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AVK COMPOSITES REPORT 01

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FIELDS OF RESEARCH OF PRACTICAL APPLICATION

Composites in Construction & Infrastructure

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HYBRID BEECH
WOOD BEAM

New development with high potential

COMPOSITES REPORT 01

Content

Dear Reader,

You are looking at the first issue of our new AVK Composites Report. As of now, this magazine will be published at half-yearly intervals, so that you can keep up to date about new developments in the fibre-reinforced plastics and composites market. This issue will focus on the use of composites in the important application segment of building structures and infrastructure. The authors of the articles work for AVK member institutions.

We are hopeful that this magazine will fill a gap, as we'd like you to gain a consolidated share of our members' know-how. The publication of this issue coincides with **JEC World in Paris (3-5 March 2020)**, and the next issue will be published at the same time as **COMPOSITES EUROPE in Stuttgart (10-12 November 2020)** and focus on the topic of transport.

Dr. Elmar Witten
AVK Managing Director

FIBER REINFORCED PLASTICS
in telecommunication sector
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THE CONSTRUCTION AND INFRASTRUCTURE SECTOR

Composites in the limelight

For many years now, the two biggest areas of application for products made from fibre-reinforced plastics and composites have been construction and infrastructure, on the one hand, and mobility, on the other. These two segments account for about a third of Europe's entire production volume. Quite often the automotive and aviation industries have been regarded as major future markets for the composites industry – particularly thanks to high-profile projects such as the BMW i3 and the Airbus 350 XWB. Recently, however, we have seen a clear shift in this area.

The use of composites in the construction and infrastructure sector has been firmly established for many decades now. Composites are frequently used in low-visibility areas like pipe, tank and plant construction, as well as in façade systems, railings and support systems – all areas where they have proved their suitability for many years. However, as well as increasingly being used in existing markets, fibre-reinforced plastics are gradually also becoming the material of the future. Whether it's in bridge construction, architecture or special installations, composites have an outstanding spectrum of properties, so that they are predestined for such use.

Considerable future opportunities are opening up, for example through the expansion of the 5G network. According to estimates, the number of 5G antennas that will be needed in Germany alone is likely to be about 800,000. Composites have many benefits because they are so light, allow plenty of freedom in design, require very little maintenance and have a high level of transparency for specific frequency signals. Moreover, for many years now there have been numerous projects in the Netherlands which show that fibre-reinforced plastics are ideally suited for use in bridge construction. Entire bridges can be prefabricated and put together on site within a very short time. Again, this is due to their lightweight construction and low maintenance requirements.

These are only two examples in an area of application that is currently beginning to (re)discover composites. Composites in construction and infrastructure are a good combination for the future!

FORTHCOMING EVENTS

9 March 2020
FRANKFURT I SEMINAR*
Processes and Tool Design

19 March 2020
PFINZTAL I SEMINAR*
Filament Winding and Pultrusion (Introductory seminar)

23 March 2020
FRANKFURT I SEMINAR*
Serial Production of Fibre Composite Components

30 March 2020
FRANKFURT I SEMINAR*
Getting Started with Reinforced Plastics (Introductory seminar)

31 March 2020
FRANKFURT I SEMINAR*
Getting Started with Reinforced Plastics (In-depth Seminar)

10-12 November 2020
STUTTGART I TRADE FAIR
Composites Europe

** German language only*

ABOUT AVK

Your Composites Network

The AVK – Federation of Reinforced Plastics is the oldest interest group in the plastics industry in Germany and exists since 1924. Members include raw material producers and suppliers as well as processors, mechanical engineers, engineering firms, audit offices and scientific institutes and cover together the entire value chain in the field of reinforced plastics.

THE TASKS AND OBJECTIVES OF THE AVK CAN BE DIVIDED INTO FIVE CENTRAL AREAS

- Image building
- Promotion of innovation
- Training
- Strengthening the sustainability
- Networking

With a wide range of services, the AVK supports its members in practice-oriented ways.

THE EXPERT TASK FORCES

The AVK members can engage in subject-specific expert task forces and work out solutions for key issues in the industry. Task force members benefit directly from new contacts. The task forces provide comprehensive, additional knowledge, which is directly integrated into the company. In addition, in the expert task forces joint marketing activities are planned and implemented.

Current expert task forces:

- Analysis of Fibers and semi-finished Products
- Characterisation and Simulation
- Continuous Fiber-Reinforced Thermoplastics
- EATC – European Alliance for Thermoplastic Composites
- Environment and Occupational Safety
- EPTA – European Pultrusion Technology Association
- Euro-RTM-Group
- GRP in Pipe-/Tankwork and Plant Engineering
- GRP Profiles and Reinforcement Systems
- GRP Safety Tanks
- GRP Swimming Pools
- Innovation Management and Composites Future Market
- Joining of Composites
- Material Testing
- Natural Fiber-Reinforced Plastics
- Open Mould
- PUR Composites
- Reparation of Composites
- SMC/BMC
- Statics – Earthquake Assessment and Connector Charges
- Sustainability
- Thermal Analysis

MARKET DATA

AVK regularly publishes market reports and articles on the latest technologies, developments and trends, with information that is of great value to its members and the composites market. The market data on glass-fibre reinforced plastics (GRP) mainly concern the German and European markets, although they also indicate global developments. In 2019, after more than five years of growth, the composites market stagnated at a total of 1.141 million tonnes. Stagnation, however, did not affect all segments, and growth was recorded, for example, in SMC/BMC, pultrusion and thermoplastic processes. The following chart shows a precise breakdown for each GRP segment.

INFORMATION

The members of the AVK regularly receive newsletters with the latest industry and association news. Moreover, we participate in trade fairs and industry events and organize seminars, conferences and congresses. Especially the field of training and education has a high priority for the AVK. The professional AVK seminars are developed in collaboration with users, experts and scientific institutes. AVK staff would be pleased to help you both practically and with advice. You may be interested in becoming a member, or you may have questions about the specific services we provide, or you may require more details about any of our forthcoming events: Whatever your needs, the AVK office will be happy to assist. AVK is also the right point of contact if you have queries about a technical issue.

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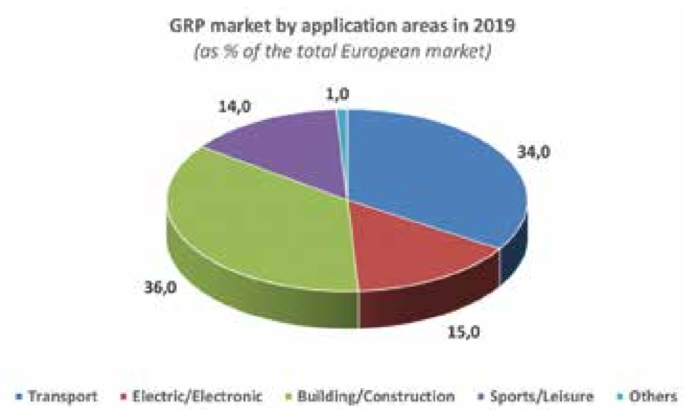
www.avk-tv.de



NOVA-INSTITUT GMBH, HÜRTH

BIOCOMPOSITES

Reducing the use of plastics without changing production technology?

140,000 t of biocomposite granulates are available for greening in Europe.

Authors: Michael Carus und Dr. Asta Partanen

Your customers today expect you to reduce plastics in your products. But this is difficult without compromising performance and processability. Biocomposites can be the solution: 30 to 80 % of plastics are replaced by biogenic fillers such as wood flour or cork, or by natural fibres for reinforcement. The advantage is that these granulates can be processed on your existing machines without major modifications, whether by injection moulding, extrusion or additive production (3D printing). At the same time, the products differ from normal plastic products in their very pleasant feel and unusual appearance. Also, mechanical properties change, the products become stiffer and more tensile and bend-resistant due to the natural fibres.

nova-Institute has now published a list of all European producers and suppliers of biocomposite granulates. The list includes 35 producers from nine different countries. The amount of granulates produced and sold in 2018 was almost 140,000 t. This is a considerable increase compared to previous years and double-digit growth is expected also in the next few years.

Major producers and suppliers of wood and natural fibre filled and reinforced plastic granulates with their production quantities in Europe in 2018

Note: If your company is missing in the list or ranked incorrectly, please contact Dr. Asta Partanen (asta.partanen@nova-institut.de).

Granulate Producer	Country	Polymers	Fibres	Production range 2018 in tonnes
AMORIM	PT	PP, TPE/TPS, Rubber	Cork	50,000 – 100,000
Beologic	BE/AT	PP, ABS, PBS, PC, PE, PHA, PHB, PLA, PMMA, PS, PVC, SAN, TPE	Wood and natural fibres and others	10,000 – 20,000
Advanced Compounding	DE	PP, PA, PE, Biopolymers	Wide range of natural fibres, pine	5,000 – 10,000
Tecnaro	DE	PP, PBAT, PBS, PE, PLA, Lignin	Wood and natural fibres	5,000 – 10,000
Actiplast	FR	PVC, rPVC	Wood, natural fibres	1,000 – 5,000
ADmajoris	FR	PP, Biopolymers	Wood and natural fibres and others	1,000 – 5,000
APM	FR	PP, rPP, PBS, Biopolymers, ABS, PVC, TPE	Natural fibres	1,000 – 5,000
Golden Compound	DE	PP, PBS, PBSA	Fibres from sun flower shells	1,000 – 5,000
Jelu Werke	DE	PP, Biopolymers	Wood and natural fibres and others	1,000 – 5,000
Naftex	DE	PA, PP, PLA, Biopolymers	Wood, bamboo, natural fibres	1,000 – 5,000
PlasticWOOD	IT	PP, Biopolymers	Wood	1,000 – 5,000
Stora Enso	SE/FI	PP, rPP, PS, Biopolymers	Wood and cellulose fibres	1,000 – 5,000
UPM	FI	PP, Biopolymers	Wood and cellulose fibres	1,000 – 5,000
Addiplast	FR	PP	Wood and natural fibres, cellulose fibres	500 – 1,000
Biowert	DE	PP, PE, PLA	Grass fibres, flax	500 – 1,000
FKuR	DE	PP, Bio-PE, Bio-PET, PBS, PHA, PLA	Wood, bamboo, cork, natural fibres	500 – 1,000
Hexpol	SE/BE	TPE	Cork	500 – 1,000
Rhenoflex	DE	PP, Polyester, PLA, PP, TPU, EVA	Corn cob, wood, rice husks, straw	500 – 1,000
Transmare	NL	PP, PE, PLA	Wood, flax and hemp fibres	500 – 1,000
Several small producers (see second table)				about 3,500
Total	**EU**			**140,000**

Created within the framework of the project „WeRümA – Material development on the basis of beet chips for market-relevant applications“. This project is funded by the European Union and the state of North Rhine-Westphalia.

EUROPÄISCHE UNION
Investition in unsere Zukunft
Europäischer Fonds für regionale Entwicklung
EFRE.NRW
Investitionen in Wachstum und Beschäftigung

WHAT ARE THE REASONS FOR THIS SUCCESS?

For one thing, there has never been a greater demand for alternatives to classic plastic products. For another thing, larger quantities of high quality granulates are available on the market for the first time. The manufacturers – often active for more than 10 years already – have used the time to further optimize their granulates. The larger volumes in turn allow for lower prices. Never before has it been so inexpensive to make your production greener without compromising on performance and processability.

Today, there are biocomposites for virtually every application: consumer goods, toys, handles and shoes, façade and terrace elements, floors, automotive interiors, and even space applications.

The Portuguese cork manufacturer AMORIM is the largest producer of such granulates with over 50,000 tons per year. Nearly everyone has products such as shoes, handles for sports equipment or bathroom floors, which are made from those cork materials. Next comes Beologic from Belgium (>10,000 t/year) and Advanced Compounding and Tecnaro from Germany with over 5,000 t/year each.

These three companies offer a wide range of polymers as well as a wide variety of wood and natural fibres as fillers and reinforcers. Even recycled toilet paper (KNN Cellulose) or blue jeans fibres or wine residues (Beologic) can now be processed into plastics. In the meantime, UPM (Finland), Sappi (South Africa) and Stora Enso (Sweden/Finland), large companies from the wood-based products and pulp sectors, have also entered into the production of biocomposites. The two tables give a comprehensive overview of the 35 biocomposite granulate manufacturers in Europe.

Among the biocomposite granulates, cork granulates account for the largest share with approx. 60%. Wood and cellulose fibre granulates account for slightly more than 25% and natural fibre granulates for 15%.

© nova-Institut: Flaxwood, Trifilon, Sulapac, Bioblo, Toys, Coperion, Amorim

SÄCHSISCHES TEXTILFORSCHUNGSINSTITUT e. V. (STFI), CHEMNITZ

Development of material for building envelopes

Resources such as mineral aggregates for concrete are becoming scarce worldwide and therfore, lightweigh construction with a particularly material-saving shape is becoming increasingly important in the construction sector. This industry is also being subject to restrictions like high price pressure with a simultaneous high need for security and reliability.

Author: Heike Metschies

Within the futureTEX initiative, a manufacturing process with main focus on design for complex shaped surface and thin-walled construction geometries was developed and carried out in a research project called "ConTex". Specialists from various engineering sciences, such as technical textiles, building materials, building construction, and FEM-based modeling worked together for technical calculations and prototyping strategies.

Objective of the project was the exploration of a manufacturing process for textile reinforced thin-walled concrete in combination with a resource-saving formwork design.


© STFI e.V.

A model of the developed pavilion is on display at the STFI stand (Hall 5 / C80).

CAD-generated data were organized in such a way that they could be used across the entire textile and building value-added chain up to the construction of a demonstrator. This particularly affected the manufacturing process of the textile reinforcement - stabilized with epoxy resin - and the formwork construction for the individual parts of concrete. The simulation models had to take into account the fiber compound between the reinforcing fibers and the concrete matrix, the bionically inspired arched geometry, and additionally representative damage scenarios. At the same time, due to the use of novel building material and the complicated curved shape, the verification of the generated data and the whole project by the building inspectorate according to DIN is essentially.

The prototype development of a concrete design („Smartie" pavilion) allowed the "real-live-testing" with experimental production and construction of a textile-reinforced shell support structure with a diameter of 5 m and wall thicknesses of only 25 to 50 mm. The manufactured components with reinforcement made of epoxy resin-impregnated carbon fiber grid could save up to 80% mass of concrete compared to conventional steel reinforced concrete. Technical aspects of production, such as prefabrication, transport, and assembly were checked in simulations and practice in order to be able to guarantee a high level of process reliability. The results achieved within the project served as a yardstick and benchmark for the practical suitability of data transfer between the different industries (textiles and construction) on the way to smart factories in a working world 4.0 and resource-saving construction methods.

Research pavilion made of carbon fibre reinforced concrete; design: Gerd Priebe gpac Dresden, research and implementation: BCS Natur- und Spezialbaustoffe GmbH Dresden, FE-Union GbR Chemnitz, IFB TU Dresden, STFI e.V. Chemnitz

ITA – INSTITUT FÜR TEXTILTECHNIK, AACHEN

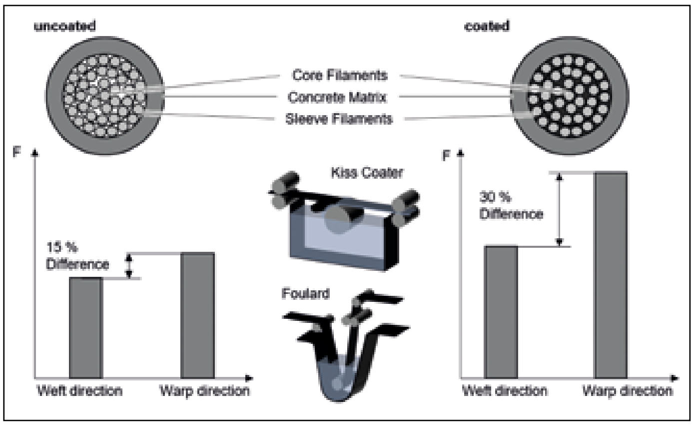
Effect of polymeric coatings on orientation-dependent properties of glass fibre reinforcements in the construction industry

The use of textiles as reinforcement in the construction sector is constantly increasing. In 2018, the Fachvereinigung Faserbeton e.V. (Fibre Concrete Association) called for a practical glass fibre textile. All glass fibre and textile reinforced concrete manufacturers who are members of this association use textiles whose strength potential is not fully exploited due to direction-dependent properties.

Author: Kira Heins

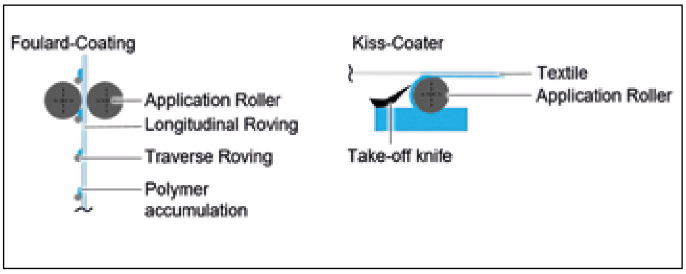
INEFFICIENCY DUE TO DIRECTION-DEPENDENT STRENGTH DISCREPANCY

With commercially available grid-like reinforcements, there is currently a difference in strength of up to 30% between the orthogonal textile directions. Since structural components are designed according to the lower strength value, the capacity of the textiles is insufficiently used and resources are wasted. The reinforcement textiles are additionally coated. Heavily impregnated textiles are not suitable for a variety of applications, as internal structural properties lead to brittle failure with dangerous spalling. On the textile side, the discrepancy is due to the architecture and damage during production. It can be further enhanced by the coating (Fig. 1).



THE COATING AS INFLUENCING FACTOR

The coating of reinforcing textiles serves to improve the composite bond. In the uncoated state, the load is transferred to outer filaments adhesively, to inner ones by friction. The coating fills gussets in the interior of the roving. The load is now transferred adhesively. Stress peaks at the edges are avoided. Usually solvent or dispersion coatings are used. The aim is to achieve a low mass portion with uniform penetration of the textile.



In the following, the problems involved in coating grid-like textiles are explained using the two most common processes (Fig. 2). When coating in the padder/foulard, the polymer is incorporated via rollers. While a uniform incorporation is achieved in the longitudinal direction, rovings in the transverse direction are only subjected to pressure momentarily. At crossing points, roving damage and polymer accumulations cannot be ruled out.

In kiss coaters, low-viscosity materials are challenging because they do not form a sufficient drag film on the application roll. High viscosity materials, on the other hand, do not penetrate to the core. The horizontal production direction leads to uneven coating between the top and bottom of the textile.

PROSPECTS

In the future, suitable coating methods and materials will have to be investigated in order to produce a uniform impregnation with a low mass fraction, which will increase component safety. The resulting conservation of resources will improve sustainability and reduce material costs (approx. 15%).

SBKS GMBH & CO. KG, ST. WENDEL

COMPOSITES in Construction

Author: Dr. Mark Kopietz

Accurate measurement of a test specimen using a calibrated caliper

The public German sewerage network now covers almost 600,000 km of municipal pipelines (as of 2015). Ageing effects such as wear, abrasion and corrosion or external influences such as intruding or damaged joints and crack formation due to root growth, for example, lead to damage to the substance over time and require a high level of rehabilitation. In contrast to cost-intensive renovation, repair and renovation methods have established themselves, whereby trenchless renovation using liners made of fibre-reinforced plastics (FRP) stands out as the most important, eco-efficient renovation method (93.5%)[1].

Depending on the length of the defect, different methods, such as short liner or tube repair, are used for rehabilitation. In this methods, the textile carrier (semi-finished fibre product, usually made of glass or synthetic fibres) is impregnated with a reactive thermosetting resin (epoxy, vinyl ester, unsaturated polyester or organomineral resin) and applied on site at the defect location. The „pipe-in-pipe“ solutions (CIPP, cured in place pipes) resulting after curing (in situ, thermally or UV-initiated) ensure that the substance can be reused through durable composites.

For the collection and monitoring of chemical, physical and mechanical parameters, in-house production controls, external monitoring and suitability tests of the resins and composites - in particular for obtaining general building authority approvals by the Deutsche Institut für Bautechnik (DIBt) - are mandatory as a quality assurance measure in accordance with DIN 18200[2].

In particular, mechanical (peak pressure, three-point bending, tensile and adhesive tensile tests), chemical (FT infrared spectroscopy, gas and high-performance liquid chromatography) or physical (dynamic differential calorimetry, dynamic-mechanical analysis, dielectric analysis, thermogravimetric analysis, rheology, calcination and microscopy) methods can be used to describe and monitor the resins and composites used, thus ensuring a high degree of quality assurance. The SBKS GmbH & Co. KG, as an accredited plastics testing laboratory, provides the high level of scientific and engineering expertise needed to carry out and evaluate the tests.

[1] *C. Berger, C. Falk, F. Hetzel, J. Pinnekamp, S. Roder, and J. Ruppelt. Zustand der Kanalisation in Deutschland: Ergebnisse der DWA-Umfrage 2015. KA – Korrespondenz Abwasser, Abfall, 2016(6): 498–508, 2016.*

[2] *DIN 18 200 „Übereinstimmungsnachweis für Bauprodukte, Werkseigene Produktionskontrolle, Fremdüberwachung und Zertifizierung von Produkten“*

ZHAW ZÜRCHER HOCHSCHULE
FÜR ANGEWANDTE WISSENSCHAFTEN, WINTERTHUR

PEDESTRIAN **BRIDGES**
made from prestressed carbon concrete CPC

Authors: Prof. Josef Kurath, Antje Sydow

CARBON PRESTRESSED CONCRETE CPC

CPC slabs are slender concrete slabs reinforced by a minimum of four layers of perpendicular prestressed carbon wires. They are structural elements with high load carrying capacity and have already been used in about 100 projects. Typical applications are balcony floors, bridge decks and complete structures with CPC slabs as primary construction elements.

Prestressed carbon reinforcement reduces the weight of the concrete slabs to about 25% compared to conventional steel reinforced concrete of the same capacity. Carbon does not corrode, therefore only minimal concrete cover is required, significantly improving sustainability. The raw slabs are produced industrially in sizes of 2.4m x 10.0m and thicknesses of 24, 40, 60 and 80mm and later machined to customer specifications.

PEDESTRIAN BRIDGE SYSTEM

A modular CPC pedestrian bridge system is being developed, consisting of a CPC bridge deck rigidly connected to carbon beam sections underneath. The system is free from metal and corrosion and easy to maintain. Due to its modular design, it is economic and adapts to the specific project requirements. Two prototypes have been built in Switzerland.

The U-shaped carbon sections are produced by Vacuum Assisted Resin Infusion. The width is fixed, but carbon layup and section height are adapted to project requirements. The beam edges are cut neatly and rectangular teeth are made. The connection is made by placing the carbon teeth into fine slots milled into the underside of the CPC slab. Remaining spaces are filled with a high-strength grout. The loads are carried by mechanical interlocking, and transferred by the teeth's contact area.

The prototype bridge in Turbenthal/ Switzerland as assembled in the workshop and placed onto its foundations by a small mobile crane

The carbon beams are produced by Vacuum Assisted Resin Infusion, lay-up and height are adapted to project requirements.

The bridge system is designed for bicycle and pedestrian bridges with maintenance vehicles. It is optimised for serial production, but adapts to individual bridge dimensions and finishes. The concrete bridge deck protects the carbon from environmental influences and any mechanical damage. The structural system of the lightweight bridges is advantageous for the foundations: replacement bridges re-use the predecessor foundations; a simple load-spreading plate is sufficient for founding new bridges onto which the bridge is set at delivery.

Robustness and safety of the bridge system were proven by laboratory testing and a 4-point-bending test of a beam in original size. When loaded to 125% of the required capacity the beam was still fully elastic and undamaged.

Research & Development:	ZHAW Zurich University of Applied Sciences, Fachgruppe Faserverbundkunststoff FVK; www.zhaw.ch/fvk
CPC technology and engineering:	CPC AG, Andelfingen/Switzerland www.cpc-betonplatten.ch
Bridge production:	Silidur AG, Andelfingen/Switzerland, www.silidur.ch
Production carbon beam:	aXpel wernli composites AG, Hottwil/Switzerland; www.w77.ch

The carbon beams are placed into the CPC slab pockets and remaining gaps are filled with a high-strength grout.

FRAUNHOFER WKI

SUSTAINABLE TEXTILES –

the future in construction

Authors: Christina Haxter, Jan Binde, René Schaldach, Marco Wolf

Fig. 1: Natural fiber-supported concrete bridge developed at the Fraunhofer WKI - on display at Bau 2019

In the construction industry, too, new requirements are constantly arising, which can only be met by the development of new materials. One innovative material is textile concrete, in which the conventional steel reinforcement is replaced by fabrics made of synthetic fibers. Due to its low component thickness, it enables versatile geometries and lighter constructions. Up to now, glass or carbon fibers have been used mainly as textile reinforcement. However, carbon fibres in particular are very energy and cost-intensive to produce and also present a particular challenge in terms of aspects such as recycling. A research team from the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI, is investigating the possible use of natural fiber fabrics in textile concrete for a wide range of applications. In addition to an improved CO_2 balance, the manufacturing costs for textile concrete can also be reduced.

An important goal of the research work at the Fraunhofer WKI in this area is the design and manufacture of suitable fabric structures adapted to the respective application. In addition to purely bio-based textile semi-finished products, hybrid structures are also being developed. Special attention is also paid to the development of functionally integrated fabrics. These enable, among other things, damage detection directly in the component, or bring further functions such as lighting into the concrete component.

The surface modification of textile semi-finished products is also a focus of the developments at the Fraunhofer WKI. The chemical or physical treatments of natural fiber fabrics are used to finish them to meet the special requirements resulting from their use in various concrete mixtures. The coating of the semi-finished products with bio-based or conventional resin systems is also being investigated, among other things to protect the fibers. Another approach to improve the durability of components made of textile concrete is the use of a high-performance concrete, which is also adapted and further developed at the Fraunhofer WKI. The investigations carried out at the Fraunhofer WKI to date clearly show that the innovative material combinations of bio-based fabrics and high-performance concretes are suitable for a wide range of applications.

Fig. 2: Different flax fabrics with varying weft density

FRAUNHOFER-INSTITUT FÜR BETRIEBSFESTIGKEIT UND SYSTEMZUVERLÄSSIGKEIT LBF, DARMSTADT

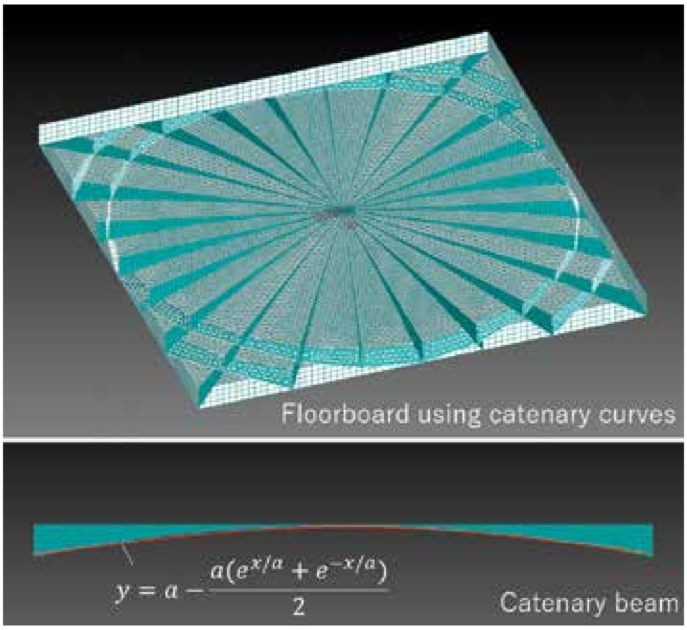
APPLICATION OF COMPOSITE MATERIALS FOR LIGHTWEIGHT BUILDING STRUCTURES

Authors: Sven Herold, Fraunhofer Institute for Structural Durability and System Reliability LBF, Hitoshi Matsushita, Research and development institute, Takenaka corporation

Building weight reduction is beneficial in various aspects. Some of them are to contribute to reduce burdens of transporting building materials, shorten construction periods, improve construction safeties, and so on. These effects also contribute to environmental load reductions, and improving the degree of freedom in architectural design. Concrete floorboards occupy approximately 35% of the building weight in case of steel-structured buildings, which is the major part of the building weight. Additionally, some parts of floorboards mostly contribute to supporting the weight of the floorboard itself rather than supporting loads on the floorboard. For these reasons, weight reduction of floorboards is effective for lightweight design of buildings.

To reduce the weight of floorboard, it would be meaningful to apply composite materials, which are lightweight and can realize high strength and high rigidity. Needs for free molding, the increasing momentum of automation and efficiency of building construction could also be a tailwind for implementation of composite materials where 3D-printing technology is relatively easy to use. On the other hand, weight reduction of floorboards involves various challenges. The higher susceptibility to vibration is one of them. Such floorboards may cause uncomfortable vibration for people who live on the floor and problems on the downstairs by sounds of footsteps. Hence, vibration and sound reduction technology is also essential for lightweight floorboard.

Based on the above background, two types of lightweight floor panel using composite materials that is unlikely to generate uncomfortable vibrations or floor impact sounds are investigated. A honeycomb structure is a representative example of a lightweight and highly rigid floorboard. Thus, if the same rigidity as a conventional floor structure in which a concrete slab is placed on steel beams is assumed, the honeycomb slab using polycarbonate and CFRP can reduce the mass of the floor structure by about 85%. Floorboards using catenary curves, which is a curve drawn by a hanged chain, are also examined. Because bending moments and tensile stresses are not generated in the inverted shape of catenary curve, it is postulated that the shape is efficient for beams bearing vertical loads. With a structure using this shape, the strain distribution with respect to its own weight became uniform, bending moments were minimized, and the mass could be further reduced by about 18% with respect to a honeycomb slab.



Lightweight Floorboard (top) with optimized ribs using catenary beams (bottom)

On the other hand, as predicted above, a deteriorated vibration performance in the frequency band higher than 20 Hz due to the weight reduction is observed. This will increase the perceivable vibration and the floor impact noise caused by walking on the floor, etc. Therefore, it is planned to study the application of passive and active vibration suppression technology, e.g. using dynamic vibration absorbers, metamaterials or piezoelectric materials. From design point of view, both the vibration characteristics of the floorboard, the walking load and human perception characteristics are important. Therefor they have to be examined comprehensively.

AVK

POTENTIAL FOR COMPOSITES

in infrastructural and telecommunication applications

Fibre-reinforced plastics have specific material properties that make them ideally suited for use in telecommunications, and for the necessary peripheral equipment, in particular. Cables, masts, antennas, power lines and much more are essential for a system to work, as well as to ensure that it can be expanded geographically as widely as possible.

Author: Volker Mathes

Setting up the necessary infrastructure also plays a central part in the discussion of the latest mobile phone standard 5G. Full network coverage must be guaranteed, for example, as a basis for autonomous driving, Industry 4.0 and an increasing level of network integration, including individual integration.

ANTENNAS, THE FOUNDATION FOR COMMUNICATION

To achieve this goal, a large number of new masts and antennas will be needed. The 5G network is based on a frequency that differs from the current one. Although the expected output will be significantly higher, the reach of a transmission mast will be much lower. Moreover, a number of applications (such as autonomous driving) will require seamless availability and communication at the highest level. This means that numerous additional masts will have to be erected – even in currently built-up environments, such as urban conglomerations, industrial estates, difficult terrain, etc.

Composites have enormous advantages for this purpose. Composites / GRPs (glass-fibre reinforced plastics) have outstanding anticorrosion qualities. In other words: they don't get rusty. Furthermore, these materials are highly durable. There are numerous products and applications that have been successfully in use for over 50 years. Provided that an object has been designed and built with the relevant purpose in mind, the materials are also extremely low in maintenance. Depending on where they are situated, this either increases their service lives or their added value during operation. GRPs continue to be dimensionally stable even under fluctuating temperatures and are therefore ideally suited for use within a confined space. Also, these materials have outstanding insulation and are non-conductive, saving the cost of earthing that would otherwise be required. In addition, GRP-based products have excellent dielectric properties: Parts made from glass fibre compounds are almost "invisible" to high-frequency waves and have therefore been used in telecommunication applications such as base stations and radomes for many years, as they cause minimal signal attenuation.

The full article was published in the German trade magazine Werkzeuge in der Fertigung (Tools in Manufacturing), issue 6/2019.

IMPRINT

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FRAUNHOFER IGCV

DEVELOPMENT OF A PULTRUSION TECHNOLOGY

based on nanoparticle-modified matrix systems for applications in the construction industry

Within the framework of the EU-funded project „OASIS“ (Open Access Single entry point for scale-up of Innovative lightweight Smart composite materials and components; https://project-oasis.eu/), lightweight construction technologies in which new potential can be generated through the use of nanoparticles are being further developed in several showcases.

Authors: Simon Schwab, Michael Sauer

One of these showcases investigates the use of nanoparticle modified resin systems for the production of fiber composite rebars through a modified pultrusion process. Fiber composite rebars have very good specific mechanical values as well as a higher corrosion resistance. These two properties make it possible to reduce the minimum concrete cover and therefore offer an enormous potential for weight reduction, as well as a material and CO² reduction. The current challenges, which will be considered within the showcase, are the mechanical performance at elevated temperatures and the optimization of the production process in terms of cost reduction.

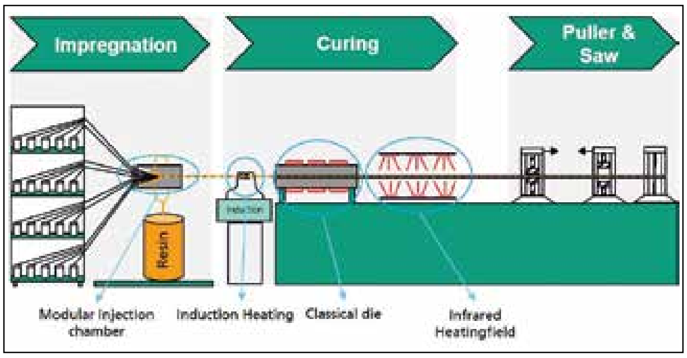

Figure 1: Pultrusion process with the investigated process steps (blue)

Within the overall OASIS consortium, this showcase is being worked on by the project partners Acciona S.A., Fraunhofer IGCV, Fraunhofer ISC, Tecnalia, and UCLM. The Fraunhofer IGCV is developing a modified pultrusion variant on the process side within the project. The focus is particularly on the processability of nanomodified resin systems and process optimization to generate higher production speeds.

These goals are achieved by a modular setupf of the pultrsion line (see Fig. 1). The impregantion takes place within a modular injection chamber, which can be adapted to different geometries by means of inserts and can be directly tempered. In initial tests, the functionality of the injection chamber was demonstrated with different resin systems (see Fig. 2). he optimization of the process speed is investigated by considering different methods of heat input, which can be used individually or in combination. As a benchmark, the current production speed, the degree of cross-linking and the mechanical characteristics of the fiber composite reinforcement bars from state-of-the-art rebar production processes will be used (project partner Acciona) and will also be adapted and investigated with regard to their heat resistance (project partners Tecnalia and UCLM).

The process route can be realized in variable order due to the individual modules. In particular, the possibility of using an inductive heating system in combination with specially developed nanoparticles (project partner Fraunhofer ISC) is very promising here. Theoretically, the heat input is then uniform across the cross section and the heating rate is very high. In initial preliminary investigations, heating rates of approx. 30°C/s could be realized. This is especially promising for a fast reaction initiation directly in front of the mould. The findings and results can also be transferred to other fields of application that can be produced by pultrusion. This technology transfer will also be considered within the framework of OASIS through the submission of subsequent sub-projects.

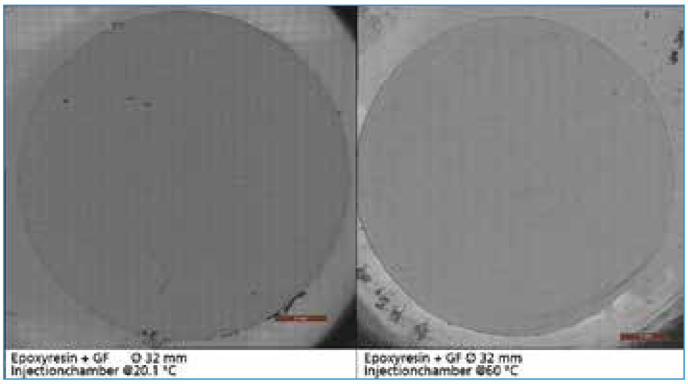

Figure 2: Microsection to validate the Injectionchamber

Open access single entry point for scale-up of innovative Smart lightweight composite materials and components. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814581.

TU CHEMNITZ

HYBRID **CONSTRUCTION**

wood in composite structures

The Lightweight Construction in Civil Engineering research group at Chemnitz University of Technology, Chair of Structural Lightweight Design and Plastics Processing, has been working under the direction of Prof. Dr. -Ing. habil. Sandra Gelbrich is involved in a wide range of developments for the demanding construction sector.

Authors: Prof. Sandra Gelbrich, Prof. Holger Cebulla, Fabian Nendel, Ralf Gloniorz and Andreas Ehrlich

The main focus of the research work is on: the development of basic principles for resource-efficient and highly resilient material composites, the generation of lightweight support structures, the integration of functions and the technological implementation of new construction methods along the entire value chain - from the idea to the transfer into a practical solution (see Fig. 1). The research spectrum ranges from the microscopic determination of crystal growth in mineral matrices to the development of entire building facades made of fibre and textile reinforced special concretes.

Fig. 1: Overview of the range of services of the research field „Lightweight Construction in Civil Engineering"

In addition to the previous research work on fibre composites with mineral or polymeric matrix, investigations on renewable raw materials, such as wood or natural fibres, have increasingly been part of the research activities in recent years. The use of these natural lightweight construction materials in combination with fibre composites opens up new possibilities because of their high strength and low weight, especially in (free-) supporting applications. Increasing demands for environmental friendliness, sustainability and resource efficiency can be met by using renewable raw materials in combination with highly resilient technical textiles.

In cooperation with the Chair of Textile Technologies under the direction of Prof. Dr. -Ing Holger Cebulla, the idea of a hybrid material composite based on a glulam beam made of spruce wood was born. This BSH is reinforced, similar to the prestressed concrete principle, with a prestressed textile on the tension side of the beam, which leads to an increase in stiffness of up to 25% (see Fig. 2). This enables the cross-sections required in the course of component design to be reduced or loads can be increased for the same cross-section. Another approach of the research project is the coating of the carrier with a natural fibre reinforced plastic. This protects the composite girder from environmental influences, increases durability and reduces the service class of the wood used. This allows inferior but native woods (spruce/pine) to be used for the executing agency, which contributes to an overall ecological approach to the project.

Fig. 2: Glass fibres prestressed and stress-free

In contrast to conventional chemical wood preservatives, the NFK coating of the carrier bypasses waste wood class 4 and thus avoids additional costs in the recycling process. Thanks to a special separating layer, the coating can be completely detached from the carrier at the end of its useful life and recycled separately. Thermal recycling of the individual components is only envisaged as a last resort. For the reinforcement of connections or junctions with rod-shaped connectors, special textile reinforcement structures manufactured in Tailored Fiber Placement (TFP) are used (see Fig. 3). These allow an even load distribution in case of a hole soffit load and significantly increase the hole soffit strength. The textile struc-tures are placed in a pocket milled around the borehole and impregnated with epoxy resin.

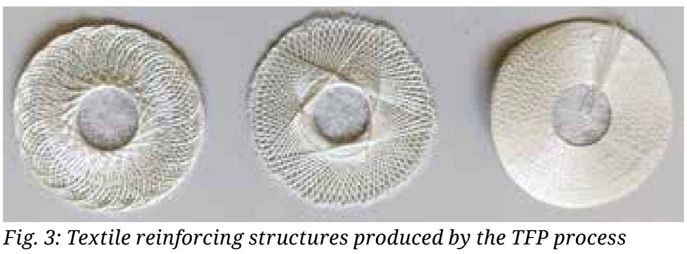

Fig. 3: Textile reinforcing structures produced by the TFP process

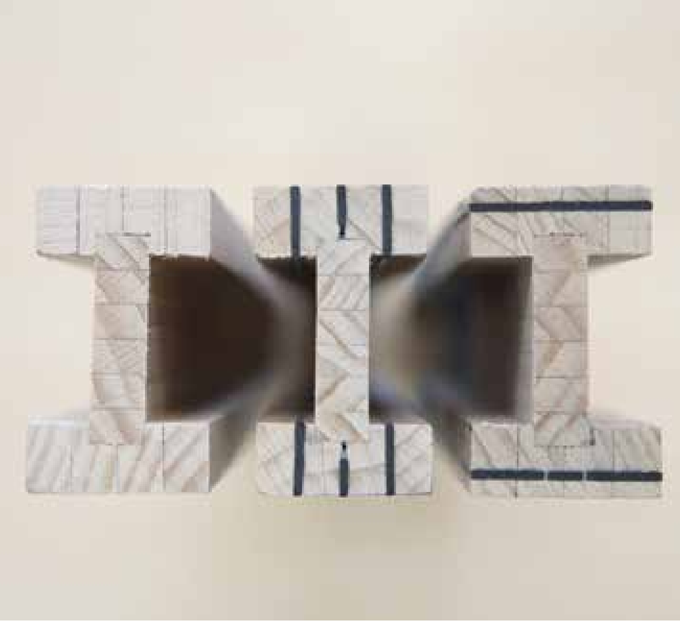

Fig. 1: Hybrid beams.

Fig. 2: Multi-purpose hall

INSTITUT FÜR VERBUNDWERKSTOFFE, UNIVERSITÄT KAISERSLAUTERN

KOBU: RECYCLED CARBON FIBER REINFORCED BEECH WOOD BEAM

Demand for carbon fiber reinforced plastic (CFRP) has risen steadily since commercial use in the 1960s. The average annual growth rate from 2010 to 2018 was over 12%. A similar high rate is expected in the future[1].

Authors: Ulrich Blass, Dr.-Ing. Nicole Motsch-Eichmann, Kompetenzfeldleiterin Bauweisen

Based on that prediction, production waste of 20.000 up to 30.000 t of CFRP is expected for the year 2025[2]. At the same time, the concentration of greenhouse gas CO_2 in the atmosphere has to be reduced if the 2 degree climate warming mark from the Paris Climate Agreement should not be missed. Both CO_2 concentration reduction as well as economically profitable recycling of CFRP production waste are aimed at as part of the KOBU research project. The specific target of the project is the development of standardized and resource efficient hybrid beech wood beams to substitute steel and concrete beams. This is to be made possible by increasing the stiffness and strength of the flanges of beech wood I-beams with lamellae made of recycled CFRP (rCFRP-lamellae) (picture 1).

The rCFRP-lamellae are based on a fleece made of carbon fibers with a specific orientation. The use of a fleece made of short carbon fibers enables the use of production waste and end-of-life products, for example in aviation and automotive industry. The orientation adjustment of the carbon fibers in the fleece allows an ideal and cost-effective use regarding the mechanical requirements within the beam length and at the bearings.

Beech wood from the middle of the trunk is used to build the hybrid beams. This kind of wood has a minor importance and is usually used as packaging material or as firewood. So far, it has not been considered for a long-term application and therefore a storage of the embedded CO_2 in the wood. Finite Elements Analyses (FEA) of a hybrid beam with an usage of 7 vol.-% rCFRP have shown an increase in bending stiffness of approx. 30% compared to unreinforced beech wood beam. Additionally, an increase of approx. 40% of the bending strength has been reached.

To validate the FEA and to examine the ideal orientation of the rCFRP lamellar within the beam, scaled hybrid beams were produced (picture 1 center, right). The hybrid beams as well as the the reference beam made of beech wood are tested in a 3-point bending test.

[1] *Sauer, W. (2019): Composites Marktbericht 2019, CC e.V.*

[2] *Rademacker, T.; Fette, M.; Jüpner, G. (2018): Nachhaltiger Einsatz von Carbonfasern dank CFK-Recycling, lightweight.design 12-19*

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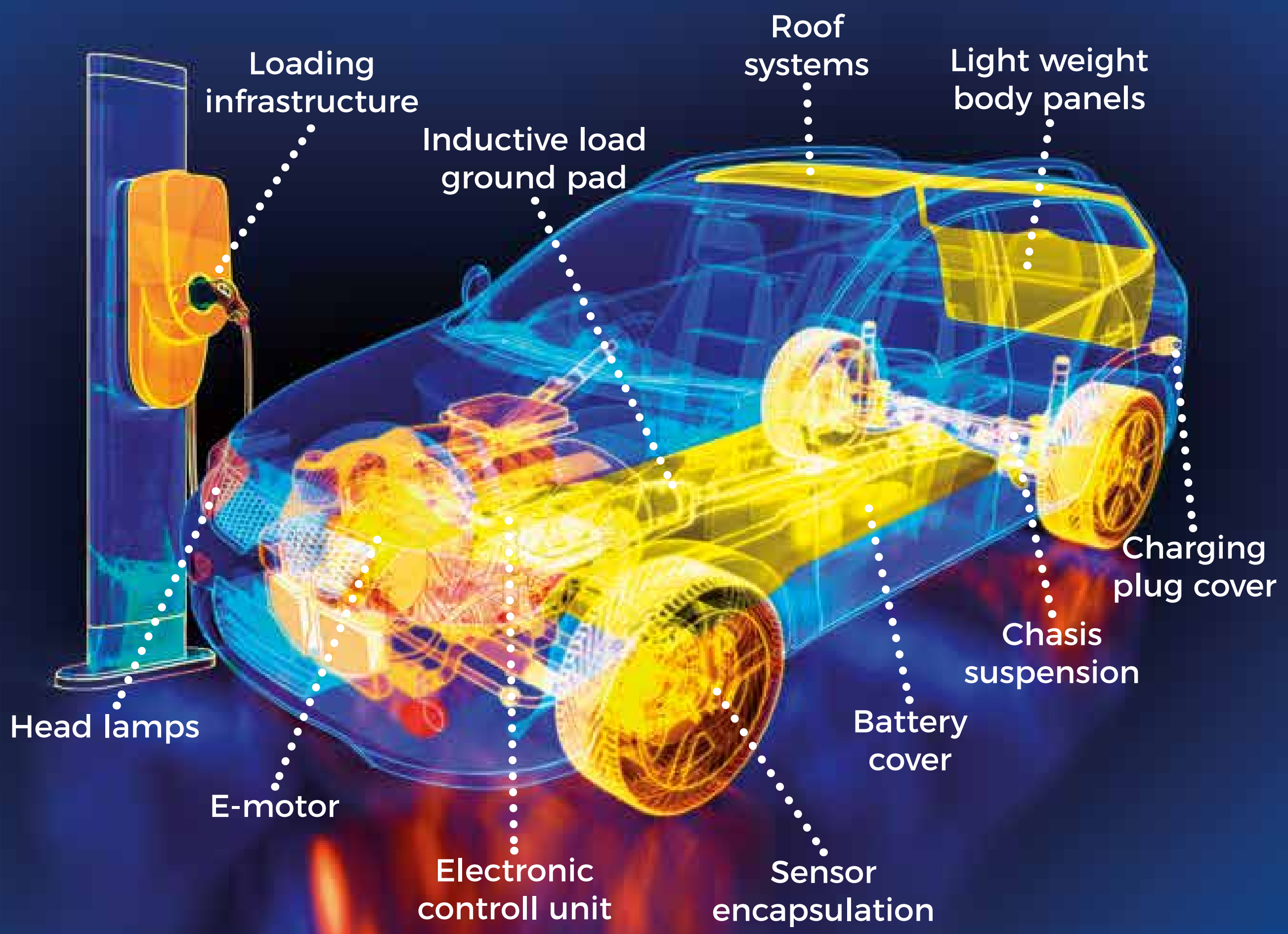

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