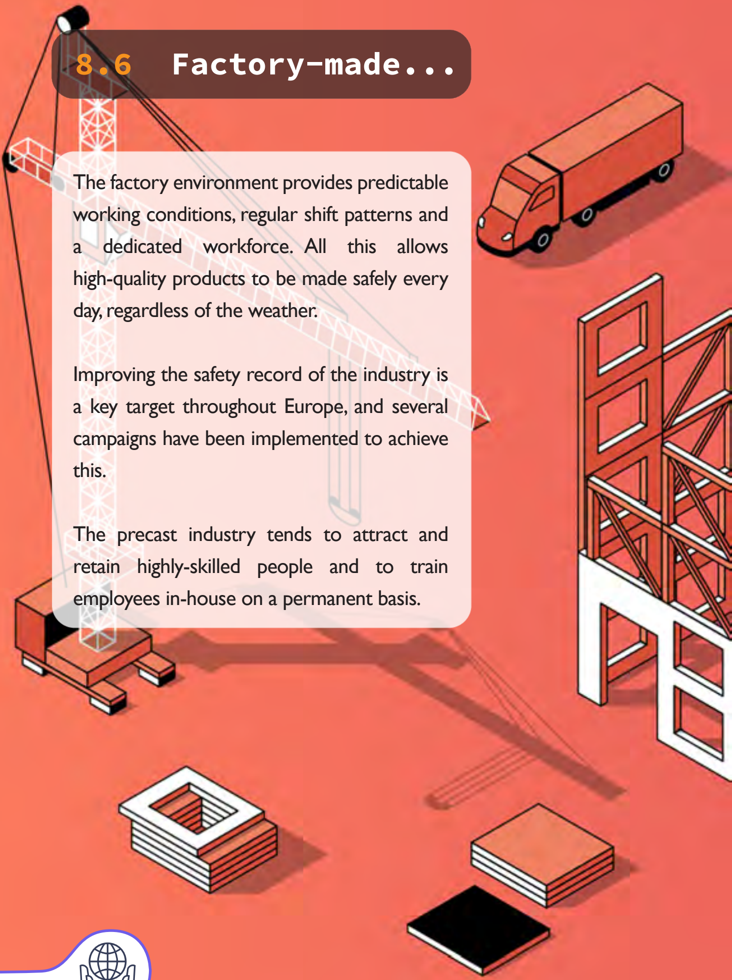
But the effect is much greater. When the precast concrete industry realises 1 euro of added value, another 2.8 euro of added value is realised by the directly linked activities in the region.



8.5 An efficient factory environment

Precast is manufactured in dedicated factories. This industrial approach allows for a high degree of automation in all steps of the engineering and production process. A strictly controlled environment guarantees optimal quality, excellent resource efficiency (labour, materials, energy) and a minimum environmental footprint.

8.6 Factory-made...

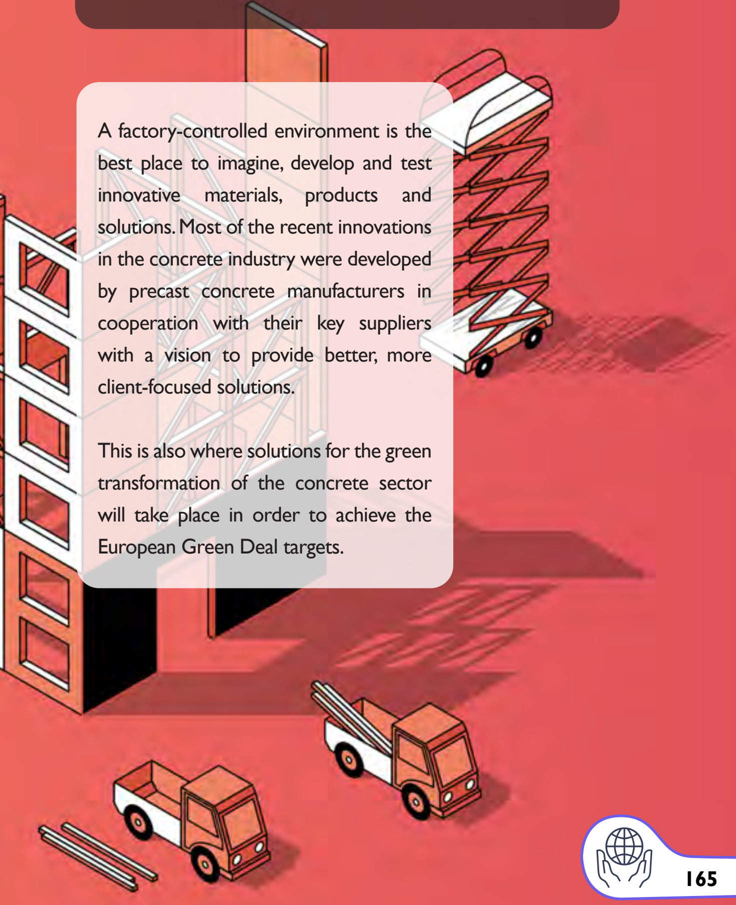


The factory environment provides predictable working conditions, regular shift patterns and a dedicated workforce. All this allows high-quality products to be made safely every day, regardless of the weather.

Improving the safety record of the industry is a key target throughout Europe, and several campaigns have been implemented to achieve this.

The precast industry tends to attract and retain highly-skilled people and to train employees in-house on a permanent basis.

8.7 ...and getting better all the time



A factory-controlled environment is the best place to imagine, develop and test innovative materials, products and solutions. Most of the recent innovations in the concrete industry were developed by precast concrete manufacturers in cooperation with their key suppliers with a vision to provide better, more client-focused solutions.

This is also where solutions for the green transformation of the concrete sector will take place in order to achieve the European Green Deal targets.

8.8 Great results, over and over again

Having decided to specify precast, it is important to have confidence in the solution. This is where factory-controlled procedures are critical. Repetition of individual units can be achieved with confidence whether 1, 10 or 100 are required.

Re-using a mould makes both environmental and economic sense – every additional cast saves materials, energy and time, and prevents moulds going to recycling or to disposal prematurely.

8.9 A mould-less future

3D printing concrete enables the manufacture of highly complex forms with great precision and within a short lead time. No moulds are required and there is also not much waste left, if any. Using 3D printing allows the production of building elements and buildings quickly and according to bespoke plans.

8.10 Tailored to requirements...

Concrete is a versatile material. The factory environment makes it possible to take full advantage of this versatility. Not only do we adjust the strength according to need, but we also master the volumetric mass, thermal behaviour and environmental footprint. For example, we can use different binders or raw materials or make concrete types that have a high volumetric mass when thermal inertia is important, or a concrete with a low volumetric mass when the emphasis is on insulating properties. And where it needs to, precast concrete fulfils both roles at the same time.

8.11 ...means you can plan ahead

By choosing precast, the specifier can work ahead of time, together with the precaster, looking at ways to improve efficiency and design out waste – before it arises. Precast is the perfect partner of BIM.

A clear, well organised production schedule for every project can easily be achieved. Effective panelisation or use of volumetrics can also reduce material waste and save time.

8.12 Reduces burden on site...

By producing off-site, you create much better conditions on-site:

- Less transport and crane movements;
- Less people;
- Less execution time;
- Less materials;
- Less waste.

This is optimisation!

8.13 ...and noise levels

Construction is often accompanied by noise nuisance for local residents and workers on the site. With precast concrete, this nuisance is dramatically reduced. Precast concrete enables the contractor to work 24 hours a day without causing noise nuisance to the local residents. The workers can largely omit hearing protection, allowing them to hear warning signals better and to communicate comfortably with each other, which also improves safety on site.

8.14 Rapid assembly on site

Precast units arrive ready for installation. Modern technology helps us to take into account possible delays of traffic jams. Our products arrive 'just-in-time' and can be put into place directly.

Less handling means less energy use and less risks. Whats more, this rapid process compared with in-situ options means precast sites are less vulnerable to delays caused by inclement weather.

8.15 Bar-codes or e-tags speed up construction and facilitate re-use

The addition of barcoding strips or embedded microchips in precast products can help distribution managers identify individual elements, making sure each one reaches its planned destination at the correct time. This technology can also help managers on site speed up the construction process while at the same time ensuring each element is accurately positioned.

E-tags can contain technical data, plus additional information on recycled material content, which ensures effective re-use or recycling at a later date.

Glossary

GGBS	Ground Granulated Blast-furnace Slag
PFA	Pulverised Fuel Ash
CCU	Carbon Capture and Utilization
CCS	Carbon Capture and Storage
EoL	End-of-Life
HSC	High Strength Concrete
TABS	Thermally Activated Building Structures
SUDS	Sustainable Urban Drainage Systems
CEA	Controlled Environment Agriculture
DfD	Design for Disassembly
BIM	Building Information Modelling

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