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EDITORIAL

Dear Friends and Partners of the Institute for Concrete and Masonry Structures,

With this current 29th issue of 'Darmstadt Concrete' we wish to continue also in 2014 the tradition of informing you at the turn of the year of our Institute's activities in research and teaching and of our work on committees in the past 12 months, thereby giving you the opportunity for rereading, reflecting and questioning. This issue also contains basic information and reports on essential decisions for future work on and at the Institute. Let's begin with a still highly topical and very gratifying event.

The procedure to fill the vacancy of the chair of 'Construction Materials', which arose in the spring of 2012, has been concluded successfully this autumn. Prof. Dr.-Ir. E.A.B. Koenders has accepted the offer of TU Darmstadt with effect from 1 November. We welcome him most sincerely and wish him success in research and teaching. Our express thanks go in particular to the colleagues in this specialist field who successfully maintained the teaching during the vacancy of this chair.

While the vacancy lasted and as early as 2013, the Research and Test Laboratory at the Institute for Concrete and Masonry Structures had to be managed by Prof. Graubner with the efficient assistance of the long-standing colleagues Dr.-Ing. K.-H. Lieberum and Dr.-Ing. T. Proske.

The reaccredidation carried out in 2014 of the courses offered by the Faculty of 'Bau- und Umweltingenieurwissenschaften' was completed successfully. The dedicated collaboration within the Faculty, the excellently structured documentation as well as the exemplary project studies were among the particularly positive points underlined in the final discussions.

This end-of year report also affords us the opportunity to thank our staff for their work and commitment. The performance and success of our Institute in 2014 would have been inconceivable without the high quality and the untiring commitment with which our scientists as well as our staff in the secretariats, technical services and laboratories accomplish their tasks and projects. We congratulate Dr. Pohl, who was able to complete his research work with the successful defence of his dissertation, and extend a warm welcome to all 'newcomers'.

So as to allow you, our Friends and Partners, the customary insight into our scientific work, as well as to thank you for your support, you will find, as in recent years, our

scientists' brief reports on their current research and development projects, both in German and English.

Not least, we would like to take this opportunity to thank the "Freunde des Instituts für Massivbau der TU Darmstadt e.V.", without whose support it would not have been possible to achieve some small but also some bigger measures at and for the Institute and its students. In particular, thanks are due here to the Chairman of the Executive Board Dr.-Ing. Six and the Executive Board members Dr.-Ing. Klemt-Albert and Dipl.-Ing. Hanek, who advise and encourage us in many different ways, for their constant and generous support.

The past year's research achievements, the successful appointment to the chair of 'Construction Materials', the high degree of student attendance of our lectures as well as the high approval ratings by and commitment of our students allow us to face the future with optimism.

On behalf of the entire Institute we wish you and your families a peaceful and happy Christmas and a good start to all your undertakings in the New Year.

Prof. Dr.-Ing. Carl-Alexander Graubner

Prof. Dr.-Ir. E.A.B. Koenders

Prof. Dr.-Ing. Gerd Simsch

REVIEW OF THE LAST YEAR

PROFFESSOR „CONSTRUCTION MATERIALS“

As per 01.11.2014 is Prof. Dr.ir. Eddie Koenders appointed a chaired professorship in the important field of Construction Materials. Main objective is to manage new developments and to find answers for the main problems that are facing us, such as for example the energy reduction, reuse of raw materials, and minimization of CO2 emissions. These current and upcoming themes tighten the boundary conditions within which we have to develop our future construction materials.

Education and research give us the opportunity to develop together with students, researchers and colleague professors advanced innovations that can be judged, implemented and used by the industry. A strong cooperation between industry and researchers is therefore indispensable.

Research and technologies that are at our disposal are increasingly approaching the smaller scale levels. More and more technological solutions are discovered by research conducted at the micro and nano-scale levels. High-tech numerical and experimental facilities enable this and may contribute to find the answers on the most important future questions such as quantification of the service-life of sustainable materials, the development of environmentally friendly cements and the assessment of the actual and residual life of current and new infrastructures like bridges, tunnels, etc. New research initiatives as self-healing materials or bio-inspired material developments could also have a contribution to this.

Prof. Koenders studied structural engineering and offshore technology at the faculty of Civil Engineering at Delft University of Technology in The Netherlands and received his doctors degree in the field of volume changes of high performance materials in 1997. After that he worked five years in a large Dutch offshore and construction company as a project and innovation manager. From 2003 on he was employed at Delft University of Technology as an assistant and associate professor being involved in many research projects such as explosive spalling of concrete due to fire exposure, durability of infrastructure, modelling hydration of sustainable cement systems and the development of

models for the prediction of the mechanical properties of concrete with recycled aggregates. From 2011 to 2014 he was a visiting professor at the Federal University of Rio de Janeiro (UFRJ) at the NUMATS center for Sustainable and Durable Materials Development in Construction.

SEMINARS AND EVENTS

Darmstadt Days for Prefabricated Concrete Elements

Due to our cooperation with the professional association "Deutscher Betonfertigteilbau e. V." and the "Beton Marketing West GmbH", we were able to host the renowned seminar series "Darmstadt Days for Prefabricated Concrete Elements" again in 2014. The presented topics varied from the characteristics of prefabricated constructions, which already begin with the initial sketch, to special construction elements and corresponding methods, such as job-mixed additions or prestressed constructions. Further, stability considerations define a focal point with examples, such as lateral buckling and the design and construction of the connections. A total of 350 structural engineers and students participated in the event. The seminars were complemented by an exhibition of renowned manufactures of construction products related to the topic of precast construction.

Due to the positive feedback from the past years, we will offer the seminar series again in 2015. The structure of the event will be setup in alliance with our former events: top-notch papers in their field will be presented, as well as practical examples and our well-attended exhibition. We are confident to attracted a highly diversified audience with a combination of interesting topics and renowned speakers form science and practice. The topics for the upcoming seminar series in spring 2015 are lined up as follows:

- Designing, manufacturing and art | 19.03.2015
- Pre-dimensioning and prestressing | 20.03.2015
- Design und concrete | 26.03.2015
- Connections: Construction and design | 27.03.2015

Generally speaking, the seminar content is tailored towards engineers from practise. However, a separate "student day" takes place in which the design of precast concrete elements will be treated. Thus, the lecture "prefabricated constructions", which takes place in the context of the Darmstadt days of prefabricated concrete elements, can be incorporated into the student's study design. The first day of the seminar series includes a special focus on the design possibilities with prefabricated concrete elements (e.g. photo concrete) aiming to target not only architects, but students in the field of architecture.

Update on the event can be found on the homepage of the Institute for Concrete and Masonry Structures (www.massivbau.tu-darmstadt.de). Enter the section named „Veranstaltungen". In case of questions, please don't hesitate to contact Mr. Valentin Förster, M.Sc.

Training seminar for structural engineers

The Institute for Concrete and Masonry Structures cordially invited engineering experts to the 2014 seminar series. Speakers from practise give presentations on newest developments in civil engineering. Throughout the year we were able to attract more than 500 structural engineers. The seminar series was almost fully booked and followed the established event concept. The seminar series in 2014 gave an overview of the latest technical developments of the civil engineering. To this end in the spring the issues of steel fiber reinforced concrete, loads and timber constructions were treated. In the autumn were lectures about scaffoldings, structural damages and fixing systems. Below you find all six individual seminars; three of which were held in spring, the other three seminars were held in autumn.

- DAfStb-guideline steel fiber concrete – backgrounds | 26.02.2014
- Eurocode 1 (actions on structures) – backgrounds | 12.03.2014
- Eurocode 5 (timber structures) – Examples for design | 02.04.2014
- Design and construction of work and supporting scaffolding | 17.09.2014
- Structural damage | 01.10.2014
- News about fixing systems | 08.10.2014

Due to the positive feedback from the past years, we will organise the seminar again in 2015. We are confident that the combination of interesting topics and renowned speakers will again attract many structural engineers.

- Design with concrete truss models | 04.03.2015
- Practical reinforcements – Samples according to book 559 | 11.03.2015
- Basics of structural fire protection | 25.03.2015
- Technical building equipment and building acoustics | 16.09.2015
- Bridge Building | 23.09.2015
- Timber constructions – detailed design | 07.10.2015

Updates on the seminars, as well as the registration can be found on the homepage of the Institute for Concrete and Masonry Structures (www.massivbau.tu-darmstadt.de) under the section „Veranstaltungen". In case of questions, please don't hesitate to contact Mr. Valentin Förster, M.Sc.

37th Darmstädter Massivbauseminar 2014 - „Building Information Modeling - in Planung und Ausführung“

On November 12th 2014, the 37th Darmstädter Massivbauseminar took place on the campus Lichtwiese of TU Darmstadt, this year under the heading item “Building Information Modeling - in Planung und Ausführung”. Together with renowned experts the participants discussed the latest developments of Building Information Modeling (BIM) in science and research as well as in the national and international BIM practice.

The board of the “Freunde des Instituts für Massivbau der TU Darmstadt e.V.” would like to thank all persons involved explicitly for their high commitment which was of crucial importance for the success of the event. Special thanks have to be directed to the speakers and numerous supporters of the 37th Darmstädter Massivbauseminar. Hereinafter you can find a list of all speakers and their oral presentations’ titles:

- Prof. Dr.-Ing. Raimar J. Scherer: Chancen und Anforderungen an BIM
- Prof. Dr.-Ing. Christoph Motzko: Bedeutung von BIM in der baubetrieblichen Hochschulbildung - Ein Erfahrungsbericht
- Dr.-Ing. Katja Hüske: Planung von Eisenbahnprojekten in virtuellen Modellen - Aktuelle Beispiele und Ausblick in die Zukunft
- Dipl.-Ing. Thomas M. Hüster: BIM - Integrale Planung und fachübergreifendes Datenmanagement
- Dipl.-Ing. Nicodemus Jansson: BIM in der Tragwerksplanung
- Dipl.-Ing. Arch. Alar Jost: BIM @ HENN - Praxis und Perspektive
- Dr.-Ing. Matthias Jacob: Vom Dreikant zu 5D - WOLFF & MÜLLER im Wandel durch BIM
- Dipl. Math. (FH) Mark Jäckel: BIM bei Goldbeck

Summer Festival

Followed by the traditional summer festival, the general meeting of the “Freunde des Instituts für Massivbau der TU Darmstadt e.V.” took place on June 5th 2014.After the official part of the event the newly elected chairman of the association, Dr. Six, welcomed numerous association members and institute staff. During the barbeque the attendees used the possibility of reunion and conversation in a comfortable atmosphere.

COLLABORATION IN STANDARD BODIES

Prof. Graubner is still chairman of the standardization committee NA 005-06-01AA "Masonry Structures", the leading national standards body dealing with issues of standardization in the field of masonry structure. He simultaneously acts as German delegate at European level. In this position he prepares the official introduction of DIN EN 1996 substituting DIN 1053 for design and construction of masonry structures in Germany. Due to his high responsibility in the above mentioned committee Prof. Graubner gave up his position as chairman of DIN-Committee NA 005-51-01 AA "Basis for Design and Calculation of Structures" in march 2013. Nonetheless, he is still member of this standard body with major focus on the reliability-based aspects of analysis and design of concrete structures. Moreover, he is selected member of standard committee NA 005-07-01 AA "Design and Construction of Reinforced Concrete".

Following the aforementioned activities in the field of masonry structures Prof. Graubner is editorial advisor for "Mauerwerk" journal. Recently he is also coeditor of "Mauerwerksbau aktuell", a yearbook which reflects the latest developments and advances in both research and practice of masonry structures.

Prof. Graubner is member of the Roundtable „Sustainable Building" consulting the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and furthermore he organizes the Roundtable "Resource Efficiency in the Building Sector" of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. He is also active in the working group "Sustainability Assessment of Road Infrastructure" at the Federal Highways Research Institute. As a long-standing member of different expert groups Prof. Graubner supports the national German Center of Competence in Civil Engineering.

Prof. Graubner was again elected as the member of assembly of TU Darmstadt for the next 3 years period. In addition he advices the "Förderinitiative Interdisziplinäre Forschung" at Technische Universität Darmstadt, which supports inter-discipline research project activities. At the same time he is a representative expert of the „Graduate School of Energy Science and Engineering" financed by German Research Foundation (DFG).

In 2014, Prof. Simsch is again member of DIN presidium and member of the advisory councils of the General Standards Committee and the Building and Civil Engineering Standards Committee, member of "Round Table for Sustainable Construction" of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and member of subcommittee for "Energy Efficiency of Buildings" at the Federation of German Industries.

Prof. Dr.ir. Eddie Koenders is member of the German Committee for Reinforced Concrete (DafStb) and the American Concrete Institute (ACI). Furthermore, he is an active member in the RILEM Technical Committees CMS (Thermal cracking of massive concrete structures), SPF (Spalling of concrete due to fire: testing and modelling) and CCD (Concrete cracking and its relation to durability: Integrating material properties with structural performance). Prof. Dr.ir. Eddie Koenders founded the RILEM Multi-scale Modelling for Concrete Course (MMC) and is responsible for the organisation of the course.

EXCURSIONS

Site Excursion to Rhineland-Palatinate

On Friday, 18th June 2014, 38 students and 8 scientific employees of the Institute of Concrete and Masonry Structures went to Rhineland-Palatinate. First stop of the excursion was the newly built bridge over the Rhine River in Worms, where the participants could get an overview of the details of this prestressed concrete bridge by representatives of the central public transport authorities in Trier (LBM).

Interior view of the Nibelungen-Bridge (left) and group photo at the Hochmosel-Bridge (right)

Afterwards the attendees got extensive information in the information center of the LBM about the planning and the execution of this 1.7 km long bridge over the Mosel River. During the following site visit the students and scientific employees got a comprehensive overview of the works on this steel bridge with orthotropic deck slab. This led to numerous interesting discussions and to intensive exchanges of views between students and scientific employees. This trip was only possible with the generous support from the “Freunde des Instituts für Massivbau der TU Darmstadt e.V.”. We would like to thank the members at this point sincerely.

Site excursion to Raunheim

On Tuesday, 17th June 2014, 16 students and 2 scientific employees of the Institute of Concrete and Masonry Structures went to the site of a cable-stayed bridge made of reinforced concrete in Raunheim. The bridge deck is made of concrete C40/50 and crosses the railway and a local road, the Pylon has an A-shape and is made of concrete C35/45. After an introduction into the project the participants got detailed information about the building process, the reinforcement layout and the used shoring. On site many questions regarding the expansion joints, the bridge caps and the surveying of the pylon and the shoring have been answered.

In the name of all participants the Institute would like to thank the site manager of the company Wolff & Müller, Mr. Brugger for the interesting site visit.

View of the cable-stayed bridge (left) and on top of the cable-stayed bridge (right)

PERSONAL MATTERS

The employment of Dipl.-Ing. (FH) **Andreas Heck** M.Eng. at the chair of building materials was finished this year. He is now employed as product manager at the HECO-Schrauben GmbH & Co. KG and intends to submit his PHD-Thesis in next spring.

Dr.-Ing. **Sebastian Pohl** obtained his PHD at the Fachbereich Bau- und Umweltingenieurwissenschaften. From the beginning of next year he will act as authorised officer of the LCEE GmbH.

Dipl.-Ing. (FH) Andreas Heck M.Eng. (left) und Dr.-Ing. Sebastian Pohl (right)

PHD

Intensive research needs the exceptional commitment of the scientific staff. With the completion of a PHD-thesis the scientist documents the most important results of his scientific work and the gained knowledge. This year, we want to congratulate the following employees of the Institute for Concrete and Masonry Structures for their successful PHD:

Dr.-Ing. Sebastian Pohl

NEW COLLEAGUES

Mr. **David Bewersdorff** M.Sc. works as scientific employee for the cooperation professorship Sustainable Reconstruction at the Institute of Concrete and Masonry Structures since April 1, 2014. He studied civil engineering at the Technical University of Darmstadt focussing on building physics and refurbishment. His field of research is sustainable renovation of residential buildings. Since 2013 he is, because of experiences in his bachelor/master thesis and comprehensive university work, working as building physicist at the Bilfinger Bauperformance GmbH Frankfurt with an additional consolidation in building simulation. These are the areas of climate, light, energy, comfort- and acoustic simulation.

Ms. Dipl.-Ing. **Ines Boß** has been employed at the chair of building materials at the Institute of Concrete and Masonry Structures since June 1st, 2014. She graduated in March 2014 with a diploma in civil engineering from the Technische Universität Darmstadt where she had focused her studies on “building materials” as well as fastening technology. As part of her focused studies, Ms. Boß wrote a thesis on the topic of „Sorption of natural stones with the help of dynamic water vapor diffusion. Further, her diploma thesis dealt with the subject of „Qualitative and quantitative determination of radiative and conductive influences on asphalt fasteners “. Besides her position within the fastening technology, Ms. Boß is responsible for the lectures „building physics“, as well as „structural building physics“. Her research will focus on „3D concrete printing technology“.

Mrs. Larissa Schwab M.Sc. is a doctoral student at the Section of Concrete and Masonry Structures since October 1st, 2014. She studied civil engineering at the Technical University of Darmstadt. During her studies she already focused on “Construction Engineering”. She graduated with her Master thesis “Effects of thermal actions on a prestressed concrete box girder bridge” in October 2013. Afterwards she worked as a structural engineer in the department for bridge building in the engineering office “König und Heunisch Planungsgesellschaft” in Frankfurt (Main) up to December 2014. During her graduation Mrs. Schwab will take care of the lectures “Spannbeton“ and “Massivbrückenbau und Traggerüste“.

GUEST RESEARCHERS

Mr. **Siddharth Awasthi** from Birla Institute of Technology and Science in Pilani was a guest-researcher at the Institute of Concrete and Masonry Structures and stayed in Darmstadt from May until July 2014. His research activity was funded by the German Academic Exchange Service (DAAD). He conducted research in the area of the design of non-loadbearing masonry walls and investigated this field by numerical calculations and evaluations of tests. Mr. Siddharth Awasthi was supervised by Mr. Michael Schmitt.

Mr. **Arunabh Choudhury** student of Civil Engineering from the National Institute of Technology Karnataka, Surathkal, has completed an internship at the Institute of Concrete and Masonry Structures from May until July 2014 at the Institute of Concrete and Masonry Structures. Under the supervision of Claudia Weißmann Mr Choudhury analyzed district heating systems with renewable energy sources. For his research he was using the Carnot blockset for MATLAB Simulink and the TRNSYS Software.

AWARDS

Bilfinger Award 2013

At TU Darmstadt every year excellent young engineers are awarded for outstanding achievements with the Bilfinger Award. At the graduation party in November 2014 this price was given to Fabian Staab for his thesis „Realisation of sustainability in buildings‘ operation - pilot phase of a certification system Sustainability in buildings‘ operation“. We congratulate Mr. Staab on this success.

Dreßler Award 2014

This year the Dreßler-Bau-Preis was awarded for the second time at the TU Darmstadt. The award will be handed over for outstanding bachelor thesis in the technical disciplines Concrete Structures and Construction Management. In November 2014, the award was given to Jonas Wilhelm Klein for his bachelor thesis "Determination of mechanical time-varying material parameters of fresh concrete and implementation in a calculation method” by the President of TU Darmstadt at a festive ceremony. We congratulate Mr. Klein on this success.

ACKNOWLEDGEMENTS

Without the support of the following organisations we would not have been able to perform our work in research and education its entirety during the past year:

Adam Hörnig Baugesellschaft GmbH, AMIG Rudi Becker, Arbeitsgemeinschaft für industrielle Forschung, Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" e.V., BASF AG, bauart Konstruktions GmbH & Co. KG, bauserve GmbH, BERNHARDT Ingenieure GmbH, Beton Kemmler GmbH, BetonMarketing West GmbH, Bilfinger Bauperformance GmbH, Bilfinger Hochbau GmbH, Bilfinger SE, Bilfinger HSG Facility Management GmbH, Bundesanstalt für Straßenwesen, Bundesministerium für Bildung und Forschung, Bundesministerium für Verkehr und digitale Infrastruktur, Bundesministerium für Umwelt, Naturschutz, Bau- und Reaktorsicherheit, Bundesverband der Deutschen Ziegelindustrie, Bundesverband der Kalksandsteinindustrie e.V., Bundesverband Porenbetonindustrie e.V., Bundesverband Deutsche Beton- und Fertigteilindustrie e.V., Bundesverband Leichtbetonzuschlagindustrie e.V., CEMWOOD GmbH, Cobiax Technologies GmbH, Daimler AG, Deutsche Bahn AG, Deutsche Bundesstiftung Umwelt, Deutsche Poroton GmbH, Deutscher Beton- und Bautechnik-Verein e.V., Deutsche Forschungsgemeinschaft e.V., Deutsche Gesellschaft für Mauerwerksbau, Deutscher Ausschuss für Stahlbeton, Deutsches Institut für Bautechnik, Dreßler Bau GmbH, Dyckerhoff AG, Evonik Degussa GmbH, Steag GmbH, Fachvereinigung Deutscher Betonfertigteilbau e. V., fischerwerke GmbH & Co. KG, Forschungsinstitut der Zementindustrie (FiZ), Forschungsvereinigung Kalk-Sand e.V., Freunde des Instituts für Massivbau der TU Darmstadt e.V., Freunde der Technischen Universität Darmstadt, Güteschutzverband Betonschalungen e. V., Halfen GmbH & Co. KG, H-Bau Technik GmbH, HeidelbergCement AG, Hilti Deutschland AG, Hochtief AG, Hoechst AG, HSE Technik GmbH, Ingenieurbüro Krebs und Kiefer, Ingenieurconsult Cornelius Schwarz Zeitler GmbH, Julius Berger International GmbH, Klimaleichtblock GmbH, König und Heunisch Planungsgesellschaft mbH & Co KG, LCEE Life Cycle Engineering Experts GmbH, Liapor GmbH & Co., Longlife-Treppen GmbH, LohrElement GmbH, MAPEI Betontechnik GmbH, Max Bögl Bauunternehmen GmbH, MEVA Schalungssysteme GmbH, pakon AG, Peikko Group, PHILIPP Gruppe, PreConTech e.K., Ruffert & Partner, Schöck Bauteile GmbH, sh minerals GmbH, Spenner Zement GmbH & Co. KG, Strabag AG, Syspro-Gruppe Betonbauteile e. V., TOGE-Dübel A. Gerhard KG, VdS Schadenverhütung GmbH, Verein Deutscher Zementwerke, Waibel KG, Wayss & Freytag Ingenieurbau AG, Wienerberger AG, Xella Technologie und Forschungsgesellschaft mbH.

We want to express our gratitude for this support and hope for a successful cooperation in the future.

In teaching, a support by experts from the private sector, the industry, administration and organizations is necessary and highly appreciated, especially in order to include all practical aspects of civil engineering.

For their personal commitment as visiting lecturers in our institute we would like to thank the following persons:

Dipl.-Ing. Elena Alexandrakis	Bauphysik, Grundlagen des konstruktiven Hochbaus, Konstruktive Bauphysik/Bauphysik (bis SS14)
Dipl.-Ing. Thomas Becker	Grundlagen der energetischen Bewertung und Optimierung von Gebäuden (bis SS14)
Dr.-Ing. Herbert Duda	Baudynamik
Dipl.-Ing. (FH) Andreas Heck, M.Eng.	Befestigungs- und Verankerungstechnik in Beton und Mauerwerk
Dipl.-Ing. Rudolf Herz	Mauerwerksbau
Dipl.-Ing. Thomas Heß	Gebäudetechnik
Dr.-Ing. Normen Langner	Konstruktive Bauphysik/Bauphysik (ab WS14/15)
Dipl.-Ing. Liane Prediger	Mauerwerksbau
Dipl.-Ing. (FH) Michael Pröll	Mauerwerksbau
Dr.-Ing. Gert Riegel	Strategisches Facility Management & Sustainable Design
Dipl.-Wirtsch.-Ing. Frank Röser	Massivbautechnologie, Werkstoffe im Bauwesen, Werkstofftechnologie I, Werkstofftechnologie I I
Dr.-Ing. Holger Schmidt	Risiko und Sicherheit im konstruktiven Ingenieurbau
Dipl.-Ing. Heinz Steiger	Massivbrückenbau und Traggerüste
Dr. phil. nat. Enno Steindlberger	Bauen im Bestand – Energetische Sanierung, Bauwerkserhaltung, Bauschäden/Bauchemie

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Dr.-Ing. Markus Spengler (Baudynamik); Dipl.-Ing. Mathias Tillmann, Dipl.-Ing. Holger Rößner, Dipl.-Ing. Heinz Eberherr, Dipl.-Ing. Alice Becke, Dipl.-Ing. Ralf Niehüser, Dr.-Ing. Georg Hellinger, Dipl.-Ing. Erwin Scholz, Dipl.-Ing. Stefan Zwolinski, Dr.-Ing. Diethelm Bosold und Dipl.-Ing. Werner Hochrein (Fertigteilkonstruktionen); Dipl.-Ing. Katrin Schubert (Grundlagen der energetischen Bewertung und Optimierung von Gebäuden ab WS 14/15); Dr.-Ing. Gerhard Zehetmaier und Dr.-Ing. Stefan Kempf (Massivbrückenbau und Traggerüste); Dr.-Ing. Torsten Mielecke (Strategisches Facility Management & Sustainable Design); Dipl.-Ing. Herbert Schäfer, Dipl.-Ing. Rudi Becker, Dipl.-Ing. Michael Sauerwein, Dr.-Ing. Benjamin von Wolf-Zdekauer, Dipl.-Ing. Olaf Pielke, Dipl.-Ing. Frank Bieber, Dipl.-Ing. Robin Engelmann und Dipl.-Ing. Patrik Bös (Technische Gebäudeausrüstung).

PUBLICATIONS

Selected Papers:

- Billberg, P.; Roussel, N.; Amziane, S.; Beitzel, M.; Charitou, G.; Freund, B.; Gardner, J. N.; Graubner, C.-A.; Keller, L.; Khayat, K. H.; Lange, D. A.; Omran, A. F.; Perrot, A.; Proske, T.; Quattrociocchi, R.; Vanhove, Y.: Field validation of models for predicting lateral form pressure exerted by SCC. Cement and Concrete Composites, Volume 54, November 2014, 70–79.
- Freund, B.; Proske, T.; Graubner, C.-A.: Experimentelle Untersuchungen und numerische Verifizierung zum Frischbetondruck bei geneigten Schalungssystemen. In: Beton- und Stahlbetonbau 109, Heft 11 (2014), Verlag Ernst & Sohn, Berlin, 2014
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DESIGN OF MASONRY WITH TOOLS

Valentin Förster, Carl-Alexander Graubner

Due to the upcoming introduction of Eurocode 6 regulations at the beginning of 2015, engineers from industry already forecast their demand for tools that allow the fast and efficient design of masonry walls. At the same time, however, such tools must guarantee material efficient solutions. Therefore, the Institute of Concrete and Masonry Structures developed several tables and diagrams (refer to (1) and (2)) for a simplified design.

For smaller masonry structures with a maximum of three floors we provide a table for design according to DIN EN 1996-3/NA Appendix A, a highly simplified design method. The most important table (see Table 1) is based on the simplified design method, which is primarily used in practice. Depending on the prevalent component (outer or inner wall), wall thickness, wall height, celling span and bearing length of the floor on the wall a table value can be read out, which directly provides the design value of the wall resistance (n_{Rd} in kN/m) when multiplied by the characteristic compressive strength of the used masonry (f_k in N/mm²). This approach comes with the enormous advantage that the entire simplified design method can be reproduced with the usage of only two tables ($f_k \geq 1{,}8$ N/mm² und $f_k < 1{,}8$ N/mm²). The verification of the minimal required load still must be determined in parallel to this: For common wall construction diagrams are available which easily release the maximum wall height. Also for walls under earth pressure similar tables for a simple and still efficient design are available.

Table 1: Extract of a design table for $f_k \geq 1{,}8$ N/mm²

Design value of the resistance of the wall n_{Rd} in kN/m = tabular value · f_k in N/mm²													
Wall thickness t in cm	Clear wall height h in m	Internal wall	Outernal wall										
			Slab									Roof	
			Slab with full bearing length a/t = 1,0						a/t = 2/3			a/t = 1,0	a/t = 2/3
		l_f in m	Floor span l_f in m										
		≤ 6,00	≤ 3,50	4,0	4,5	5,0	5,5	6,0	≤ 5,00	5,5	6,0	≤ 6,00	
11,5	≤ 2,50	36	36				32	26	- [1]			21	- [1]
17,5	≤ 2,50	71	71		69	59	49	39	33			33	33
24,0	≤ 2,50	102	102		95	81	68	54	60		54	45	45
30,0	≤ 2,50	131	131		119	102	85	68	82		68	56	56
36,5	≤ 2,50	165	165		144	124	103	82	105	103	82	68	68
42,5	≤ 2,50	195	195	192	168	144	120	96	125	120	96	79	79
49,0	≤ 2,50	228	228	222	194	166	138	111	147	138	111	91	91
11,5	≤ 2,75	32	32					26	- [1]			21	- [1]
17,5	≤ 2,75	69	69			59	49	39	28			33	28
24,0	≤ 2,75	99	99		95	81	68	54	56		54	45	45
30,0	≤ 2,75	128	128		119	102	85	68	79		68	56	56
36,5	≤ 2,75	162	162		144	124	103	82	103		82	68	68
42,5	≤ 2,75	193	193	192	168	144	120	96	124	120	96	80	80
49,0	≤ 2,75	226	226	222	194	166	138	111	146	138	111	92	92

[1] Not permissible because minimum bearing depth is not observed

Conditions for application:

- The conditions for using the simplified calculation method in accordance with DIN EN 1996-3/NA must be regarded (see section 3)
- Characteristic compressive strength of masonry $f_k \geq 1{,}8$ N/mm²
- Reduction of buckling length as a result of fully supported reinforced concrete slabs has already been included (assumption: restraint on two sides)

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PRESSURE OF FRESH CONCRETE – SIMULATION WITH A FEM MODEL

Björn Freund, Carl-Alexander Graubner

In the DFG-research-project "Basics for the development of adaptive formwork systems for free formed concrete structures" which belongs to the DFG-priority-programm 1542 fifteen full-scale-tests were carried out (1). With a theoretical model, based on FE-method, the pressure of fresh concrete can be calculated for free-form formwork systems (2).

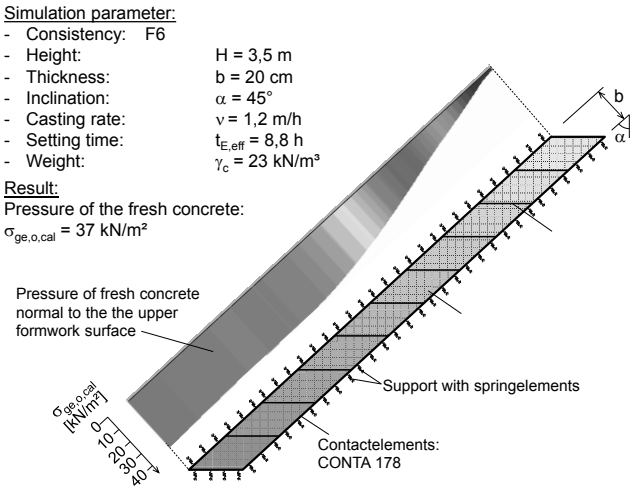

Figure 1: Example for the numerical model with the distribution of fresh concrete pressure on the upper formwork

Figure 1 shows the calculation model exemplary for a inclined wall with constant wall thickness. The modeling was performed with ANSYS. Furthermore, figure 1 shows the pressure of the fresh concrete normal to the upper formwork for an exemplary example. In a simulation, the concrete is activated in layers in the model. When enabling a new layer, the material parameters of the underlying layers are changed, according the simulated casting rate v and the setting time t_E. The time-varying material behavior continues to be recognized over the temporally variable pressure ratio λ (t / $t_{E,eff}$) and the temporally variable coefficient of friction μ (t / $t_{E,eff}$). Therefore, adequate functions for consistency classes F5, F6 and SVB were implemented in the model.

Comparative calculations show a good correlation between the calculated results and the measured values of the full-scale tests.

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TRAFFIC LOAD SIMULATIONS WITH „AISPROC“ ON INTEGRAL ROAD BRIDGES

Jaroslav Kohoutek, Ngoc Linh Tran, Carolin Bieker

Traffic loads play a major role for determination of failure probability of road bridges. Currently, bridge design is based on the load model 1 according to DIN EN 1991-2/NA. Especially for probability analyses, it has to be checked whether this load model well reflects the actual traffic situation on road bridges with the defined target safety index. For this purpose in course of a master thesis (1) traffic simulations based on current traffic measurements were carried out on three integral reinforced and prestressed concrete bridges.

For traffic simulations bending moment and shear force influence lines of the investigated bridges were created with the use of the program SOFiSTiK 2014. The simulations were executed with the simulation program “AISProc” (2), which was developed at the institute of concrete and masonry structures. The main inputs for simulations are statistical values of traffic measurements which was carried out between the years 2004 and 2005. Furthermore, an increase factor to determine the future traffic was developed in (1) using traffic forecasts of the federal ministry of Transport, Building and Urban Development (BMVBS). In addition to the simulations of the current traffic, simulations of the future traffic in 50 and 100 years were also executed. In the simulations traffic scenarios “flowing traffic” and “traffic jam” as well as for one or two heavy traffic lanes were taken into account. For the simulation for a period of one year, the half hour maximum values were determined and presented in histograms. The internal forces of the traffic loads were modeled with a sufficient accuracy by normal probability distribution functions (PDF). In Figure 1 the simulation results of the “Nordbrücke Berching” are shown for the bending

moment at the middle of the span with “traffic jam” situation. Accordingly, the future heavy traffic in 100 years was applied to the traffic lanes one and two.

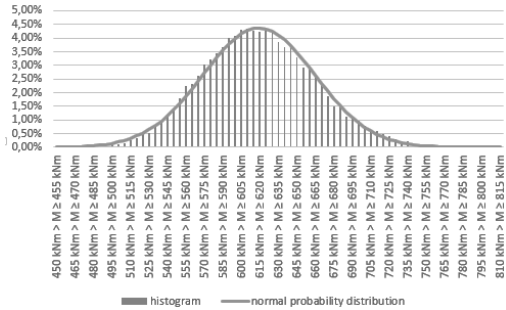

Figure 1: Histogram and probability distribution functions of the bending moment at the middle of the span of the “Nordbrücke Berching” due to traffic loading (1)

From these PDFs, the characteristic internal forces were determined and compared with the internal forces of the load model 1 according to DIN EN 1991-2/NA. In all calculated scenarios, significant deviations between the characteristic internal forces of the simulations and the load model 1 were identified. These differences are mainly caused by new vehicle concepts which had been used for the development of the load model 1 according to DIN EN 1991-2/NA.

In summary the determined normal PDFs are very well suited for reliability analyses. The conducted traffic simulations can be used for the recalculation of existing bridges which cannot fulfill the verifications on the basis of the load model 1, too.

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MEMBRANE EFFECTS IN NON-LOAD-BEARING MASONRY WALLS – A THIRD ORDER PHENOMENON

Michael Schmitt

In general, non-load-bearing walls are supported by other structural elements like reinforced concrete columns and slabs. If the joint between the slab and the wall is filled with Mineral cotton and a steel profile, only a horizontal support is given. The carrying capacity is determined by the flexural strength. Horizontal and vertical undisplaceable edges – for example the joint is filled with mortar – influence the load bearing capacity positive. Test results show that the potential factor is about 3 (cf. (1)). Besides full scale tests and numerical analyses it is possible to determine the carrying capacity of non-load-bearing masonry walls in consideration of membrane forces with the help of the analytics. Characterizing the carrying capacity in an exact way it is essential to describe the load-deformation curve and the interaction between bending and arching effect.

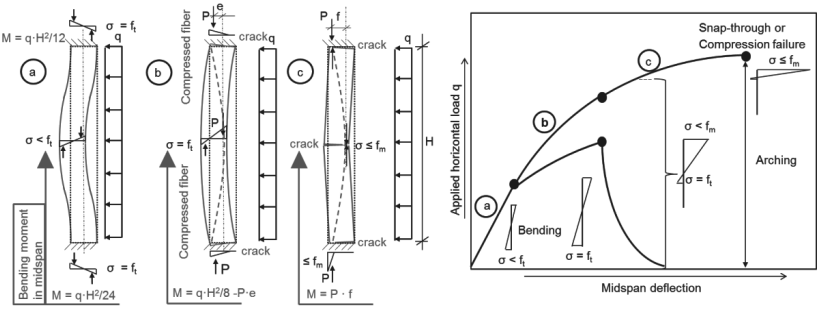

Figure 1: Structural systems and load-bearing-behaviour

On the left side figure 1 shows the structural systems, which occur with increasing loads. On the ride side there is shown the corresponding load-deformation-curve. Assuming a linear elastic material behaviour under low loads the cross-section remains uncracked and the bending moment is carried by compressive and tensile stresses (area a). At this moment no membrane forces are existing. Because of the low flexural strength of masonry with increasing loads, the cross-section cracks at the supports. The stiffness decreases and therefore the deflection increases disproportionately. If the flexural strength is exceeded in midspan, the load bearing capacity is reached.

With undisplaceable supports the extension of the left outside fiber, which results from the rotation of the cross-section, is precluded. So the axial shortening leads to an excentric additional normal force P, which results in an additional restoring bending moment. This effect is a third order effect. Beside the vertical deformation of second order theory the axial shortening of the bar has to be taken into account. So the carrying capacity increases in area b till the tensile strength is reached in mid-height of the wall.

After cracking in mid-height the carrying behaviour is given by equilibrium between extern horizontal forces and the intern arch force P with the lever f (area c). With increasing loads the sag exceeds, the arch rise f decreases and the carrying capacity reaches. Two failure modes are possible: In very thin panels and supports with low stiffness snap-through can occur. Additionally, if the compressive strength is reached, compression failure occurs. Taking into account membrane stresses the load carrying capacity of horizontal loaded infill walls therefore depends on the wall geometry, the stiffness of the supports (rotation and translation), the Young's modulus and the compressive strength as well. In the ultimate limit state the flexural strength perpendicular and parallel of the bed joint have no influence.

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NUMERICAL MODELING OF STRUCTURAL BEHAVIOR OF FIBRE REINFORCED CONCRETE STRUCTURES

Ngoc Linh Tran, Ulf Grziwa

By adding steel fibres, mechanical properties of reinforced concrete can be significantly improved, especially when components are subjected to train. Due to the largely random distribution and orientation of fibres, the fibre-reinforced concrete shows a large dispersion of the strength. This can be observed especially in the post-failure behaviour of steel fibre-reinforced components. Essential influence factors are type of fibre, fibre geometry, fibre content, fibre distribution and orientation as well as the bond between fibres and concrete.

In the numerical modelling of structural components the material behaviour must be based on suitable stress-strain curves. In the case of steel fibre concrete stress-strain curves describe the behaviour of the composite material under consideration of the bond between concrete and steel fibres. The identification of stress-strain curves is performed by the evaluation of experimental tests and usually describes the uniaxial material behaviour. This constitutes a disadvantage, since the multi-axial material behaviour can not normally be derived from these experiments. Especially by fibre concretes further investigations are required, since the material behaviour depends also on the three-dimensional distribution and orientation of the fibres.

In this paper, a modelling method for fibre concrete is presented. The main idea of the new method is a detailed modelling of the fibres analogous to conventional reinforcing steel. Using the so-called "smear model", the fibre position can be freely defined in the concrete element mesh. The effect of fibres is expressed by an equivalent stiffness and transferred into corresponding concrete elements. The bond between concrete and fibres is also considered. Existing FE programs already allow this modelling method. An example of

this is the program ATENA3D, which was developed by Červenka Consulting. A disadvantage of the existing software is no supporting for the input with scattering material properties, which can be used e.g. in reliability analysis. Because of this, a pre-processing program for modelling fibre reinforced concrete was developed at the Institute of Concrete and Masonry Structures. With this program, fibre-reinforced concrete structural model can be automatically generated. After doing structural analysis, which ATENA 3D is done using the downstream software, the calculation results are displayed graphically. Figure 1 illustrates load-deformation curves of fibre concrete beams with different fibre contents as the first results of the modelling. In general, the results so far have shown that the modelling method reflects very well the behaviour of fibre concrete. Therefore, this method can be used for further investigations.

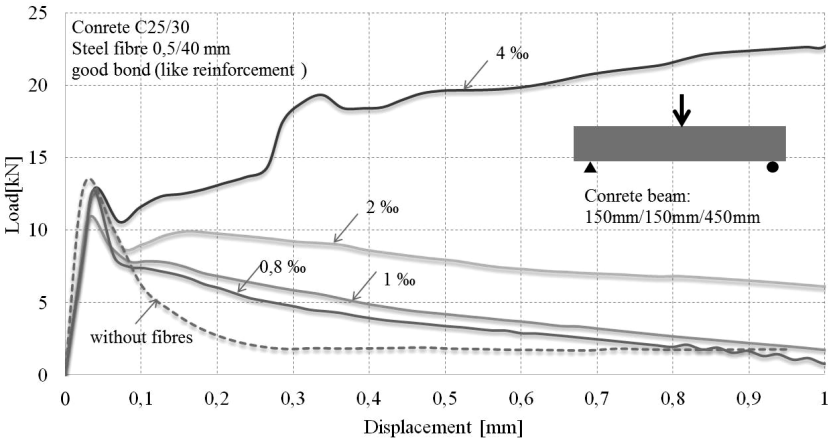

Fig. 1: Load-displacement line of concrete beam with different fibre contents

With the new modelling method, the multi-axis structural behaviour of components made of fibre concrete can be represented accurately. Another application field of this software tool are investigations of the behaviour of fibre concrete components under combined shear, torsion and bending load.

A NEW APPROACH TO THE PRODUCTION OF MINERALIZED FOAM

Albrecht Gilka-Bötzow

Due to recent developments the production process of mineralized foam is reliably controlled by mixing binder slurry into aqueous foam. By using colloidal mixing systems and through utilization of enclosed secondary mixers it is possible to unerringly produce dry bulk densities under 100 kg/m³.

However, in this process the slurry is mixed with the liquid contained in the foam lamellae. Accordingly, the water-cement ratio increases by the water content of the foam which can't chemically be taken into account. Even if a very light aqueous foam with a density of 60 kg/m³ is used and the water cement ratio of the binder slurry is reduced to 0.38, to reach in the end a relatively high dry bulk density of 500 kg/m³ for the mineralized foam, it is only possible to realize a minimal real water-cement ratio of 0.50. Considering the fact that the cement stone structure is significantly influenced by the water-cement ratio, the unintended raise of the value leads to undesired consequences. For instance, the cement stone shrinkage is due to a combination of causes, which are all based on changes in the moisture condition in the porous structure (1).

Thermodynamically seen, foams are unstable multi-phase systems which do never reach a real metastable equilibrium. Because of different concurrent processes (Fig. 1) their form is permanently subject to change (2, 3). For this reason, a longer freshness phase inevitably leads to enlarged pores and involves the risk of total destruction. Until now, the successfully pursued way of production of mineralized foams lay in the usage of intensively mixed viscous binder slurries which were supposed to ensure a high stability of the fresh state as long as possible. This however leads to the technological problems

described above. A new approach may be the direct foaming of binder slurries. In that case, the use of slurries with water-like consistency is required. The setting properties of the slurries need to be accelerated by the use of admixtures. In addition to the procedural development issues, there are also some new problem areas arising.

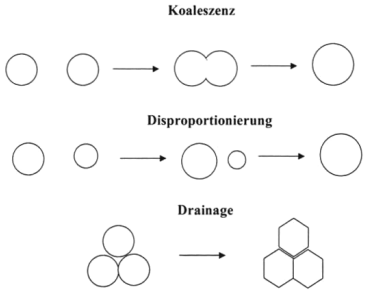

Figure 1: Foam decomposition processes (2, 4)

A new research and technical approach to increase the strength and to reduce the shrinkage may therefore be the reduction of the water content by procedural adjustments for the direct foaming of colloidal and highly flowable binder slurries. Therefore, it is necessary to use accelerators specially designed to fit to the metastable phase of the foam. In addition, the interactions of the different additives have to be studied. This is especially important due to the fact that the foam is strongly influenced by the purity and the concentration of the surfactant, from a chemical as well as from a physical point of view (5).

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INFLUENCE OF FOAMING AGENTS ON THE HYDRATION OF CEMENT

Albrecht Gilka-Bötzow, Fabian Fink, Harald Garrecht

The prolonged freshness phase during the production process of mineralized foams as a result of retarding effects leads to enlarged pores and involves the risk of structural collapse due to the metastability of the foam. In addition therefor, there are procedural discontinuities. Against this background, a study was carried out at the Department of Construction Materials in order to investigate the temporal and energetic influences of various foaming agents on the hydration process of the cement paste. In this study, samples of cement paste were examined by using an isothermal heat flux calorimeter. In addition, potential interactions of foaming agents with different accelerators and superplasticizers were the subject of further analysis (1). The tests and the sample storage were conducted in a special room which was air-conditioned to the temperature of measurement of 20 °C in order to eliminate external influences on the sensitive measurement as far as possible. The calorimeter provided the feature to carry out a parallel measurement with an inert material for reference. The fluctuations that occurred could be removed in a following downstream computational analysis. Accordingly, it was possible to realize measurement accuracies in a milliwatt range. The cement hydration reaction kinetics are divided into five periods. Once a certain saturation concentration of Ca^{2+}- and OH^{-}- ions is exceeded during the second period, the so called dormant phase, the hydrate phases crystallize to short fibrous C-S-H crystals. Subsequently, the acceleration period begins under significant heat generation. At the same time, the remaining C_3A phases convert together with the ettringite to mono sulfates, after the gypsum has been totally consumed as a sulphate agent for the formation of ettringite (2). Especially the changes in the course of the acceleration period allow significant conclusions on the retarding effect of foaming agents.

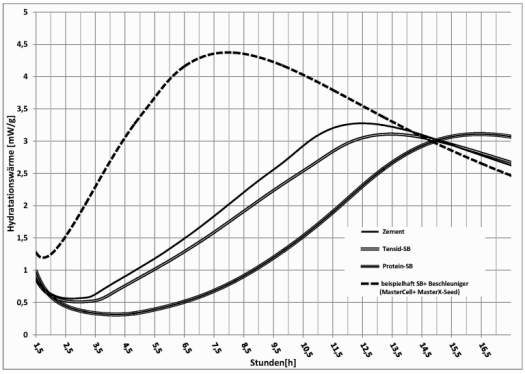


Figure 1: Example of a hydration profile of the experimental combination cement-accelerator-foaming agent

When using pure cement paste, the beginning of this period could be detected after 3 h with a renewed increase in heat generation, following the sharp drop during the dormant period. The maximum was reached at about 12.5 h after the initial mixing process. The summed average energy during acceleration period was 66.81 J/g. In no combination of active agents unusual exothermic reactions, due to chemical interactions could be observed. Retarding effects induced by foaming agents can completely cancel by accelerators. Between the different mixtures using foaming agents and accelerators, just slight deviations to the samples only using accelerators could be observed. This suggests that interactions between foaming agent and accelerator possibly occur only to a minor degree. Superpositions of the retarding effects of foaming agents and flow agents, however, were quite detectable. Nevertheless, these effects are very dependent on the combination of the different superplasticizers and foaming agent. Foaming agents based on tenside surfactant show a weaker deceleration of hydration as those based on protein.

(1) Daniel Jansen; Friedlinde Götz-Neunhoeffer: Analytik in Forschung und Entwicklung: Wärmeflusskalorimetrie zur Untersuchung von Kinetik und Reaktionswärmen von Baustoffen; GDCh; Die Aktuelle Wochenschau zu Bauen und Chemie Woche 7, 2011.
(2) Roland Benedix: Bauchemie: Einführung in die Chemie für Bauingenieure und Architekten. Vieweg+ Teubner | GWV Fachverlag GmbH, Wiesbaden 4. Auflage, 2008.

INFLUENCE OF FIBRE DISTRIBUTION AND FIBRE ORIENTATION ON THE MATERIAL BEHAVIOR OF ULTRA HIGH PERFORMANCE CONCRETE

Ulf Grziwa, Carl-Alexander Graubner

Thanks to the development of material technology, nowadays Ultra High Performance Concrete (UHPC) can be produced with compressive strength of about 150 N/mm² unerringly. Especially the cross-sectional dimensions of highly stressed compression members, such as columns in buildings and industrial structures, can be reduced significantly compared to members made of ordinary reinforced concrete. Mechanical properties of fiber reinforced concrete and UHPC depend significantly on the distribution and orientation of steel fibers.

Based on the results of the research project „Structural reliability of high compression members made of UHPC“, which is already concluded at the Institute of concrete and masonry structures, an experimental test program for determining material properties of UHPC taken into account the fibre distribution and orientation is carried out. One of the aims of this project is extending the database to determine the statistical parameters referred to the tensile or compressive strength as well as the modulus of elasticity. Hereby separate test specimens are prepared and analysed. To determine fibre distribution and fibre orientation computer-tomography and opto-analytical measurement methods are used. In contrast to the computer-tomography, which includes the whole volume of the specimen, analysis using the opto-analytical measurement methods are limited to the cut surfaces of the specimens. The high-definition shot of a specimen’s cut surface (Fig. 1 A) needs to be reworked digitally (Fig. 1 B) before analyzing the cut surfaces of the single

fibers (Fig. 1 C and D). Fig. 1 E is generated by using the computer-tomography and shows the distribution and the orientation of single fibers exemplarily.

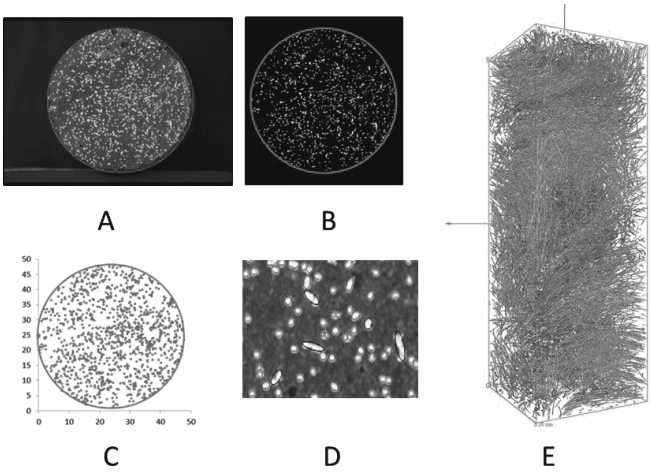


Fig 1: A-D opto-analytical measurement methods to determine the fibre distribution and orientation; E Analysis using the computer-tomography

Beside determining the statistical parameters by analyzing individual specimens, investigations concerning the spatial dispersion of material parameters by taking into account the whole length of the components are also carried out. For this purpose large-scale test specimens are prepared and the spatially-related correlation coefficients of the parameter concrete compressive and tensile strength, the modulus of elasticity as well as the geometrical deviations are determined by doing appropriate tests. The results of these investigations describing the spatial inhomogeneity of UHPC components are the basis for further stochastic analysis.

The authors thank the DFG for financial supporting the research project.

INFLUENCE OF A SUBSEQUENT MOISTURE CURING ON THE COMPRESSIVE STRENGTH OF CONCRETE

Stefan Hainer, Tilo Proske

In general, it is assumed that short-time cured concretes have a lower degree of hydration in the surface areas than longer cured concretes. Concretes that were not able to hydrate completely because of a short curing time can possibly hydrate after a subsequent treatment. This applies particularly to components which are exposed to rain. However, for this purpose water must be able to penetrate to the non-hydrated phases. Whether and to what extent a subsequent supply of moisture can affect the compressive strength of concrete was the target of the present investigation. The effect of subsequent supply of moisture was investigated on 4 concretes. The specimens were remolded after one day, treated in a water bath at 20°C until an age of 2 and 7 days and subsequently stored in a climate chamber (20°C, 65% RH). At the age of 28 days, some specimens were once again placed in the water basin to simulate a subsequent supply of moisture. For a maximum degree of hydration additional specimens were stored in water continuously up to an age of 56 days. The compressive strength was tested after 28 and 84 days. Results of the studies on the effect of subsequent moisture supply and curing time on the compressive strength are illustrated in Fig. 1. More detailed results and the influence on the carbonation depth includes (1). Fig. 1 demonstrates that the compressive strengths at a curing time of two days is significantly lower than at a curing time of 7 days. If the specimens have no subsequent moisture supply, no increase in compressive strength can be observed.

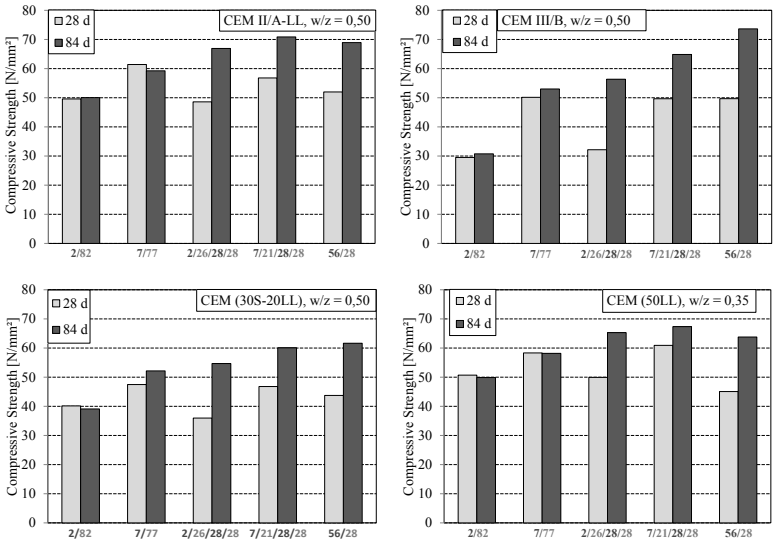


Fig. 1: Compressive strengths depending on the pre-storage and type of cement

With a subsequent moisture supply, the compressive strengths after 84 days are significantly higher than the strengths after 28 days. Consequently the degree of hydration of shortly cured specimens can be increased by subsequent moisture supply. Particular in the case of concretes with CEM III/B, which are sensitive to a short curing time, the moisture support has a significant influence. Concretes with CEM II/A-LL, CEM (30S 20LL) and CEM (50LL) which were treated for 7 days and afterwards exposed to moisture supply even achieved the compressive strengths of 56-day cured samples after 84 days.

(1) Hainer, S.; Proske, T.; Graubner, C.-A.: Einfluss der Nachbehandlung auf das Karbonatisierungsverhalten von Beton aus klinkerarmen Zementen. In: Beton- und Stahlbetonbau (1/2015), Verlag Ernst & Sohn, Berlin, 2015.

CEMENTS WITH REDUCED ENVIRONMENTAL IMPACTS THROUGH EFFICIENT SUBSTITUTION OF BLAST FURNACE SLAG

Moien Rezvani, Stefan Hainer, Tilo Proske, Carl-Alexander Graubner

The aim of this cooperative project "Reduction of environmental impact of construction through new furnace slag-based cements and thereof concretes" with Spenner Cement Co. and German Cement Work Association is to examine the performance of new cements with high limestone and slag contents as well as their applicability for conventional structural concrete. This project which is mainly based on the accomplished project in 2013 entitled as "Reduction of environmental impact of construction through new cements and thereof concretes by using broadly-available raw materials (see [1])" is funded by German Federal Environmental Foundation (DBU).

Although in draft of new DIN EN 197-1:2014 the allowable limits of slag and limestone are broadened, the further replacement of Portland cement clinker through slag and limestone is aimed within this project. Due to significant reduction of Portland cement clinker in these cements, structural concretes with sufficient mechanical and durability properties cannot be achieved by applying conventional water-cement-ratios. Therefore, application of such resource efficient cements with reduced environmental impacts is possible only under a modified concrete technology. This modification principally includes optimization of packing density as well as use of high performance superplasticizers which enables significant reduction of water-cement-ratio.

Fig. 1 shows limits of normative (EN 197-1:2014) and investigated cements (during accomplished and current projects) in a ternary diagram, exhibiting Portland cement clinker (K), limestone (LL) and furnace slag (S) contents in percent.

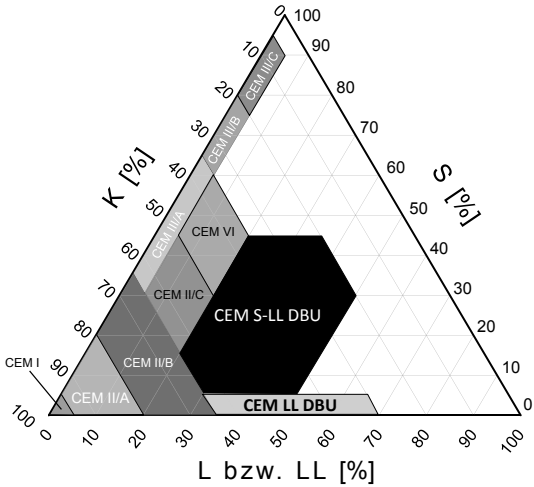


Fig 1: Limits of Portland cement clinker, furnace slag and limestone of different cement types according to EN 197-1:2014 and cements from accomposished and running projects

After comprehensive experimental investigations on mortar samples, the proper cements will be selected and produced in Spenner cement plant in large scales. In further step, extensive complementary tests will be carried out on concrete samples made of plant cements. These experiments include tests regarding to the rheology, workability, mechanical and durability properties and test to verify the suitability of these concretes in structural elements. In parallel, life-cycle-assessment analysis will be conducted on the cast concrete mixtures to evaluate the environmental impacts of these cements. All in all, a save in global warming potential up to 40% compared to concrete made of German average cement with a comparable performance is expected.

(1) Müller, Ch.; Palm, S.; Graubner, C.-A.; Proske, T.; Hainer, S.; Rezvani, M.; Neufert, W.; Reuken, I.: Zemente mit hohen Kalksteingehalten – Dauerhaftigkeit und praktische Umsetzbarkeit. In: Beton (64), 1/2 2014. 43-50

CHARACTERIZATION OF PORE STRUCTURE OF LIGHTWEIGHT AGGREGATES PRODUCED FROM SAND SLUDGE

Svetlana Volland, Olga Kazmina, Vladimir Vereshchagin

As the most promising future construction materials can be considered those that combine high heat insulation capabilities, construction possibilities, fire safety and durability. Although considerable scientific and practical experience of their production and application has been accumulated, a number of important questions remain to be answered, concerning in particular an extension of the spectrum of raw materials for production of such materials. Processing of industrial waste is an important topic not only from the point of view of reducing dangerous environmental pollution, but also their beneficial use as an alternative source of raw materials. Therefore as initial raw materials for receiving lightweight aggregates the preference is given to technogenic and substandard raw materials. As an example of an alternative raw material sand sludge can be mentioned. Sang sludge is silt-clay waste that is generated in the classification cycle of sand and gravel. The mineralogical composition of sand sludge represents a mixture of quartz, feldspar, different clay minerals, carbonates and oxides. The granulometric composition of sand sludge covers a particle size range of 2 μm - 63 μm.

The research task was to identify the optimal temperature regimes for foaming of the green granules. The frit was milled, mixed with the foaming agent, formed into granules and finally foamed alternatively at 900 ^{o}C, 925 ^{o}C, 950 ^{o}C and 975 ^{o}C. Optimum results with respect to material strength and density were obtained for the samples of lightweight aggregate foamed at 950 °C. A further increase of the foaming temperature above 950 °C leads to a decrease in viscosity, increase in pore size, and deformation of granules, owing to their melting (1).

Mercury intrusion porosimetry, one of the most common methods, was used to investigate the porous structure of the lightweight aggregates from sand sludge.

For definition of the quantitative content of the amorphous phase in the so produced materials X-ray diagrams were taken and analyzed using the computer program RENEX. This program is especially suited for the analysis of X-ray powder diffraction patterns with numerous overlapping peaks. According to the results of the quantitative XRD analysis, an increase of the foaming temperature from 900 ^{o}C to 975 °C, reduces the quantity of the residual crystalline phase to corresponding values of 23 to 8% respectively.

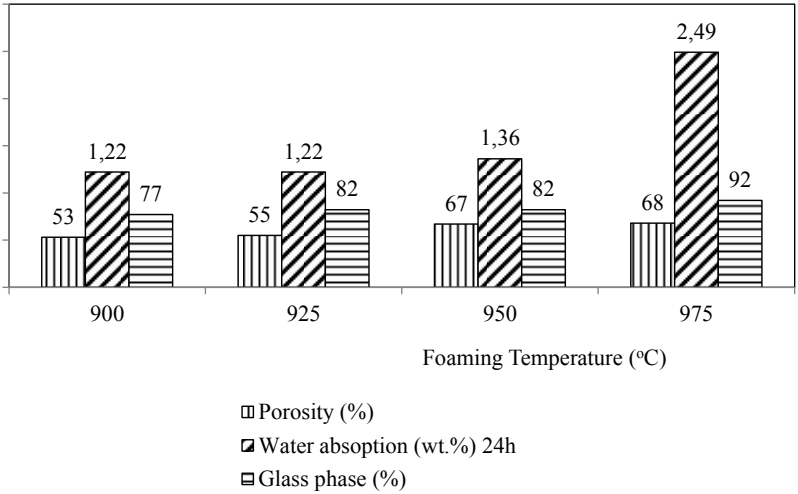


Figure 1 Porosity, water absorption and glass phase of the lightweight aggregates vs. foaming temperature.

(1) S.Volland, V. Vereshchagin, O. Kazmina, M. Dushkina. Recycling sand sludge as a resource for lightweight aggregates. Construction and building materials. 52, 2014, 361-365.

ENERGY EFFICIENCY AND COMFORT OF EXISTING BUILDINGS (1920 - 2000) IN THE CONTEXT OF NORMATIVE AND LEGALLY REGULATION

David Bewersdorff, Gerd Simsch

For the areas of energy efficiency and comfort the importance of air quality was determined in 1879. This promoted the heater and contributed that residential buildings of the wealthy layer were first used by subsequent users to dry the substance to ensure the health of the owners. In 1899 for the first time thermal insulation areas were specified in the German Baukalender, which all oriented themselves on a proven wall made of one and a half full of stones (38cm brick wall). The coal crisis after the First World War did not change this system, although a directive on the promotion of the heat economy was issued in response, but urged only in a more economical heating behavior. At this time the research already found other wall structures that improve the energy values provided (1921). The typical insulation material developed in this period was the lightweight wooden plate, but it had a shadowy existence eked out to 1974, as the 38cm brick wall still remained the proper construction. Their weaknesses were the large inertial mass and poor insulation effect. This was recognized by the DIN 4107 (1929), but not adequately tackled from today's perspective. It was a supplement to the radiator and boiler size introduced, instead of recommending a different wall structure. This approach was also reflected in the DIN 4110 (1934), as in the "Technical provision to allow the new construction" the normal wall as a definition persisted, even as by the K-value calculation a more precise analysis of the wall structures and new insulating materials (for example, glass wool (λ = 0.045 W/mK)) was made possible in 1936.

The feasible calculations of the temperature gradients in the wall and the moisture conditions produced new regulations, for example the internal temperature should maintain above 13 °C and condensed water was allowed to surfaces during the night reduction/periodic heating. Under current knowledge these arrangements permitted structurally incorrect solutions. The resulting wet masonry and surface humidity promote mold growth, increasing the thermal conductivity and get intensified by a pure window replacement in isolated considerated refurbishment. The previously condensed humidity on windows falls now in addition to walls and unplanned venting existing leaks get closed. Despite extensive research and architectural style-building periods such as the Weimar Republic (1910-1933), the wall structures remained at a level of 1.0 W/m²K and 1.6 W/m²K and the windows at 2.3 W/m²K to 4.8 W/m²K. Even after 1945 comfort was still generated by strong heating, although the evidence and criticism became even louder, recommending new wall structures.

1974 methods of accounting for primary energies were placed laying the foundation for the thermal protection regulation and its subsequent course towards Energy Saving Ordinance (EnEV), whereby the boundaries of the energetic quality of the building step by step increased. This opened the market for a large variation of wall constructions, building designs and materials. While the normative boundaries were determined gradually stricter, the research always maintained a clear lead in the thermal protection regulation (1995) and has already produced the zero-energy house. The reduced heat loss and drafts of this standard allowed a significant gain of comfort for the user.

(1) Werner Spillhagen, Hygienisches Memorandum, in: „neue Bauwelt“ Heft 25, 1949
(2) ISOVER, Die warme Wand, Broschüre, Ludwigshafen 1961
(3) J.S. Cammerer, Konstruktive Grundlagen des Wärme- und Kälteschutzes im Wohn- und Industriebau, Berlin 1936

ENERGY REMEDATION IN HOUSING - EFFICIENT COMFORT

David Bewersdorff, Gerd Simsch

The building sector in Germany consumes about 40% of final energy and produces about 30% of the CO2 emissions, so it is one main influencing factor and driver of energy savings potentials. From a technical point of view, in existing buildings with energy renovations it is possible to achieve a saving up to 80%, but it also involves considerable financial expenses. The residential buildings with more than 18 million buildings, 40 million residential units and 3.5 billion m² usable area have a significant meaning.[1]

More than 70% of the residential buildings are older than 25 years. The necessary renovation rate to raise the energy saving potentials and to prevent congestion of remediation should be higher than 2%, the actual renovation rate is currently less than 1%. Consequential questions to raising remediation rates and efficiency of remediation measures themselves can come to the fore alongside demographic and functional aspects, in particular the user "human" and his claims like building physical comfort or room hygiene. The comfort and air quality are strongly influenced by the surface temperature and prevailing room temperature; by insulation, window replacement and heating concepts suitable intelligent solutions can be achieved. Important factors such as humidity and indoor air quality are taken into account by suitable ventilation strategies and in the context of user satisfaction. The encountered drafts in non-renovated existing buildings due to leaks or cold air drop on windows act significantly comfort reducing, but can be generally improved by the renewal of windows and proper insulation of walls.

[1] German Office of Statistics, 2012

Performed tests show significant differences in the assessment of solutions of normative requirements or supported by public funding rehabilitation programs compared with the minimum sufficient version for comfort, which could be determined by normative static back-calculation of the surface temperature calculation. By using the last-mentioned requirements and the requirements of the KfW and Energy Saving Ordinance of individual components on the three buildings of the building age class E (1958 - 1968) and one of the building age class H (1984 - 1994), the following results were:

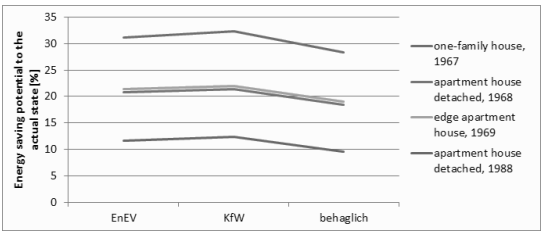


Figure: saving potentials of various remediation requirements for external walls

The figure clearly shows that the level of energy savings potential of various requirement categories is of the same magnitude. On average, it only results in an additional primary energy savings of 4% between the KfW-variant and the comfort level variant. Remarkably enough, there is an average of 42% less insulation needed to achieve the comfortable variant to KfW variant so that the resulting lower consumption of resources and the economic advantage may lead to increased advocacy of remedial measures. Remediation rates could be increased with a corresponding increase in housing quality and energy saving in a holistic consideration of the redevelopment area.

(1) DIN EN ISO 7730 (2003) / DIN EN 15251 (2012-12)

RESOURCE EFFICIENCY IN THE BUILDING SECTOR

Katharina Fritz, Carl-Alexander Graubner

The sparing use of natural resources and the preservation of these resources are important protection targets of sustainability in general and sustainable building in particular. Accordingly, the key indicator resource conservation is integrated in the principle of intergenerational equity in the German Sustainable Development Strategy. By means of several indictors within this key indicator the progress of realising a preservative and efficient use of resources is meant to be measured. The indicator raw material productivity, which is defined by the ratio of gross domestic product to used abiotic primary material, is one of these indicators. In the German sustainability strategy the Federal Government set the target of doubling the indicator raw material productivity between the years 1994 and 2020. For the period between 1994 and 2012, however, the indicator increased only by roughly 50 per cent. A forward projection of the increasing rate based on the last five years indicates that the target strived for will not be achieved by 2020 (1). To enforce the achievement of the target, the German Resource Efficiency Programme (ProgRess) was established in 2012. Instead of including all raw materials and all the other natural resources, ProgRess is focused on selected raw materials only. Fossil and biotic fuels, food and feedstuff as well as other natural resources like water, air etc. are not addressed in ProgRess. In the further development of ProgRess, which is actually carried out under the working title ProgRess II, it is planned to expand the focus and to include fossil and biotic fuels in the programme (2).

Due to the current definition of resources and the calculating rules for the indicator raw material productivity the material-intensive building sector, which uses abiotic primary materials in a large scale, gains high significance regarding the achievement of the target

of doubling the raw material productivity. With the present definitions and targets, individual specifics of the building sector, like the very long service life of products, are not considered within the programme. Furthermore the resource term has to be extended as focusing solely on raw materials is not sufficient.

Taking all this into account, an evaluation method for resource efficiency in the building sector is currently developed within the scope of a research project. By means of this method it aimed to allow an appropriate assessment of the resource efficiency in the building sector. Besides considering the individual characteristics of the buildings sector, the assessment method shall also be able to allow a socio-political balance of different stakeholders. An intersectoral applicability of the developed assessment method is a further condition, to allow the comparison of the resource efficiency of different sectors. The development of the assessment method will be completed by the end of 2015. Interim results of the research project will be presented and discussed regularly at the round-table discussion "Ressourceneffizienz im Bauwesen", which is organized by the Institute for Concrete and Masonry Structures during the runtime of the project. The round-table discussion "Ressourceneffizienz im Bauwesen" was founded as information and discussion forum in 2013 under the leading role of the former Federal Ministry of Transport, Building and Urban Development (BMVBS) (3) and meets half-yearly in Berlin. The next meeting is scheduled for spring 2015.

(1) Statistisches Bundesamt [Hrsg.]: Umweltökonomische Gesamtrechnungen, Indikatoren zu Umwelt und Ökonomie, Statistisches Bundesamt, Wiesbaden, 2014.
(2) Kaiser, R.: ProgRess II – Das deutsche Ressourceneffizienzprogramm 2016. In: UmweltWirtschaftsForum, Vol. 22, Issue 2-3, S. 115-123.
(3) Menzer, D.: Ressourceneffizienz: Indikatoren und Messgrößen im Bausektor. In: Bundesbaublatt, Jg. 62, Ausgabe 10, 2013, S. 58-59.

NEW CERTIFICATION SYSTEM FOR THE SUSTAINABILITY OF BUILDINGS' OPERATION PHASE

Sebastian Pohl, Carl-Alexander Graubner

Due to its enormous resource extraction out of and equally huge input of substances into the environment the construction and real estate industry is considered to be a key sector for a sustainable development. Especially the operation of buildings stands for massive impacts or vice versa considerable potentials concerning sustainability. So far these potentials are only inadequately activated because the relevant players, e.g. facility management service providers, have no methodology to operationalise the holistic strategic sustainability approach for the operation of buildings. Although sustainability rating systems such as those of *Deutsches Gütesiegel Nachhaltiges Bauen* address the entire life cycle of buildings and hence the use and operating phase as well, the systems in fact still have a prognostic approach looking at the life cycle timeline and do only model prerequisites of a sustainable buildings' operation. In addition they are lacking the clear direction for the steps to be taken, which the services and processes of the buildings' operation phase require.

Between 2011 and 2013 and cooperating with a leading German facility management supplier the Department of Concrete and Masonry Structures had already developed a new assessment approach for a sustainable operation of buildings within the framework of a research project as the first step towards a diversifying certification methodology. Its catalogue of criteria ensures an objectified appraisal as well as a measure focused and action-oriented substantiation of the entire building operation's service range. Furthermore the new approach is characterised by a structural and conceptual compatibility with the already established systems of the *Deutsches Gütesiegel Nachhaltiges Bauen*.

Meanwhile the assessment and certification of the building operation's sustainability quality has explicitly moved onto the agenda of facility management as an important industrial sector. One crucial effect of this development is the establishment of a task force *Sustainability* within the *German Facility Management Association (GEFMA)* as the leading German branch organisation. It mainly aims at the identification, definition and dissemination of a unified understanding and standardised quality and assessment criteria of a sustainable facility management. As an active member of this task force the Department of Concrete and Masonry Structures was able to bring its experiences in research and development outlined above concerning a new assessment approach for the sustainable buildings' operation phase. Thus, the Department participated responsibly in realising the new *GEFMA*-guideline *160 Sustainability in facility management - basics and concept* whose release is an important milestone of the task force's agenda.

Based on this guideline and especially the newly developed assessment system of the Department of Concrete and Masonry Structures, the GEFMA will henceforth launch and operate a certification system of full value in cooperation with the *German Sustainable Building Council* (*Deutsche Gesellschaft für Nachhaltiges Bauen e.V.*, *DGNB*) as the supporting conformity assessment body. In this context the Department and its spin-off LCEE GmbH currently supervise the initial application phase (pilot phase) of the new certification system which will end with awarding the participating pilot projects their certificates for sustainable facility management.

Moreover the Department of Concrete and Masonry Structure will support further activities of the *GEFMA* task force scientifically, e.g. concerning the necessary ongoing certification system updating or a further development for other buildings than the basic typology of office buildings. In addition the Department will also take responsibility for the education and training of the new system's users (*auditors*) together with LCEE GmbH and thereby contribute to the long-term establishment of the new certification system.

TENSION BETWEEN THE LCA PROCEDURES OF *DEUTSCHES GÜTESIEGEL NACHHALTIGES BAUEN*

Sebastian Pohl

The Life Cycle Assessment (LCA) according to DIN EN ISO 14040 and 14044 is an established method to determine environmental impacts of a product system and represents a crucial part of the ecological sustainability assessment of buildings within the certification methodology of *Deutsches Gütesiegel Nachhaltiges Bauen*. Here, the duality of two LCA procedure options (Complete vs. simplified procedure) - in conjunction with a lack of experience in applying the complete, but a dominating application of the simplified procedure - causes a strategic sustainability-related problem. The question is if a possible deviation of results between both procedures induces a systematic assessment error of environmental impacts of buildings with regard to a sustainability assessment. Realising the investigations of a research project - described by this paper in a condensed manner - the Department for Concrete and Masonry Structures derived the first scientifically substantiated knowledge of this effect.

The crucial difference between both LCA procedures is determined by the completeness level of the model-link mapping of a building: whereas the complete procedure requires a gapless consideration of all construction components with regard to DIN 276 (cost groups 300 and 400), the simplified procedure allows a limitation on essential construction components of the cost groups 300 and 400, whereby on the technical building equipment's part one only has to balance the heat generation plant. Moreover the simplified procedure's LCA results of the building substance must be impinged with a factor of 10 %. Consequently the reason for a deviation of LCA results can especially expected in the sphere of the technical building equipment, interconnected with the

question, if the mentioned factor, which is meant to compensate the reduction of completeness within the simplified procedure, is calibrated adequately. Looking at the significance of the result deviations it has to be stated for the overall result level - including the environmental impact of the operation phase's energy demand -, that the relative deviations are small enough not to cause a considerable spread in the LCA assessments of the *Deutsches Gütesiegel Nachhaltiges Bauen*.

The reasons for this are twofold. Besides the fact that the simplified procedure already ensures a relatively precise mapping of the building construction, it is foremost the - for both LCA procedures identical - assessment of the operation phase's energy demand which causes up to 90 % of the environmental impact. According to this finding it must be expected that improvements of the energetic building standard, increases in efficiency of the technical building equipment or an enhanced renewable energy supply will lead to a noticeably higher significance of result deviations and thus will question a rash continuation of the dominating application of the simplified procedure. However, the alternative to stipulate an obligatory use of the complete procedure is no practically suitable option, because it causes a demonstrable additional effort of approximately 80 up to 120 %, especially concerning the required data collection.

The key findings of the research project rather suggest that the future consolidation of the LCA within the Deutsches Gütesiegel Nachhaltiges Bauen needs an "equalizing" strategy which complies with scientific requirements of precision as well as practical needs of (economic) efficiency, which subsequently relieves the tension between both opposite views. In this sense, one exclusive, ecologically adjusted, economically rationalised and functionally optimised procedure is the most "sustainable" alternative of consolidation. Its main characteristic is the integration of those technical building equipment components which represent a crucial part of the environmental impact and drive the LCA results, but can be assessed with an acceptable effort at the same time. Thus, this alternative would also dissolve the present duality of LCA procedure as the mentioned origin of the strategic sustainability-related problem.

PRE-CHECK SYSTEM FOR THE SUSTAINABILITY ASSESSMENT OF ROAD BRIDGES IN THE EARLY PLANING STAGES

Peter Ramge, Carl-Alexander Graubner

For a long time sustainability assessment evaluation focused on buildings only. By means of sustainability assessment systems, like the „Bewertungssystem Nachhaltiges Bauen für Bundesgebäude“ (BNB) for example, buildings can be evaluated regarding the three dimensions of sustainability (ecology, economy and socio-cultural aspects) as well as regarding the building specific cross section qualities (technical quality and process quality). A sustainability assessment system for road bridges was developed at the Institute for Concrete and Masonry Structures within the scope of a research project funded by the Federal Highway Research Institute (BASt) in 2010. The developed system is based on the assessment system for buildings. Since then a number of subsequent research projects on the topic of traffic infrastructure were accomplished. Currently a project dealing with the revision of the first system of 2010 and the development of a new pre-check system for the sustainability assessment in the early planning stages of road bridges is carried out.

In the first step of the ongoing project the previous projects on traffic infrastructure as well as further current publications on this topic are analysed regarding improvement potentials. The project pilot study for example in which the assessment system of 2010 was tested on real bridges for the first time is a major source of improvement potentials. In the pilot study suggestions for more precise specifications or general amendments of individual aspects were derived from the experience of the practical application. Based on these suggestions the revision of the basic system of 2010 is carried out taking also such criteria into account that were previously put on hold. Where possible and reasonable these criteria

are also worked out and integrated in the assessment system. Besides the specification of individual checklist questions major issues such as the choice of an adequate datum plane (functional unit) for road bridges, instructions for the handling of criteria and checklist questions that cannot be applied in individual cases or the definition and adjustment of reference values for quantifiable measurement values, is also meant to be addressed and settled during the revision process. Furthermore a harmonisation of the layout and the score card structure of the subsystems for bridges, roads and tunnels will be carried out.

The second part of the current research project deals with the development of a pre-check system for road bridges in the early planning stages. Aim of this system is to verify sustainability potentials during the planning process as early as possible in order to maximize the effectiveness of their implementation. In a first step an analysis of the relevant planning phases is carried out including the determination of which relevant information is available at which stages of the planning and which information can therefore actually be used at the various planning stages to influence the further planning regarding an optimized sustainability. Due to the fact that road bridges are generally constructed in the context of a roadway system interactions with the subsystem “roadway systems” have to be considered. Based thereon, the early planning stage can be confined to distinguish the application point for the pre-check system. The criteria of the existing system (revised version) will be altered for the use within the pre-check application during the further duration of the project. Major attention will naturally be given to those criteria that provide a high steering potential regarding the sustainability of road bridges. To assure the applicability of the system the assessment and evaluation rules as well as reference, target and limit values will be worked over. Thus an easy to apply system for the sustainability assessment in the early planning stages will be available for practical application.

INFLUENCE OF FLEXIBILITY ON LIFE CYCLE COSTS OF INDUSTRIAL BUILDINGS

Gökhan Uysal, Carl-Alexander Graubner

Industrial companies are confronted with new problems during the strong competition and cost pressure on the global markets. The increasing volatility in the demand of consumer products means that companies have to react to market changes faster and faster. In this context, new challenges arise for industrial buildings.

The common practice to build short-term investment reduced solutions and extensions which are driven by the current needs of the production is a waste of construction resources. Furthermore this way to build leads to significant downtimes of the production and to heavy production interruptions during the construction period. For these reasons, it is seen in the optimization of the conversion capability, in the following called flexibility, a chance to reduce the life cycle costs of industrial buildings and the downtime of the production.

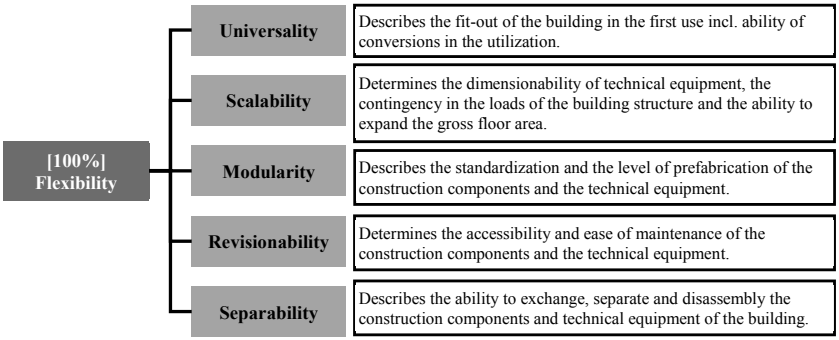


Figure 1: Individual factors of flexibility

To include the flexibility of an industrial building in the life cycle cost calculation, first of all, the term hast to be objectified and made measurable. As shown in the Figure 1, this is done in this approach by splitting the term flexibility to individual factors. The approach is also based on the premise that an ordinary industrial building has an average level of flexibility. The resulting life cycle costs of this reference level can than be adjusted by using correction factors (KF) for the targeted level. The correction values of the individual factors are added together to give the total correction value for flexibility. This is shown in the formula 1.

$$KF_{Flexibility} = KF_{Universality} + KF_{Scalability} + KF_{Modularity} + KF_{Revisionability} + KF_{\text{Separability}}$$

Formula 1: Calculation of the correction factor for flexibility

To adjust the complete life cycle costs, it is required to calculate correction factors for each considered cost category. In this case for construction costs (HK), running costs (BK) and conversion costs (ÄK). It is also necessary to have a correction value for the service lifetime of the construction components and the technical equipment of the building. Correction factors can be evaluated with expert interviews based on the Analytic Hierarchy Process (AHP-Method). With this method the cost weights of the individual factors are calculated by pairwise comparisons for a given level of flexibility. To determine the assessed levels a 9-stage scale was chosen (see table 1).

Level of Flexibility		HK	BK	ÄK	ND
0%	**Extremely low**	96,0%	110,0%	146,0%	98,0%
10%	**Very low**	96,5%	107,5%	132,5%	98,5%
20%	**Low**	97,5%	105,0%	120,7%	99,0%
30%	**Below average**	98,0%	102,5%	110,0%	99,5%
40%	**Average**	100,0%	100,0%	100,0%	100,0%
50%	**Above average**	114,5%	98,5%	50,0%	106,0%
70%	**High**	119,0%	97,0%	25,0%	112,0%
80%	**Very high**	124,0%	95,5%	12,5%	118,0%
90%	**Excellent**	135,0%	94,0%	6,3%	124,0%

Table 1: Exemplary correction factors for flexibility separated by cost categories

APPLICATION OF THE METHODOLOGIES LIFE CYCLE COSTING (LCC) AND LIFE CYCLE ASSESSMENT (LCA) FOR PLUS-ENERGY-BUILDINGS

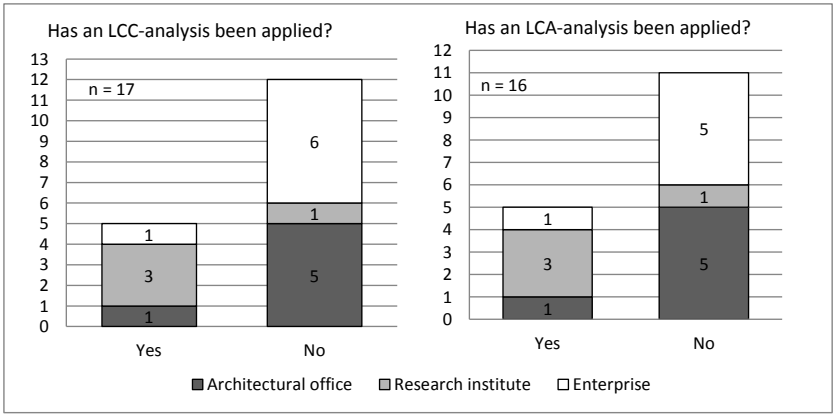
Claudia Weißmann

Within the context of the turnaround in the German energy policy, plus-energy-buildings are increasingly becoming established in the building and construction industry as this sector is responsible for one third of the German primary energy consumption. Up to now the evaluation of different plus-energy-building concepts was focused on evaluating the efficiency in energy consumption. However the economical quality and ecological quality of these buildings are also important factors for an integrated analysis and a long-term existence in the market. A remarkable feature of plus-energy buildings is the connection between a higher concentration of resources in production (e.g. innovative system technology) and the resulting savings of these buildings in operation (e.g. electricity and heat). To map this connection between different phases in the building life cycle, a life cycle oriented evaluation methodology should be used for an integrated analysis. For the economical evaluation the life cycle costing (LCC) methodology can be adopted while for the ecological analysis a life cycle assessment (LCA) can be applied. Both methodologies are already being used for the evaluation of conventional buildings.

For analyzing if these methodologies are applied for plus-energy-buildings as well, the Institute of Concrete and Masonry Structures conducted an empirical study initiated by the Institute of Business Administration, Controlling and Audit. In this study the application and the applicability of both methodologies for plus-energy-buildings conform to the German Effizienzhaus-Plus standard by the *Federal Ministry of Transport, Building and Urban Development (BMVBS)* was investigated (17 buildings at the time the study was conducted).

The results of this study show that in five of 17 projects the LCC- and the LCA-analysis were applied. In most of those cases a research institute had been involved in the planning process. The methodologies were mainly used for proofing the economic and ecological advantages of plus-energy-buildings compared to conventional buildings. For the greater part of the interviewed enterprises (most from the prefabricated housing sector) and architectural offices the methodologies seemed to be useful in theory but not applicable in their daily business as they require too much labor time and therefore lead to additional costs.

Regarding the applicability of the methodologies it was remarkable that in most cases where an LCC- and an LCA-analysis had been applied the simplified methodologies by the *Deutsches Gütesiegel Nachhaltiges Bauen (DGNB)* and the *BMVBS* had been used. Conform to those, the negative effects of the installation and the disposal of plus-energy-building key elements – such as innovative housing technology – don´t have to be assessed which is why in many cases only the resulting savings in energy costs, primary energy demand and emissions had been calculated. Hence, the target of further research could be to develop the methodologies LCC and LCA for the purpose of a better applicability for plus-energy-buildings, so that an integrated comparison of the economic and ecological quality of plus-energy-buildings with different building technology equipment would be possible.



WHIT EXCURSION
TO DÜSSELDORF AND SURROUNDINGS

Jochen Zeier, Peter Ramge

This year's Whit Excursion of the Section of Concrete and Masonry Structures took place from June 10th to June 13th. It belongs to the excursion-series organized by the Section of Concrete and Masonry Structures together with the Institute of Concrete Structures and Structural Design of the Technical University of Kaiserslautern. The destination of the eleventh jointly organized excursion was Düsseldorf and surroundings.

In Düsseldorf there were thunderstorms in the night of June 9th to June 10th. We arrived there in the morning after this thunderstorm when all the damages were visible. Large traffic jams dominated the city and we could not move fast. A talent for improvisation was essential to be at the "House of the medical fraternity" in time. Within the scope of the excursion we visited several buildings in different phases of the life time cycle (build/utilization/modification). We visited the "House of the medical fraternity" (Düsseldorf), the new TÜV Süd administration building (Köln) and the Gerling-Quarter (complex of buildings in Cologne). We have been to large infrastructure projects including the Wehrhahnlinie (new subway) in Düsseldorf, the motorway interchange Kaarst (A57) and the Lahntalbrücke close to Limburg (new bridge for the A3).

Noteworthy highlights of this excursion were the visit to the open-cast mining of the RWE Power AG at Garzweiler and the visit to the precast-segment factory of the company Goldbeck in Hamm.

During a tour with the night watchman we learned a lot about the customs and traditions of Düsseldorf. We also had a guided tour through the Cologne Cathedral.

On the last evening we had a warm dinner with tapas and lots of Düsseldorf Alt while watching the soccer world cup opening from Brasil.

Figure 1: group picture in front of the Lahntalbrücke

We are very grateful for the financial support of the excursion through the „Freunde des Instituts für Massivbau der TU Darmstadt e.V.". Therefore we would like to express hereby our sincere thanks.

The following Whit excursion will take place from Mai 26th to Mai 29th 2015. Contact for Whit Excursion 2015: Mr. Jochen Zeier.