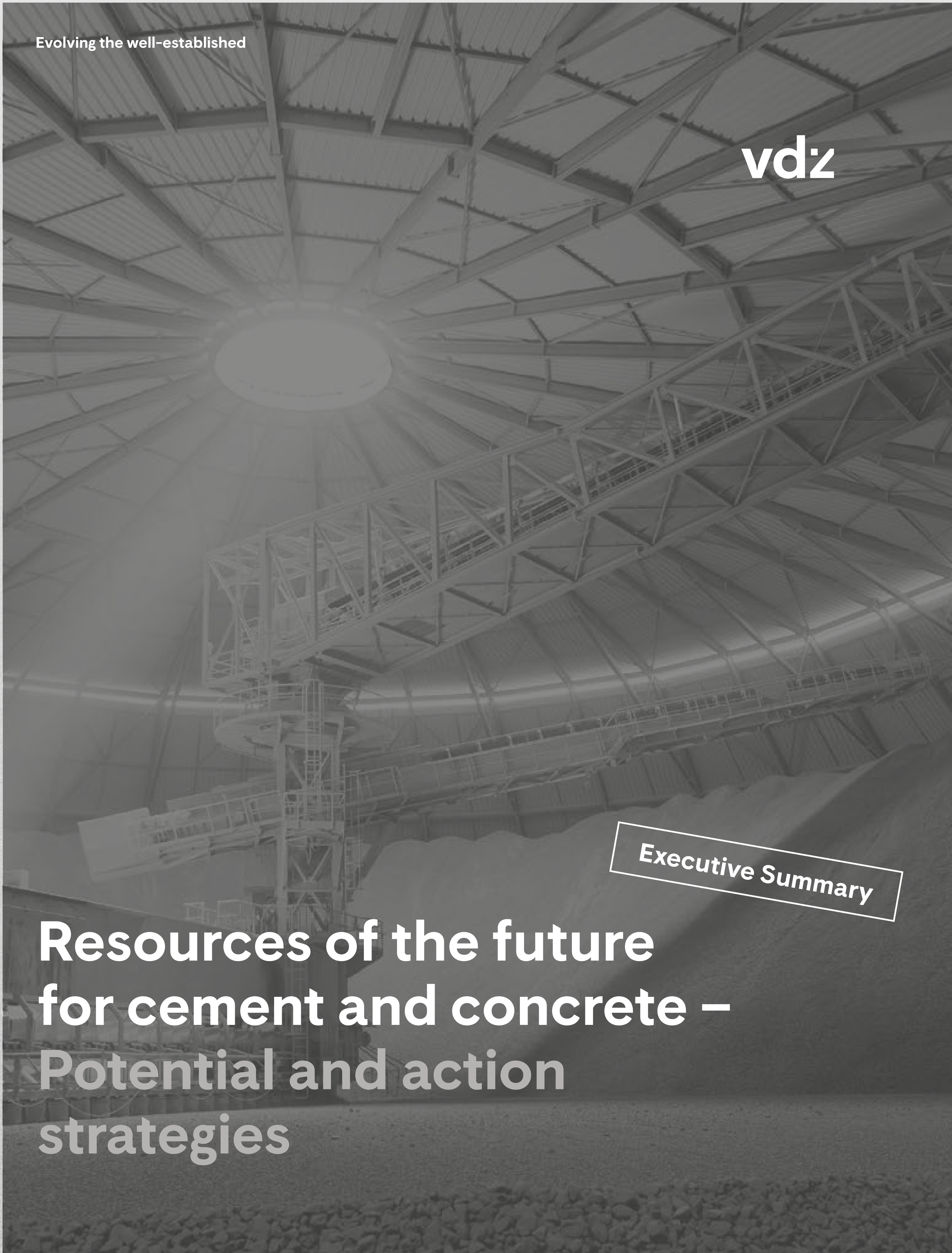

Evolving the well-established

vdz

Executive Summary

Resources of the future for cement and concrete – Potential and action strategies

Resources of the future for cement and concrete

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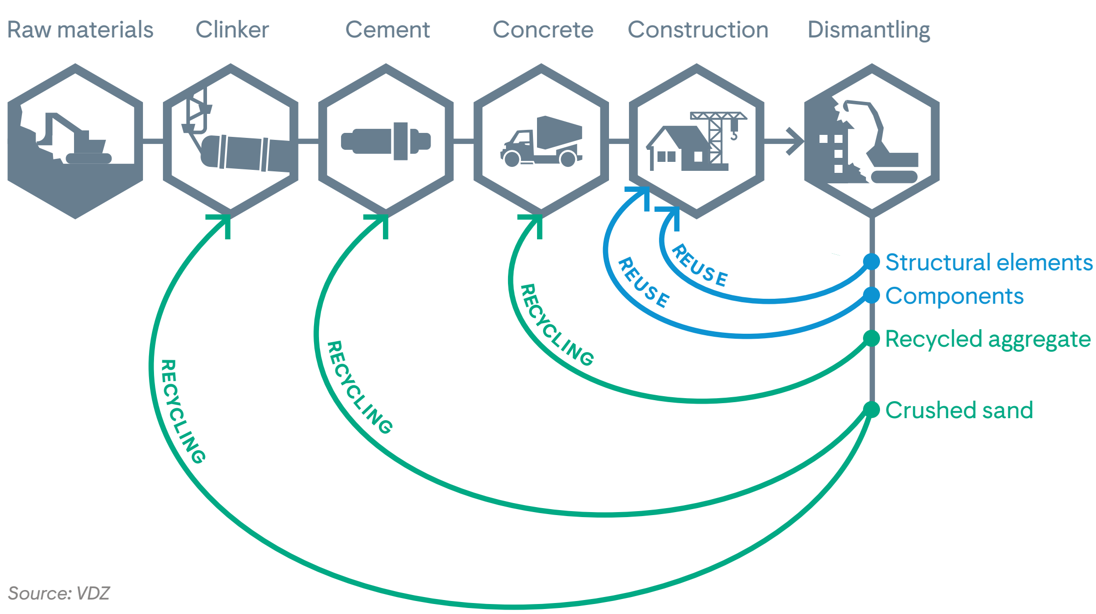
Preservation of natural resources along the cement and concrete value chain

Alongside climate and species protection, the preservation of natural resources is one of the major ecological challenges of our age. This study accordingly highlights the ambition of cement manufacturers in Germany to achieve an even greater reduction in the use of primary raw materials along the cement and concrete value chain, for instance by further developing existing material cycles and creating completely new ones (Fig. 1).

With regard to raw material requirements, a distinction can be made between mineral and biotic raw materials and fossil energy sources. Together with energy companies and industry, the building sector is the largest user of raw materials and therefore has a particular responsibility for their conservation. Cement and concrete play an important part in this context, as the construction of housing, industrial buildings, bridges, tunnels and locks, not to mention wind turbines and power grids, would be inconceivable without these. The manufacture of cement and concrete accounts for roughly one fifth of the primary raw materials employed in Germany each year (approx. 236 million tonnes). Apart from a small quantity of fossil fuels, these primarily include mineral raw materials such as limestone as a principal constituent of cement, but also gravel, sand and natural stone, which are used together with water, cement and other additives and admixtures to produce concrete.

In full awareness of these resource requirements and under the auspices of VDZ and the European Cement Research Academy (ECRA), the German cement and concrete manufacturers have long been studying the question of how building materials can be produced using fewer natural resources. As a result, alternative raw materials now account for nearly one fifth of the resources required for cement manufacture in Germany, which represents an annual saving of around 10 million tonnes of limestone as primary raw material. The purpose of this study is to consider and quantify further ambitious potential approaches aimed at reducing the use of resources. The analysis primarily concentrates on measures to save natural resources in the production of clinker, cement and concrete. Attention is also given to further potential aspects, arising for example from new construction methods and the extension of the service life of structures. In addition to the purely technical issues, this study also identifies external prerequisites for successful transformation of the industry and sets out specific areas of action.

Fig. 1: Material cycles along the cement and concrete value chain



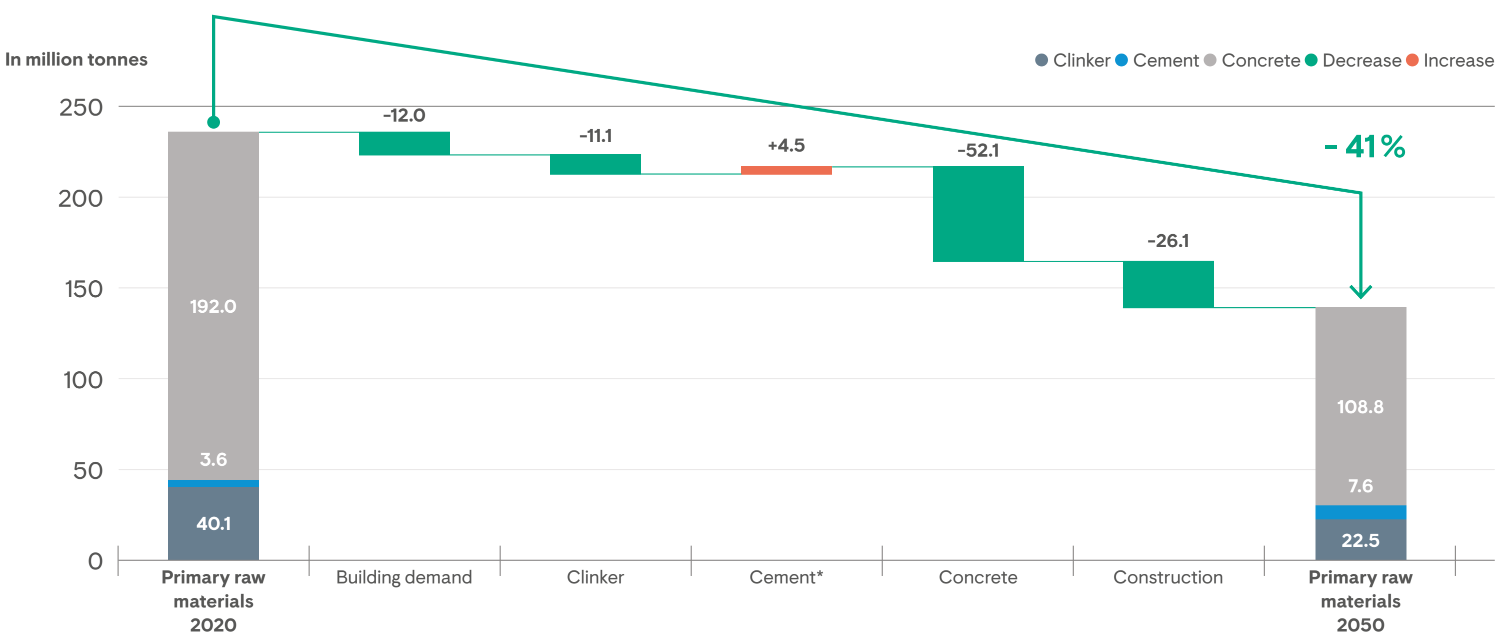
Source: VDZ

Resource-saving cements and concretes – 2050 scenario

In the 2050 scenario, the measures considered in this study would lead to a total reduction in the use of primary raw materials along the cement and concrete value chain of 96.8 million tonnes in the year 2050, corresponding to a **decrease of -41%** as compared to 2020 (Fig. 2). The greatest potential for savings is to be found in the area of **concrete manufacture** (-52.1 million tonnes), by replacing a significant proportion of the natural aggregate in the concrete (gravel, sand, natural stone) with recycled aggregates in future. These are obtained from the treatment of crushed concrete and masonry rubble which occur with the dismantling and demolition of building structures. This process also yields fine fractions, so-called recycled fines, which are used on the one hand as a cement constituent and also, to a certain extent, as a substitute for raw meal in the clinker burning process. With the above-mentioned measures it would be possible to replace more than 4 million tonnes of limestone in **clinker and cement production** in the 2050 scenario. **Opposing effects** are however also encountered, particularly in the case of cement production, which necessitate the increased use of certain primary raw materials. This relates primarily to limestone and calcined clays to reduce the clinker content of the cement. One reason for this will be the drop in the quantity of blast furnace slag available by 2050 as a result of the planned conversion to the hydrogen-based direct reduction process in ironmaking. It is also likely that the supply of fly ash for cement and concrete will come to an end with the disuse of coal. The future shortage of FGD gypsum[1] for cement production could be compensated for by way of the increased recycling of waste gypsum.

At the **construction level**, the advancement of concrete construction methods and the lengthening of structure service lives in the 2050 scenario

Fig. 2: Resource savings along the value chain in the 2050 scenario



Source: VDZ

Note:
* *Includes primary main constituents and sulphate agents; clinker is considered separately.*

1 FGD gypsum = Gypsum from flue gas desulphurisation in coal-fired power stations

would permit a saving of 26.1 million tonnes of natural raw materials. Correspondingly, more material-efficient building planning is one of the important factors in this context. Another assumption is that greater use is made of construction methods which achieve a comparable performance with a reduced volume of concrete.

Beyond the year 2050 further potential is foreseeable in the form of modular construction methods permitting the increased reuse of components or entire building structures.

Based on the forecasts contained in the 2050 scenario, a slight drop in **building demand** was viewed as an external effect contributing to a reduction (-12.0 million tonnes). No consideration is given to fuels in this scenario, as they account for a relatively small proportion of the materials used. It is assumed that the fossil fuels currently still being employed in some cases will have been completely replaced by alternative fuels and hydrogen by 2050. Overall, the resultant quantity of materials used will probably be of a similar magnitude to that of the present day (approx. 5 million tonnes, including approx. 0.2 million tonnes of green hydrogen). Another factor not contained in the scenario is the use of water for concrete production. It can be assumed that the quantity will decline, not least in connection with the increasing market share of clinker-efficient cements. As the clinker content decreases, there will be more and more cases in which the water-cement (w/c) ratio has to be reduced in order to obtain adequate concrete properties.

All assumptions made in the described scenario are summed up in Fig. 3.

Resource savings: Prerequisites and areas of action

A far more pronounced awareness and greater knowledge in the areas of durability, material efficiency, reuse and recycling will be called for throughout the entire construction process in future if full use is to be made of the potential for saving natural mineral raw materials as outlined in this study. Strict adherence to this principle should govern all aspects of planning, tendering procedures, procurement and construction. An efficient and successful circular economy in the building and civil engineering sectors demands **concerted action by all involved in the construction process** and an approach based on material flows and a lifecycle perspective along the entire value chain (Fig. 1). **Communication in the planning and construction process** is of crucial importance, as any measure taken to preserve resources in one part of the value chain is almost bound to affect some other area as well. It will also be necessary to tread completely new paths with regard to more careful use of the resources available.

In addition to greater material efficiency and the reuse of components, the key factor with regard to the preservation of natural resources in cement and concrete manufacture is the comprehensive utilisation of recycled building materials. **Appropriate material flows have to be identified and mobilised** for this purpose. A central aspect in this regard is **Urban Mining**, the systematic process of reclaiming raw materials from the anthropogenic stock. This involves recording the building materials, their constituents and methods of installation, for instance in the form of material passports, for both new and existing structures. Digitisation of the planning and construction processes and the application of Building Information Modelling (BIM) methods will then be essential.

The efficient utilisation of raw materials from the anthropogenic stock will for example require the

Fig. 3 Assumptions for determining the potential for savings of primary raw materials for cement and concrete in the 2050 scenario

- 5 % drop in demand for concrete

- 3.9 mill. tonnes of recycled fines, 4.3 mill. tonnes of calcined clays and 1.0 mill. tonnes of limestone as substitute for clinker, blast furnace slag and fly ash

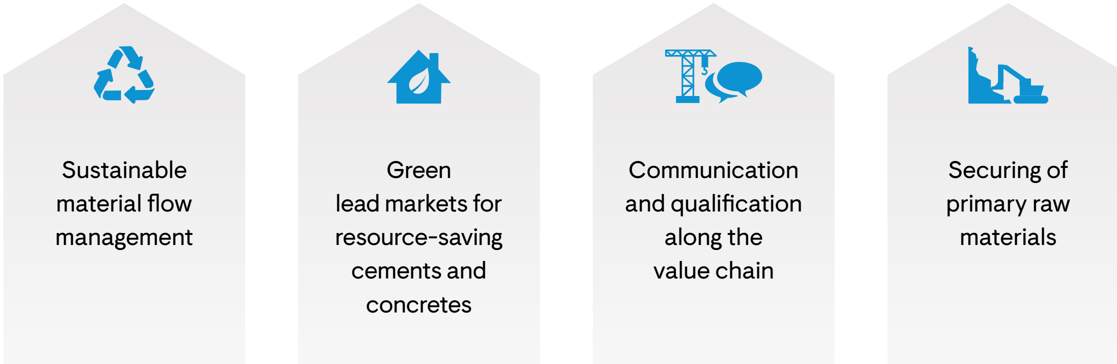
- Reduction of the clinker-cement factor to 53 %
- 2.5 mill. tonnes of recycled fines as raw meal component

- 53.3 mill. tonnes of recycled aggregates in concrete
- Cement and rock powder as substitute for fly ash in concrete

- Resource-saving concrete construction methods
- Reuse of components and building structures
- Extended service life of structures

Source: VDZ

Fig. 4: Prerequisites and areas of action for resource-saving concrete construction



Source: VDZ

further improvement of treatment methods such as electrodynamic fragmentation and sensor-based approaches to the sorting of mass flows.

Similarly to natural raw materials such as limestone, gravel and natural stone, cement and concrete manufacturers also require a steady supply of recycled building materials. An important prerequisite for this is the establishment of **urban areas as building material treatment centres**. This is the only way of guaranteeing short transportation routes, which have a major influence on the cost-effectiveness and ecological efficiency of the recycling process.

Alongside the recycling of materials, the reuse of components will help to preserve resources. In the short term more potential could be made accessible by keeping a record of used components on corresponding digital platforms. It will also be necessary to design building structures with a view to facilitating the dismantling of the individual elements.

A further central area of action is the **promotion of demand for resource-saving construction.** Despite the fact that applicable regulations for concrete recycling already exist, recycled material currently accounts for less than 1 % of the total aggregates used in concrete in Germany. A way of increasing this proportion would be to remove obstacles whilst at the same time creating incentives to use this material.

At present the waste legislation and the not always positive image of recycled building materials can be viewed as deterrents to their use. To help remedy the situation **recycled aggregates** should, immediately following their production, no longer be classed as waste but rather as products **(product status)** in future. When drawing up regulations, recycled materials should also not be put at a disadvantage compared to primary raw materials with regard to stipulations on potentially harmful substances. Ultimately, the aim should be to create a balance between the protection of health, soil and groundwater on the one hand and the use of recycled aggregates and building materials on the other.

The **public sector has an important part to play** with regard to **promoting the use of recycled building materials.** As the greatest demand for construction work comes from Federal, state and local governments, these are in a position to spe-

cifically request such materials and encourage private investors to do the same. The preferential use of recycled building materials, or possibly setting down quotas for recycled products in calls for tender taking into account local availability, could be an effective means of initialising new sales markets. For architects and building owners, it is important to have transparent information available on building materials with recycled constituents. **Certification and labelling** should play a more significant role and place more emphasis on resource savings.

The preservation of natural resources can only succeed if all those involved along the value chain work together to find solutions. Consequently, **communication between cement and concrete manufacturers, planners, architects, building owners and the building and recycling industry** is of paramount importance. Dialogue is necessary to achieve a consensus of opinion on the particular challenges and opportunities offered by more efficient material utilisation as well as the reuse and recycling of components and building materials.

This study shows that under optimum conditions, the need for primary raw materials in cement and concrete manufacture can be reduced by around 41%. Conversely, this however means that even with a highly ambitious circular economy, natural resources will continue to make up the largest part of the raw materials required for cement and concrete in 2050. Accordingly, the raw material mix of the future will contain increasing proportions of recycled materials and reused components, but will still primarily be composed of minerals obtained from natural sources such as limestone, gravel, sand, natural stone, clay and gypsum. In other words, the **securing of domestic raw material deposits remains a further central area of action**, as this forms an existential basis for cement and concrete production. Dialogue between members of the political administration, trade and industry, and society in general must emphasise the significance of domestic raw materials alongside the increasing use of recycled materials. Only through the exploitation of local raw materials will it be possible to achieve important political goals such as the development of renewable energies and sustainable traffic infrastructures, as well as the creation of affordable housing.

Prerequisites for resource-optimised and competitive concrete construction

- **Focus on the entire value chain in the conservation of natural resources**, starting with clinker and cement production, through the production of concrete, to the building structure (reuse, deconstruction/demolition and recycling of building materials).

- **Intensify communication along the cement and concrete value chain** in order to jointly develop concepts for a sustainable circular economy in construction.

- **Promote urban mining** and systematically document building materials as well as their components and installation methods (e.g. with building resource passports). The digitalisation of planning and construction and the application of Building Information Modelling (BIM) are of great importance.

- **Improve reusability of building components**, through building designs (e.g. modular) that facilitate selective deconstruction and use of digital platforms to collect and evaluate used components.

- **Improve processing methods for building materials recycling** (e.g. sensor-based, electrodynamic fragmentation).

- **Establish urban areas as centres of building materials processing**, including through additional commercial space. Ensure short transport distances and a continuous supply with recycling materials.

- **Establish use of recycled materials from crushed concrete in cement and concrete.**

- **Classify recycled aggregates as a product directly after manufacture** – and not only at the time of installation. Prevent a negative image and the disadvantage of recycled building materials compared to building materials based on primary materials.

- **Improve the competitiveness of recycled materials**, e.g. through subsidy programmes, tax incentives.

- **Strengthen the exemplary function of the public sector** – promote construction with resource-saving cements and concretes. Recycling quotas taking into account local availability as an effective instrument for initialising markets.

- **Make recycled materials recognisable on the market**. Certification and labelling (e.g. by the Concrete Sustainability Council (CSC)), or entire buildings (e.g. by the DGNB) are important elements.

- **Secure domestic primary raw material sources and speed up approval procedures**. Limestone, gravel, sand, natural stone and clays will continue to play an important role in the raw material mix of the future. Appropriate extraction must be ensured.

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