Building sustainably - actively protecting the climate

Using renewable and recycled raw materials, minimising the use of water and energy during construction works and subsequent operation of a building, conserving resources and protecting the environment while maintaining biodiversity are all important components of sustainable building construction. Companies and universities in Baden-Württemberg are working hard to make building construction more sustainable.

Making cities and human settlements inclusive, safe, resilient and sustainable is one of the 17 2030 Agenda Sustainable Development Goals (SDG) adopted by all Member States in September 2015 at the United Nations World Summit on Sustainable Development. Building long-lasting and energy-efficient housing is necessary in order to achieve this target. This and other requirements are part of the "Guideline for Sustainable Building" (LFNB) published by the German government in 2001 in response to the decision taken at the Rio de Janeiro World Climate Change Conference in 1992.

Meeting demand, preserving nature

Weighting (percentage) of the main criteria for sustainable construction based on the Assessment System for Sustainable Building (BNB).

Sustainability, which is the basis of a bioeconomy, is about meeting the need for food, energy and chemicals while preserving nature. The principle of sustainability, i.e. the idea of not consuming more than can be regrown, as stipulated in the New York agreement, must therefore also be applied to the construction industry. Here, one can draw on the three pillars of sustainability: economic, social and environmental. The economic dimension of sustainability involves, amongst other things, building-related life cycle costs (LCC), cost-effectiveness and value stability. One of the goals is therefore to reduce LCC whilst preserving the capital employed.

The socio-cultural dimension is much more abstract and focuses on user needs (human health) and building functionality as well as the quality and aesthetic importance of buildings. From an ecological point of view, the primary goals are to save resources by optimising the use of construction materials and products, maintaining and promoting biodiversity, minimising energy and water consumption (keyword: energy efficiency) and using as little land as possible for the planned building. The "Guideline for Sustainable Building" contains the requirements that the Federal Government as the developer imposes for all new or refurbished buildings. It is based on the Assessment System for Sustainable Building (BNB), which, in addition to the three sustainability aspects listed above (each accounting for 22.5%), also takes into account technical quality (22.5%) and process quality (10%). Added to this are the separately assessed site characteristics (see diagram)[1]. The German Sustainable Building Council (DGNB) offers a certification system for use with private buildings.

The sustainable use of renewable raw materials

Wool, a by-product of sheep farming, is an excellent insulation material. Source: anaterate / Pixabay (pixabay.com.de) | common license / https://pixabay.com/de/photos/schafe-herde-pfrech-schafherde-3080951/

The environmental dimension aims at protecting the ecosystem and preserving the natural resources. In order to save natural resources, renewable raw materials also play an important role as building materials. When constructing sustainable buildings, the goal is therefore to use sustainably produced renewable raw materials. The simplest example of this is wood[2]. KAMPA GmbH from Aalen, for example, builds one- and multi-storey wooden houses that are made from sustainably grown wood and have a positive eco-balance[3].

As far as making insulation materials is concerned, numerous renewable raw materials such as straw, sheep's wool and hemp

are available. They all have inherent advantages and disadvantages. Renewable raw materials are already available for use as floor coverings (e.g. linoleum, cotton carpets), coatings (e.g. vegetable oil paints) and interior finishes (e.g. interior walls made of clay and reed). In many cases, they can be used to create a pleasant indoor climate through a good moisture balance[4]. The use of by-products from other sectors is also of interest, including sheep's wool, which accumulates as a by-product of animal husbandry, or wood chips, which accumulate when planing wood, native conifer wood, for example. Sheep's wool and wood chips can be used as insulation materials[5].

The WECOBIS[6] website operated by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) in cooperation with the Bavarian Chamber of Architects, as well as the Agency for Renewable Resources (FNR) supply structured information about environmental and health issues relating to many building product groups and basic materials to help in the design of buildings with sustainable building materials. In future, the list will be expanded to include new, innovative building materials. For example, the "PULaCell" consortium funded by the Federal Ministry of Food and Agriculture (BMEL) is researching bio-based polyurethane for use in reinforcing lamellae for timber constructions.

Recycling procedures of high industrial quality

The reuse of waste materials is of major importance in all phases of a building's life cycle. Building work not only has to comply with the Closed Substance Cycle Waste Management Act, but care must be taken to avoid waste and either recover unavoidable waste properly, without causing any damage to the environment or dispose of it in a way that is in the best public interest. Waste and recycling concepts are therefore part of the requirements for sustainable buildings. According to a survey carried out by the German Federal Statistics Office in 2016, 16 years after the publication of the first "Guideline for Sustainable Building", the proportion of construction and demolition waste still accounted for 52 percent of the total German waste volume of 408 million tons[7]. A "Mineral Building Waste" monitoring report[8] from 2014 details an environmentally sound recovery of around 90 percent of all mineral construction waste in Germany.

This data suggests that the circular economy has already fully arrived in the construction sector. However, the Federal Environment Agency is of a different opinion. It points out that the mineral fractions of the construction and demolition waste largely end up as sub-base for roads or as filling material rather than being used for recovering valuable products from waste concrete. This practice is referred to as downcycling[9]. However, the goal must be to upcycle construction waste material in a way that adds value to it. The draft of an ordinance stipulating requirements for the use of secondary construction materials and soil protection which was approved by the German Federal Cabinet in early May 2017 lays out how this target can be achieved[10]. The draft ordinance provides for a change in the way mineral waste is recycled and used in technical buildings, and will most likely come into force some time during the current legislative period.

The recycling of concrete is an excellent example to illustrate the potential of reusing construction waste material. Construction materials need to be separated at the time a house is demolished in order enable the effective reuse of concrete. Wood, plastic window frames and rubble can therefore be collected separately. A company called Heinrich Feeß GmbH & Co. KG has pioneered concrete recycling. In 2016, the company's managing director, Walter Feeß, and Prof. Dr.-Ing. Angelika Mettke from the Brandenburg Technical University (BTU) Cottbus-Senftenberg were awarded the German Environment Prize. Recycling concrete requires crushing building rubble into small pieces and subsequently removing unwanted substances. Stones at least two millimetres in diameter can later be reused along with other stones, sand, water and cement to produce concrete. The proportion of recycled stones can be up to 45 percent. Tests have shown that concrete made of recycled material is of the same quality as conventional concrete[11].

Energy efficiency is a must

The living units of the "aktivhaus" 700 series can be used and designed very flexibly. The modules are prefabricated and preinstalled at the factory.

When manufacturing the building components to construct more sustainable buildings, care must be taken to choose suitable resources and suitable techniques. Using modules is an excellent and innovative way of saving resources. Façade modules that come with a plug-in system[12] are easy to assemble on the construction site. Complete prefabricated housing modules can also be assembled on site. AH Active House GmbH from Stuttgart supplies such modules. The company builds houses according to the Triple Zero® concept, a standard for sustainable architecture developed by Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h.c. Werner Sobek, architect and director of the Institute for Lightweight Design and Engineering at the University of Stuttgart, and fischerwerke GmbH. Sobek used the Triple Zero® concept to build the "world's first active house" in the Weißenhofsiedlung residential estate in Stuttgart. The building, known as B10 because its address is Bruckmannweg 10, produces twice as much electricity from sustainable energy sources as it requires.

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safey is promoting the construction of model houses that achieve the so-called "Efficiency House Plus" standard, which means that these houses

produce significantly more energy than they need. Technical and scientific guidance on the funding programme for model projects built according to the "Efficiency House Plus" standard is provided by the Fraunhofer Institute for Building Physics (IBP)[13]. The Triple Zero® standard defined by Werner Sobek - Zero Energy, Zero Emission and Zero Waste - meets the Efficiency House Plus standard requirements for sustainable buildings. The "aktivhaus" 700 series developed by AH Aktiv-Haus GmbH from Stuttgart, whose shareholders include fischerwerke GmbH, Prof. Dr. Wolfgang Schuster from the Institute for Sustainable Urban Development in Stuttgart and the Ganter Group, has won many awards including the German Timber Construction Award 2017[14].

Furthermore, additive manufacturing, i.e. the building of 3D objects by adding layers of materials such as plastic, metal or concrete, has made tremendous progress in recent years. It is already possible to print entire houses using 3D printing. In China, for example, a residential building was manufactured in this way in 2015[15], and the US company Apis Cor uses a mobile construction 3D printer with a print area of 132 m^2 capable of printing complete residential buildings on site[16]. Additive manufacturing can also be used to develop innovative architectural structures that would be hard to create using conventional methods. The "Biological Design and Integrative Structures - Analysis, Simulation and Implementation in Architecture" collaborative research centre funded by the German Research Foundation (DFG), which involves 16 institutes from the Universities of Freiburg, Stuttgart and Tübingen, the Fraunhofer Institute for Building Physics and the Stuttgart State Museum of Natural History, deals with such structures. Using a method known as fused deposition modelling (FDM), the partners can produce lightweight structures by building parts layer by layer based on the model of biological structures. This also saves resources thanks to innovative print heads and control systems[17].

It is clear that there are many ways to save resources and make buildings more sustainable. It is also clear that Germany will miss various climate protection targets by 2020, as numerous various studies have found[18,19]. However, the projects and initiatives from Baden-Württemberg also show that buildings can be planned, constructed and operated in a sustainable manner, both in the public and private sectors.

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