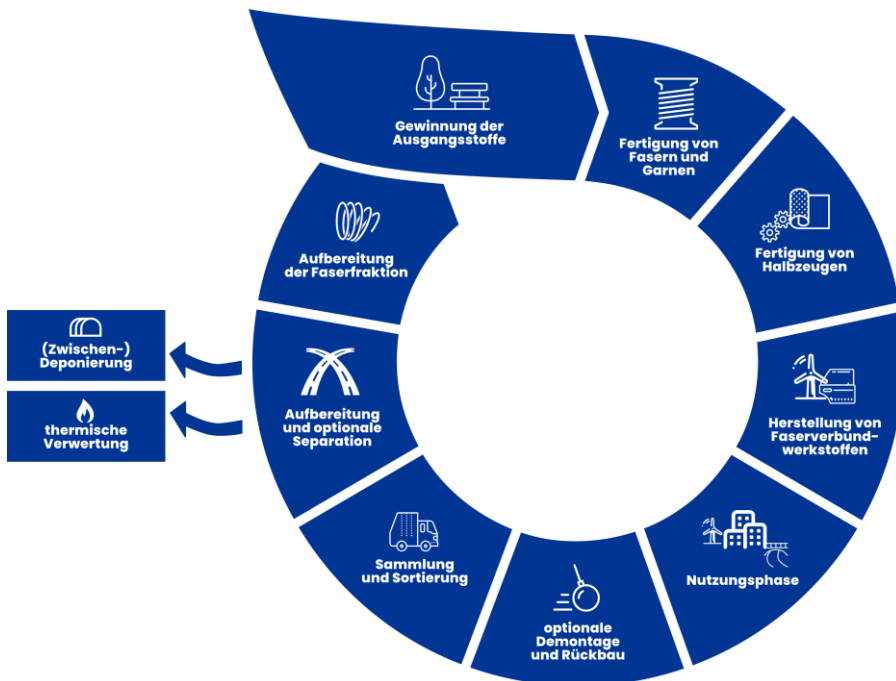


Fact Sheet

Material cycle for carbon concrete

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Material cycle of carbon concrete | © C³Association

Initial situation

Fibre composites or plastics made of carbon fibres are increasingly finding new areas of application in all areas of life in the Federal Republic of Germany and worldwide. Analogous to the other sectors, waste containing fibres is generated in the construction industry with the substitution of metals. According to the German Kreislaufwirtschaftsgesetz (Closed Substance Cycle Waste Management Act (KrWG)), natural resources must be conserved and people and the environment must be protected during the generation and management of waste.

With regard to carbon concrete construction, it is demonstrably known that all phases of the material cycle for a circular economy already exist in practice. The institutions – which can be assigned to the individual phases – have extensive existing knowledge, ready-to-use technologies and initial processes

for planning, manufacturing, transferring into use and recycling products made of carbon concrete and reusing the recycled materials for manufacturing new products.

Material cycle

Extraction of the raw material

The raw material of the fibres for the mat- and bar-shaped reinforcements to be produced is carbon. Currently, the carbon is obtained from crude oil.

Manufacturing fibres and yarns

For the production of carbon fibres, the raw material polyacrylonitrile (PAN) is spun and drawn into fibres of virtually endless length to form the so-called PAN precursor. The initially white-coloured sliver is further processed in several process steps

(oxidation, carbonisation and graphitisation) at different temperatures and pressures. This results in black fibres of almost pure carbon. Subsequently, the individual fibres are combined in parallel next to each other to form a thread bundle (roving strand) and finally wound onto bobbins. A roving strand is thus made up of several thousand individual carbon fibres (filaments), for example 50,000 or 50 K.

Manufacturing semi-finished products

For the production of mat- or bar-shaped reinforcements, the rovings are processed in textile or pultrusion technology processes and impregnated with a plastic matrix.

Production of fibre composites

In the construction industry, new components of the carbon concrete construction method are manufactured in precast concrete plants with the mat- or bar-shaped structures. If existing steel reinforced concrete structures are strengthened or repaired with carbon concrete, this takes place on-site, directly on the construction site.

Usage phase

Carbon concrete impresses with its outstanding material efficiency. Throughout the entire phase of use, the material can be processed and repaired by means of drilling, sawing, cutting or another process.

Optional dismantling and deconstruction

Structures and components made of carbon concrete can be crushed and prepared for further processing at the end of their service life using common deconstruction methods.

Collection and sorting

A targeted further recycling of carbon concrete requires separate collection. The

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material must then be processed for further recycling. The carbon concrete is crushed in industrial crushers and shredders, whereby the fibres containing carbon are separated from the matrix. The subsequent sorting takes place in sorting plants that separate the fractions from each other according to specific criteria. Sensor-based sorting systems can also be used, which differentiate according to shape and colour when sorting plastics.

Treatment and optional separation

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For the material recycling of recovered carbon fibres, the plastic matrix of the impregnation is removed from the carbon fibre if required. For this purpose, the fibre structures to be cleaned are fed into a pyrolysis or solvolysis process. Carbon concrete that is present in heterogeneous mixtures of materials and that cannot be provided free of foreign substances and unmixed during collection and sorting must be separated from these foreign substances by means of special processes.

Treatment of the fibre fraction

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After the fibres have been separated from the plastic matrix, they must undergo further treatment (strength tests, longitudinal alignment, blending with virgin fibres etc.) before the recovered fibres can be used to manufacture yarns and semi-finished products.

Material use of the fibre fraction (manufacturing of semi-finished products and materials from recovered fibres)

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In the short term, a large proportion of the recycled fibres containing carbon is to be used in the construction industry for the production of mat and bar-shaped reinforcements.

Previous applications in non-construction industries include, among other things, the production of front spoilers and rear aprons for cars, frames and attachments for bicycles made of textiles containing

carbon fibres and nonwoven materials. In the medium term, new applications for lightweight construction, mechanical engineering and the automotive industry will expand the product portfolio by manufacturing structural components first by combining recycled and virgin fibres and later exclusively from recycled fibres. In the long term, recycled carbon fibres will have comparable processability and quality to virgin fibres.

Thermal utilisation of the fibre fraction

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For very short (3 mm and 6 mm) as well as ground carbon fibres, there is a global market that already comprises several hundred tonnes per year. In addition, there is a great need within the cement and chemical industries to thermally utilise such fibres.

(Temporary) landfilling of the fibre fraction

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Part of the waste containing carbon is not yet an established part of a closed material cycle and is sometimes temporarily and finally disposed of at landfill sites. However, this amount of recyclable material will gradually be transferred to material recycling as the material cycle is expanded.

Further development

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In order to establish applications using these high-quality fibrous secondary raw materials across the board, the technical and organisational processes for extensive material recycling of the fibrous fractions must be expanded. This also includes offering further marketable products made from recycled fibres.

For this reason, the C³Association and its members are taking the initiative in the project "WIR! recylen Fasern" (We recycle fibres) to establish an alliance for the recycling and resource management of fibre composites. The focus is on optimising materials, collecting and bundling waste streams, collecting and

treatment of unmixed materials as well as the development of new products and training concepts.

Further literature

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Jehle P., Kortmann J.: Validierung des Stoffkreislaufes für Carbonbeton. In: C³ – Carbon Concrete Composite e. V. (Hrsg.): Studien des C³Verbandes. 2019. 35 S.

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Further links including explanatory films

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<https://carbon-concrete.org/carbonbeton/recycling>

<https://www.wir-recyeln-fasern.de>



Exploratory tests for the production of fibres and yarns from recycled fibres | © C³Association

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