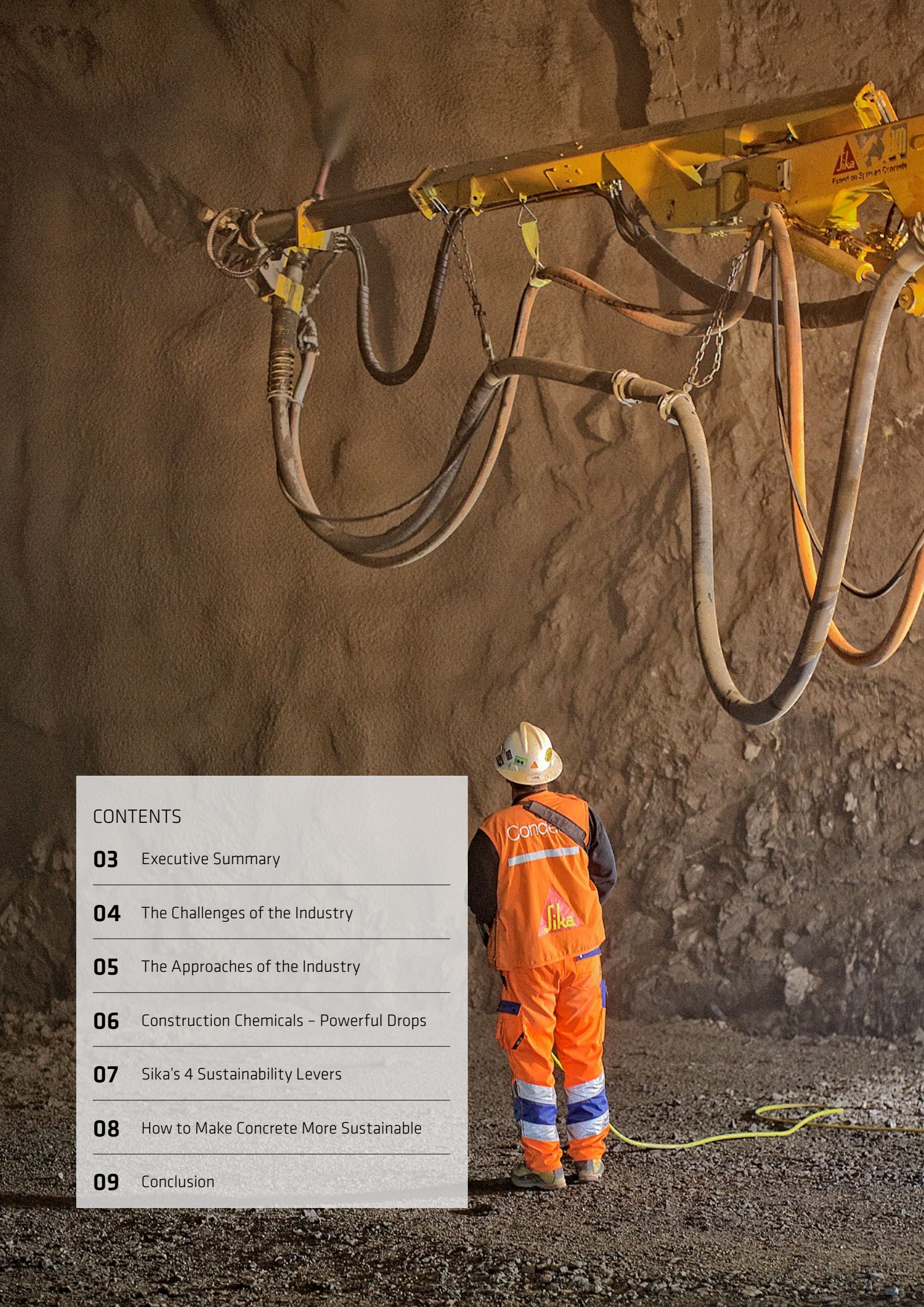
WHITE PAPER
MAKING CONCRETE A MORE SUSTAINABLE BUILDING MATERIAL

BUILDING TRUST



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EXECUTIVE SUMMARY

Concrete is an outstanding building material. It is widely available, economical, hard and durable like stone, and easy to work with – all attractive properties for the construction industry. However, concrete also has its disadvantages. The cement contained in concrete consumes a lot of energy during its production process and emits large amounts of CO_2. This, combined with the enormous demand for concrete and the simultaneous low recycling rate, makes concrete less-than-friendly for the environment.

However, there is no feasible alternative to concrete because – at least in the near-term – no other building material in the world can replace concrete in terms of volume. That is why there is only one way: The industry partners must make concrete more sustainable along its entire value chain. The cement and concrete industry have taken an important step in this regard. They have committed themselves to a "Net Zero Pledge 2050" and drafted an action plan with measures for CO_2 reduction[1].

Not only greenhouse gas emissions, but also the consumption of resources and the gray energy cause high environmental impacts: Limestone processed into cement together with aggregates and water are mixed into millions of tons of concrete every year. The energy demand of concrete does not stop with the preparation of the individual raw materials and their mixing into concrete – it continues with the formworking, the concrete transport to the construction site, the installation of the concrete and its deconstruction at the end of its service life.

Demand for concrete will continue to grow as a result of several megatrends. Conventional approaches will therefore not be sufficient to make concrete a sustainable building material. New ideas must be implemented to improve the input-output balance of the industry, such as digitalization to streamline concrete processing or new design ideas to make it easier to reuse concrete components (circular economy). Despite all efforts, "Net Zero" in the construction industry will only be possible with the help of Negative Emissions Technologies (NETs).

This white paper shows how Sika – a global leader in construction chemicals – is tackling this enormous task with a holistic approach along the concrete value chain. New products and services are being developed according to Sika's sustainability levers Less3C (clinker, cement, concrete), Water & Aggregates, Productivity & Efficiency and NETs to achieve a high sustainable impact in the market. In addition, a strong focus is being placed on employee training to make the concrete process as sustainable as possible, from raw materials to recycling.

[1] Global Cement and Concrete Association (GCCA), "The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete", www.gccassociation.org (2022).

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THE CHALLENGES OF THE INDUSTRY

Concrete is the most popular building material in the world and the second most consumed substance of all (after water). The success story of concrete began several thousand years ago, but it really took off in the 19th century when concrete and steel were combined to form a composite material. The new composite had many advantages. It was widely available, cheap, durable, easy to work with, and provided a high degree of freedom in structural design.

However, there are three main factors that make concrete sustainably problematic: its consumption, the carbon footprint of cement (figure 1), and the composite material itself. Whereas in the past building materials such as wood, stone, and mortar could be separated from each other during demolition and subsequently reused, today the composite material reinforced concrete must be crushed and downcycled. Only the steel can be fully recycled; most of the concrete demolition waste ends up as landfill[2]. The carbon footprint of concrete is high, as the cement industry is responsible for 7% of global CO_2 emissions[5] and 30 – 60% of cement production[3,4] is used to make concrete.

In 2021, 4 billion tons of cement[5] were produced. If 50% of it is used for concrete production, 300 kg of cement is assumed for 1 m^3 of concrete, and a water-cement ratio of 0.5 applies, then 1 billion tons of fresh water and 13 billion tons of aggregates are used annually. These huge quantities are crushed at the end of the concrete's service life and often used as roadbed material for road construction (down-cycling).

In addition to the high consumption of raw materials, the construction industry also suffers from a relatively low level of automation. Work on the construction site is still very resource intensive. The prefabrication industry has made great progress in recent decades, but since labor costs are still very low in many places, it is still cheaper to do the formwork and pour the concrete on site.

2 World Business Council for Sustainable Development (WBCSD), "Recycling Concrete"; The Cement Sustainability Initiative (2009).

3 Scrivener, John, Gartner, "Eco-efficient cements: Potential economically viable solutions for low-CO_2 cement-based materials", Cement and Concrete Research 114 (2018) 2-26.

4 Sika Services AG, Market Intelligence Department; "Sika 2-year survey" to Sika TM Concrete managers (2020).

5 International Cement Review, "The Global Cement Report", fourteenth edition (2021).

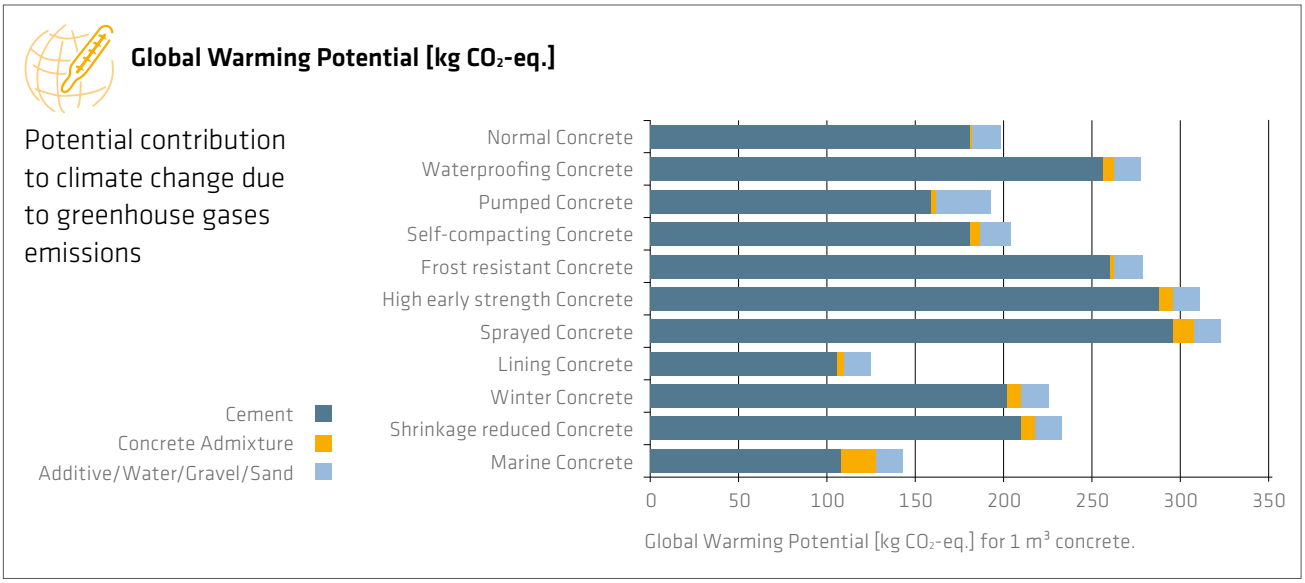

Figure 1: **Life cycle assessment (LCA) by Sika Mix Design Tool**

THE APPROACHES OF THE INDUSTRY

The construction industry is under pressure from society, customers, investors, and policymakers to improve its environmental footprint through process optimization, further automation, new design approaches and the use of alternate raw materials. For this reason, several associations of the concrete industry, such as the Global Cement & Concrete Association (GCCA) and the European Precast Concrete Industry Federation (BIBM), have developed strategy papers to improve their sustainability. The GCCA published the "Net Zero Pathway" in 2022 (see Figure 2)[1]. Its main approaches focus on decarbonation of electricity, carbon capture, utilization, and storage (CCUS), recarbonation, new directions in design and construction, and CO_2 savings in clinker and cement. BIBM lists measures to improve its ecological footprint in the 2021 edition of "The Little Green Book of Concrete."[6] It includes ideas similar to those of the GCCA, but expanded to include shorter transportation distances, alternative reinforcement and more.

The sustainability approaches of the customer groups in this case the cement manufacturers, concrete producers and concrete applicators are the signpost to the future activities of the construction chemicals industry.

6 Federation of the European Precast Concrete Industry (BIBM), "The Little Green Book of Concrete 2021", www.bibm.eu.

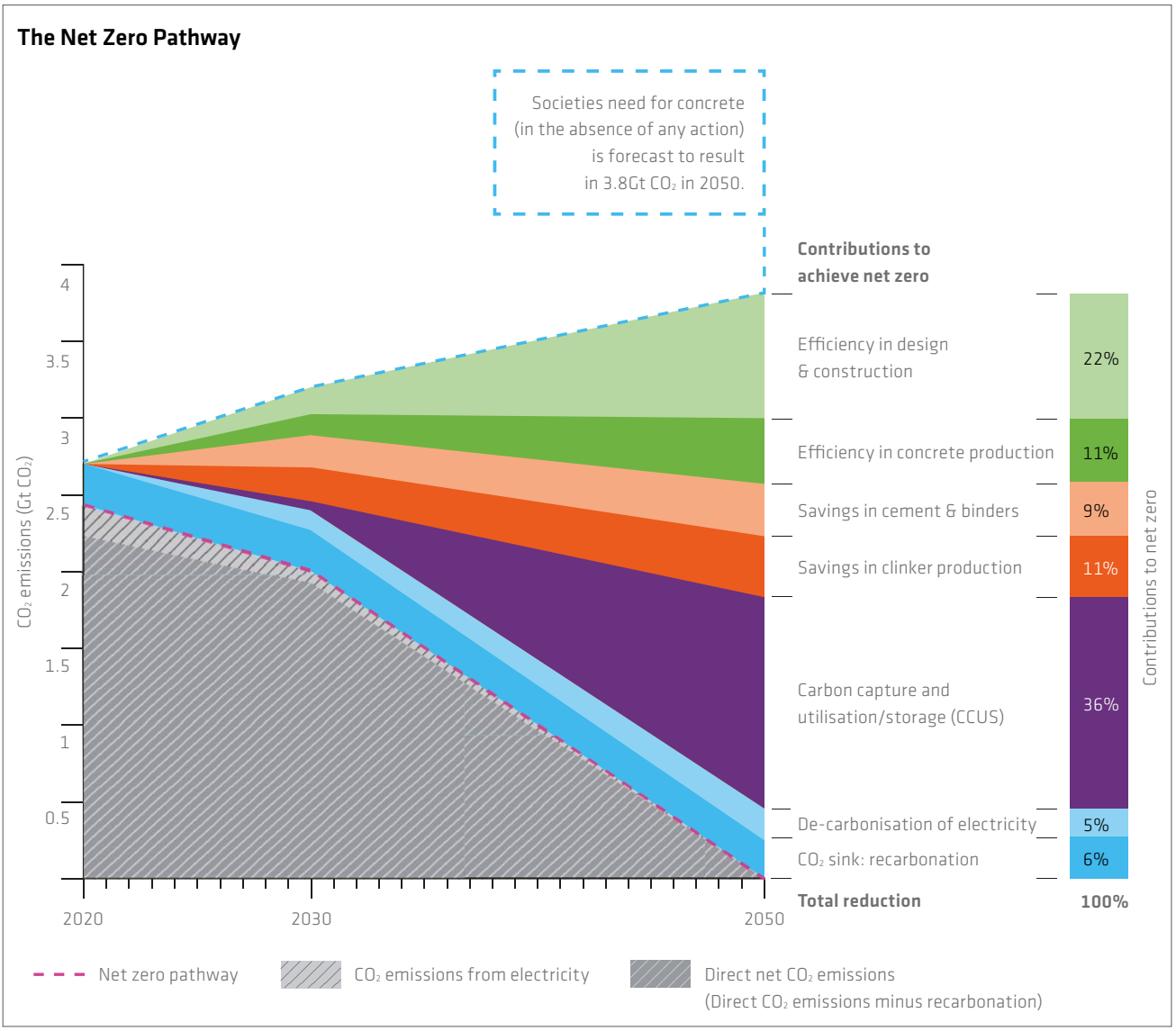

Figure 2: **Net Zero Pathway of GCCA (Source: www.gccassociation.org)**

CONSTRUCTION CHEMICALS – POWERFUL DROPS

Superplasticizers are powerful drops. Compared to the weight of concrete, only one thousandth needs to be added to have a strong impact on better workability, higher strength and durability of concrete, as well as water and cement saving in the production of concrete. Only thanks to these drops concrete does become a modern building material, which is transported over long distances and then pumped, sprayed or poured to create lean and durable concrete structures.

Along the concrete value chain (figure 3), there are several construction chemical products used to optimize concrete processing, ranging from cement grinding aids to recycling technologies for aggregates from concrete demolition waste (CDW). For providing further solutions to improve sustainability, Sika has aligned all its activities with industry challenges and approaches and combined them with the concrete value chain into four sustainability levers:

All new products and services will be aligned with these levers. To achieve this, employees must be trained, and users (customers) informed, which will be the task of the new Sika Concrete Academy 2.0. Digitalization will be used as an opportunity to strongly support our four levers. A digital platform has recently became available to simplify aggregate analysis, optimize mix design development and support quality control on the construction site. Projects are also underway around the world with partners from academia and industry to master the transition to a more sustainable and digitalized construction world. New ground has already been broken with Sika 3D concrete printing and the Sika reCO$_2$ver® process.

Less3C: Less clinker, cement and concrete	**W&A:** Careful use of water and aggregates
P&E: Productivity and efficiency increase	**NETs:** Negative Emissions Technologies

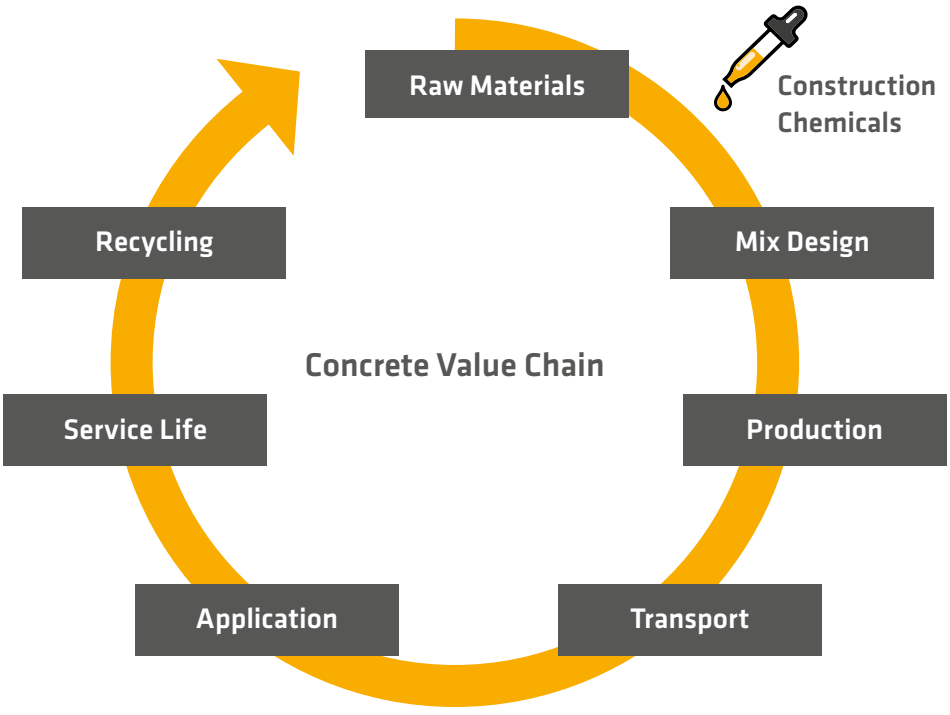

Figure 3: **The value chain of concrete driven by construction chemicals**

SIKA'S 4 SUSTAINABILITY LEVERS

Less3C

Less clinker, cement and concrete

The superplasticizers Sika® ViscoCrete® and Sikament® and the cement additive SikaGrind® save 100 million tons of cement annually. That adds up to 65 million tons of CO_2 saved per year. These figures do not include the further savings in concrete due to leaner and more durable construction made possible by the superplasticizers. Furthermore, the latest generation of Sika admixtures allow the use of LC^3 technology, which is a promising approach by the cement industry to its Net Zero Strategy. And the new Sika mix design app allows performance, cost and environmentally optimized concrete formulations with integrated life cycle assessment (LCA).

Excursus: Sika Concrete Academy

In order to pursue a successful market penetration strategy, it is very important to have well-trained employees who can provide customers with optimal advice. Therefore, the Sika Concrete Academy is an important pillar in Sika's service approach. The training sessions from concrete basics to advanced concrete applications and cement production include manuals, e-learnings, lab sessions and monthly published knowledge nuggets called Concrete Snacks.

W&A

Careful use of water and aggregates

Up to 40% water savings can be achieved in concrete production thanks to Sika® ViscoCrete® technology. Together with the other Sika plasticizer technologies, this saves 7 billion liters of water per year in concrete production. The Sika CODE concept supports concrete mix design development for less suitable aggregates. A key component here is the Sika Sand App, which uses artificial intelligence-based image processing to allow fast and accurate aggregate analysis via mobile phone. Sika reCO_2ver® turns demolished concrete waste (CDW) back into full-value aggregates for concrete and thus represents a milestone towards a circular economy.

P&E

Productivity and efficiency increase

The Sika 3D Technology Center develops 1K and 2K printer inks for new resource-saving design approaches and production approaches in the construction industry. The Sika Shotcrete App for standardized and efficient quality control of shotcrete connects wirelessly to sensors for measuring concrete strength development. SikaFiber® and Sika® Sigunit® accelerate the construction of excavation stabilization in tunneling and mining. Only superplasticizer technologies such as Sika® ViscoCrete® allow targeted development of concrete mix designs that represent efficient application methods: Pumped concrete, self-compacting concrete, shotcrete, slip form concrete and many more.

Excursus: Digitalization

Digitalization has the potential to improve all processes along the concrete value chain. Therefore, it will also be a strong lever for sustainability. However, the main driver for digitization in the construction industry will be the possibility to increase margins by improving productivity and efficiency. Or simply put, that the input-output balance can be optimized. This means that digital tools can be used to find new ways to build faster with fewer resources.

NETs

Negative Emissions Technologies

Since Net Zero is not possible without CCUS (figure 2), Sika is also focusing on NETs: In the re-CO_2ver® process, the fragments from the concrete demolition waste are broken down into their components – namely, stones, sand, and cement paste powder. This powder is brought into contact with CO_2 and binds it through carbonation. The aggregates are mechanically cleaned from the cement paste powder. The cleaned aggregates require less cement in the concrete mix and the carbonated powder can be used as additive and potentially as cement replacement.

HOW TO MAKE CONCRETE MORE SUSTAINABLE

The sustainability of concrete can be improved by adjusting various elements during concrete processing. Switching to raw materials with reduced carbon footprints is of central importance, but the ecological footprint can also be greatly improved by increasing efficiency and productivity. This does not even have to be about commitment to a greener world, but also about doing better business by optimizing profit margins. See table 1.

The concrete value chain is very complex (figure 3). Along it, there are many players who also have an interest in making this building material more sustainable. Not every stakeholder should try to solve the problem on their own. Partners should be selected who understand the value chain (figure 3) and are able to improve their customers' growth, margins and environmental footprint through appropriate products and services. It is therefore important that the supplier has their own sustainability plan such as Net Zero 2050 (SBTi), strong research and development, partnership programs with universities, a digitalization strategy, and local organizations with well-trained staff who understand local challenges and can provide tailored solutions.

Table 1: **Approaches to improve the sustainability of concrete from the point of view of concrete producers and processors**

Objective:	**Environmental (= E of ESG)**					
Path:	**Profit margins**				**Concrete eco-footprint** (Mix Design)	
	Productivity increase (output ↑ / input →)		**Efficiency increase** (output → / input ↓)			
Lever:	**Faster Concrete in**	Production	**Less Concrete by**	Longer use (durability)	**Greener Concrete by**	Clinker / cement reduction
		Application		Leaner structures (strength)		Water reduction
		Use		Less waste (fresh & CDW)		Aggregates care

The following list is a selection of products and services from the construction chemicals industry, which includes Sika, that make the concrete value chain more efficient and sustainable:

- Energy savings in cement production: SikaGrind®
- Clinker reduction in cement by strength enhancing: SikaGrind®
- Optimizations in concrete mix design: Sika Mix Design App
- Water and cement reduction in concrete production: Sika® ViscoCrete®
- Enabling of project-specific concrete application methods: Sika® ViscoCrete®
- Waste reduction of fresh and returned concrete: Sika® Retarder
- Faster demoulding of concrete: SikaRapid® and Sika Separol®
- Longer use of concrete structures by durability enhancement: SikaControl®
- Time savings by replacing steel reinforcement: SikaFiber®
- Efficiency in quality control management: Sika Shotcrete App
- Circular economy for aggregates coming from concrete demolition waste (CDW): Sika reCO$_2$ver®
- Efficiency in aggregate management: Sika Sand App

CONCLUSIONS

Concrete is a huge consumer of raw materials and energy and has a very high carbon footprint. Consumption of concrete, the main building material, will continue to increase driven by megatrends such as urbanization. The industry is under pressure to optimize its entire business: doing more and faster with less and greener. This is an opportunity for the construction chemicals industry. Indeed, Net Zero 2050 may never happen without continued innovations from companies like Sika. Sika has therefore developed 4 strategic levers to support the construction industry along the entire value chain, with products and services that enable customers to reduce emissions and drive the development toward circularity in construction. The focus on digitalization will be an important key to mastering the major challenges of the construction industry.

To make its own business model more sustainable, Sika has committed to the Net Zero Pledge 2050 according to the Science Based Targets initiative (SBTi). In addition, the company is involved in working groups addressing the topic of avoided emissions and downstream customer benefits with the World Business Council for Sustainable Development (WBCSD). With the 4 levers as a guide, Sika will continue to invest in sustainable products and services that enable a greener concrete value chain. Specialized teams are working on digitalization, knowledge transfer and research to further drive customers' and Sika's journey toward Net Zero.

Let's make concrete a modern and sustainable building material together!

WATER SAVINGS IN CONCRETE BEYOND THE EXPECTED

MahaNakhon, Bangkok, Thailand, built with innovative concrete solutions from Sika

Sika superplasticizers reduce the amount of water in concrete by up to 40% while maintaining the high strength required in high-rise construction. This improves sustainability by allowing for thinner walls, material savings, and maximized floor space, without compromising on durability and safety even when faced with high winds, seismic events, or corrosive environmental conditions.

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