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double facades

boxed window facade

second skin facade

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chimney boxed window facade

alternating facade

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Facade Research Group / TU Delft
In cooperation with Prof ass. Dr. Tillman Klein

Institute for Structural Mechanics and Design / TU Darmstadt
in cooperation with Prof Dr. Jens Schneider
Biomimicry utilization of thermo-regulation for dynamic façades

Development of a biomimetic ontology to exploit the potential of thermal adaptability in nature for dynamic façade design

In respect to the level of energy efficiency of a building, the façade is highly required to achieve maximum efficiency by dynamic adaptability. By the integration of active technologies and materials, the façade shall be able to react autonomously and dynamically to changing thermal conditions. The complexity of such systems, their failure potential and reliability might be improved by investigating biological thermoregulation principles and by transferring abstracted functions and relations to new design patterns of dynamic façades.

Adaptability is one of nature’s most basic survival strategies. A very effective approach represents the thermoregulation of organisms that is optimally exploited at maximum efficiency by using both locally available resources as well as that much energy and material as necessary. It is controlled by complex interactions of matter, energy and information between the organism and the environment. Each item is ideally adjusted to the overall function and highly flexible, which creates not only a highly efficient system, but also wide implementation variations.

The key challenge of the work is to investigate the various approaches of natural organisms, respectively for thermal-dynamically active skins and envelopes: How do thermoregulation processes in nature work? Which functions and parameters are crucial? Particular attention is given to the analysis of characteristics that are analogous to architectural design parameters, such as geometry, size, or positioning.

Thus, based on defined search criteria, principles of biological thermoregulation are investigated using the biomimetic approach. The findings are transformed systematically into a classification system, which is the basis for a biomimetic ontology. The system visualizes the functional role and design patterns of constructive parameters, with each function subdivided in objects (matter, energy, information) and operations (actions, relationships). This gives insights into the interaction of “constructive parameters” for the task “thermal-dynamic adaptation to increase efficiency.”

The goal of the work is to investigate biological principles that contribute to a highly efficient thermal performance through smart constructive measures and to transfer them into functional design patterns for dynamic façades.
Fabric Formwork in Building Industry

Sascha Hickert, M.A.

Formwork today is challenged to be material and cost efficient. Ideally both parts, the formwork and the concrete, need on the minimum amount of material. Conventional formwork has to deal with high labour cost and comparably low costs for concrete. It is economically sensible to produce simple shapes rather than to be material efficient.

Conventional Formwork

Beyond the amount of concrete being used is the material of the formwork itself that contributes to its resource intensity. Using one part multiple times is a benefit (ratio for the costs). On the other hand, systemized formwork can limit the geometry. Not only form which result from the force flows analyses are challenging. Modern architects like Hadid, Gehry or Libeskind design freeform shapes which bear a high level of complexity for the formwork. Production chains and formwork to build freeform concrete shapes are already applied. Most common procedures for curved building elements are the following:

Small sized tests

The small-sized tests investigate the fabric and the impact on the concrete. The following physical properties are investigated:

- Elasticity
- Permeability / absorption
- Reusability
- Surface quality
- Surface colour
- Surface hardness
- Mass function

These aspects are mostly taken from the German Regulation of the requirements of face concrete ("Markblatt Schichtbeton"). The majority of tests have been completed. They were developed in cooperation with the bachelor thesis.

Case studies

After analysing built examples aiming and learning from literature, it was decided to build the most common building elements: beam, column, wall, slab and wall and prototype for one or two projects.

Experimantal formwork techniques

Case study - wall

Kontakt:

Sascha Hickert
lacken@ism+d.tu-darmstadt.de

Technische Universität Darmstadt
Institut für Stahl und Konstruktion
Franziska Braun-St. 3
64287 Darmstadt, Germany
Leasable Facades as a Product-Service System

Developing a business-to-client product-service system (PSS) for resource-efficient facades

Product-Service Systems (PSS) are an emerging method for designing, producing and managing property. This project will explore the adaptability of PSS into the realm of façade fabrication and building construction. It will make use of our team’s strong links with key players in both the supply and demand sides of the architecture industry in the Netherlands, to identify the main financial, industrial and ecological benefits of a PSS-based façade system. PSS has the potential to fundamentally change existing outright-purchase systems used in the building (and particularly the façade) industry towards high performance, energy saving models. A new PSS approach will lead to better products that include circular economy principles, and will create new business opportunities in times of financial crisis in Europe.

Opportunity

Within the current process for designing, manufacturing and operating façades there is a gap between supply-side developers and demand-side needs which hinders the implementation of resource-efficient façades. façade leasing as a PSS keeps suppliers committed, throughout the building’s service-life, to safeguard optimum performance in use while actively stimulating clients to adopt innovative solutions.

Principle

This project builds upon the advantages offered by new systems of integrated façades, which include technologies such as mechanical shading devices, automated climate control, energy management and generation systems, media projection and others within the construct of a building’s envelope. A PSS approach to the marketing and management of all these individual technological products would lead to a more widespread use of innovative and sustainable façade-integrated systems, allowing for a faster and more effective market-integration and shorter technological life cycles.

Context

Clients increasingly focus on both the performance (value) and the costs of resource-efficient solutions during the building’s lifetime. However, limited access to information or unwillingness to invest on emerging, untested technologies results in sub-optimal decisions during the planning stages of a project (sometimes sacrificing potential value, such as energy performance, in exchange for a lower initial investment cost). By exploring new methods of financially-driven technological integration, this project aims to close the knowledge gap between consumers and suppliers of building envelopes, in order to guarantee long-term collaboration and responsibility among the different players in a building's design, construction and management process.

Proposal

PSS façades could be a new tool for clients, contractors and suppliers to manage risks and costs over the 30 to 50 years of a building’s contractual service-life. ClimaticKING funding provides the opportunity to generate a solid PSS-based business plan, as well as an initial technical configuration, with which to approach a larger innovation network.

PROJECT INFORMATION

Researcher: MSc Ing. Juan P. Aciar-Atayagre
Postdoc: Prof. Dr. ing. Alexsander Den Hoog
PhD Student: Dr. ing. Thomas Kian
Partners: TUDelft, ClimaticKING
Period: 2015-16

RELATED PUBLICATIONS


TUDelft

Delft University of Technology
Faculty of Architecture
Department of Architectural Engineering & Technology
Facade integrated energy generation and long term energy storing

Research on energy autarkic buildings

Facades have more and more changed to be appreciated as energy envelopes than only as weather climatic shelters. The amount of fossil energy resources on earth is endless. The use of energy for building climatisation has to be more efficient than several decades ago. Building envelopes need to be less energy permeable in case of fossil energy driven complexes or need to generate energy for conditioning in respect to environmental energy sources by themselves. Long term or seasonal energy storages are necessary for demand related provisions.

Current European primary energy supply regulations, a dislocation of renewable energy generation and energy consumption abroad BRD and an overstrained and insufficient public supply network in Germany as well emphasize the necessity of research in decentralized energy generation and storing.

Several technologies have established throughout the decades being sufficiently as energy collectors based on environmental renewable energy sources. Appropriate solutions for every scale of usage or building offer a huge variety and independence towards fossil sources. Facades are constructive layers which regulate climatic exchange and energy losses of a building.

It seems to be obvious that facades should also be able to manage climatic exchange and energetic generation in one.

Environmental energy sources are extremely linked to day and season. The temporal differences between offering and demand make energy storages essential.

Modern volumetrical and gravimetrical energy storage technologies are physically and chemically complex. The engineering task will be defined by a sufficient adjustment of facade integrated energy collectors, energy storages and technical devices to provide specific levels of thermal comfort.

Researches on the three above mentioned key topics require an integral method of analysing and working.
Integral Transparent Facades

Green Building Innovation Projects Façade Research Group

Sparkasse Ludwigshafen
New façades and the building services for Sparkasse Vorderpfalz, Ludwigshafen, Germany

Sparkasse Vorderpfalz is a regional bank in southern Germany. The PhD research “Re-Face” developed a refurbishment solution for this building, which was applied in practice. The major challenge was that the entire building process had to take place while the building was kept in operation. The final solution managed to renew façade and HVAC within 8 working days per floor and improves the energy performance by 75%.

The refurbishment proposal for the office façades takes advantage of the existing service platforms. It places an additional façade layer on the outer position of the service platforms. Vertical profiles, suspended from a steel-framework, which rests on the main bearing structure, carry vertical loads. Horizontal loads are brought into the existing consoles. After the outer façade was closed, the interior façade could be renovated independently of the weather. The sub-structure of the original façade could stay in place. Only the filling elements are replaced by new windows and insulated panels. New climate units are installed inside the cavity.

For the refurbishment of the outer corners of the tower a very simple and effective solution could be found. The cavity provided sufficient space for additional insulation. The original aluminium panels have proven to be of a very high quality. They were cleaned, anodised to prevent efflorescence, newly coated and re-mounted onto the existing structure using the old pressure plates and new gaskets. Thus, more than 80% (approximately 700m²) of the old façades could be saved.

The climate concept uses the double façade. Decentralised HVAC units in each room provide individual ventilation with heat recovery as well as heating or cooling by water-air heat exchangers. In winter, the incoming air is pre-conditioned by solar radiation and taken from the cavity. Used air is extracted by horizontal ducts directly to the outside. In summer the system is reversed. The stack effect inside the cavity draws air from the rooms: no fan power is needed. Fresh air is fed from the outside.

This project has achieved the European “Green Building Certificate” and the first prize in the international “Re-Skining Award” in the category “Large Commercial”.

zerofootprint
Re-Skining Awards
WINNER
LARGE COMMERCIAL
Integral Massive Facades

Advection Based Adaptive Building Envelopes:
Component surface morphology and entropy management of a ceramic building facade

Xella Technologie und Forschung
Systembauweise Energie Plus

Through the last decades the facade industry has witnessed significant development. New materials were introduced, energy performances were enhanced, and new functions were added. But on the other hand, the industry is still depending on scattered decisions taken by scattered disciplines and that results at the end in a layered façade system. Other more developed industries, like car and airplane industries, are trying to enhance their products through more applying more integrated designs. The façade industry must adopt the same integration strategy in order to move forward. But how can the façade industry respond to such a strategy?

In today’s façade industry, every specialist is concerned with certain aspects related to his discipline, which results mostly in a final product composed of many layers, each representing a function. More functions mean more layers. This industry is adopting the layered strategy for many years now for the sake of practicality and cost saving. On the other hand, other developed industries, like car industry for example, although their production is of highly precise measurements and they rely totally on industrial and technological process in manufacturing their products, they are trying to lessen their product’s parts through more integrated designs. This helps them to enhance the quality of their products.

The scattered design solutions, is something the building industry in general, and the façade section in particular, must abandon if it is to move forward and improve. Solutions should be oriented towards integrated designs. However, such a strategy cannot be implemented in the current design process with scattered parties and decision making. Implementing any integrated design solution will result in major changes in the current design processes. Disciplines will come together in a different way, with new shared decisions, demands, inputs, etc.

The objective of this research is to enhance the building industry by proposing new integrated design strategies for solid facades. This will take place through investigating how the design and construction process in the façade section will recognize to the integrated design approach than proposing methods that can be followed to implement integrated façade design solutions.
House Schlaich in Berlin (Ger) / Arge Bonne + Schlaich - Infra-Light Concrete
House Schlaich in Berlin (Ger) / Arge Bonne + Schlaich - Infra-Light Concrete
Design School Essen - SANAA / Tokyo
in collaboration with Mathias Schuller - Transsolar and Holger Techen - Bollinger und Grogmann
Design School Essen - SANAA / Tokyo
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To avoid the classical heating units in front of the glass surfaces these unglazed units should be used as heating / cooling surfaces. The developed facade panels are formed of fiber reinforced concrete which is imbedded with textile. They are used as load bearing construction of the panels and can be inserted into the facade framework. The surface oriented towards the room is inlaid with meadows of capillary tubes which heat in summer and cool in winter. The use of fiber reinforced concrete provides a good heat conduction as well as stability.
integrated sandwich construction / Jackbox

Idea of the project JACKBOX refers to a sensible combination of technical possibilities and intelligent materials to be able to produce multifunctional system components. The sandwich panels made in vacuum procedure exist of the following construction:

- external GRP skin as weather protective coating
- sandwich core out of PU foam, in addition, as a heat insulation
- inside layer of fiber reinforced concrete with integrated cooling-heating capillary pipe mats, beside thermal component mass, in addition, an efficient radiation heating.

The parts of the building conceived as single modules were produced as a GRP sandwich with fiberglass-reinforced plastic skin and hard foam cores as large-size elements and afterwards were cutted. It is to be folded by incisions in the roof area possibly the wall elements in the desired form. After the elements were fixed in the desired form, became the inside layer of textile-reinforced concrete with inlaid capillary pipes sprayed.

Marcel Bilow / Ulrich Knaack / TU Delft + HS OWL
ETA Fabrik @ TU Darmstadt

Prof Dr. Jens Schneider, Prof Dr. H. Gerecht, Prof Dr. E. Abele / TU Darmstadt
ENERGY-ACTIVE BUILDING ENVELOPES FOR INDUSTRIAL BUILDINGS

Dipl.-Ing. Andreas Maier M.Eng.

Energy efficiency in the industry is typically achieved through separate measures on the level of individual machines. It can be improved with a holistic, integrated approach which links the machines, the production process, the technical infrastructure and the building. Part of this is the development of a new prefabricated element for facades and roofs which consists of mineral materials and can be energetically activated by capillary tubes integrated in the surface layers from micro-reinforced, ultra-high-performance concrete and conventional reinforced concrete. A mineralized protein foam is used for the insulating core. It combines limiting, bearing, insulating and thermal activation.

Introduction

The subject of this research is the development of a new prefabricated element for facades and roofs, which took place in the context of a research project called eStar at TUM Darmstadt, Germany. The idea of the project is the integration of individual energy-active technologies in a suitable energy concept with the aid of an energy management system. This holistic approach aims at 40% energy savings compared to conventional facades.

One important idea is the thermal activation of the building envelope in combination with thermal storages to allow heating and cooling of the factory. Environmental energy from solar radiation and thermal energy from the process can be collected and stored in a separate storages and used in a district system. Moreover, cooling by using the building envelope instead of energy-intensive cooling units in summer can further increase energy efficiency and the well-being of workers. Cool water passes through a fine capillary network in the inner layer of the material. This network acts as a thermal bridge between the building and the environment. The gained heat can be used for a suitable step in the production process.

Numerical and experimental investigations for a new type of thermal activated element

The energy activated building envelope and the production process requires special cladding elements, a rapid thermal inertia and a high-mechanical durability of the production elements. The new thermal activated element for facades and facades of industrial buildings with a height of 10 to respectively 20 m and a width of 2 m. Energy functionality is assigned to different component levels according to their material behavior. Concrete in particular is suitable because of its possible structural and energy-optimal geometry, its high availability and high potential in the reduction of primary energy requirements.

The outer layer consists of a 5.5 cm thick micro-reinforced ultra-high-performance concrete (micro-HPC) to achieve a higher component thickness due to its high mechanical capacity, resistance against thermal changes, surface quality and low permeability. The capillary network consists of a fine tube system made of capillary tubes (about 1 cm diameter) networked in a dense arrangement of pipes with an inside diameter of approx. 0.5 cm and the insulation in the surface layer of the thermal highly conductive micro-HPC leads to a necessary high thermal elements of such a system, which distinguishes it from conventional systems with an activation of concrete elements and acts as a large-heat-cooling surfaces which can react to thermal changes and store the heat gained by hot and using the finite element method (FEM) that the cooling panels can heat up to 5 K within 20 minutes and the temperature distribution in the cross-section shows almost constant. It was also possible to do an non-linear simulation with FEM about a time of one day. The resulting values were very close to the values cut from measurements (Fig. 3).

Prospective research issues

- Development of long production time and low HPC mixture
- Numerical model for foam and reinforced concrete
- Development of a high load-bearing sandwich element from HPC reinforced foam
- FE Model for such a sandwich element

Contact:
Andreas Maier, maier@email.tu-darmstadt.de
Technische Universität Darmstadt
Institut für Strukturmechanik und Design
Franziska-Braun-Straße 3
64227 Darmstadt, Germany
Integral Facades
Integrating building services into solid facades

Through the last decades the facade industry has witnessed significant development. New materials were introduced, energy performances were enhanced, and new functions were added. But on the other hand, the industry is still depending on scattered decisions taken by scattered disciplines and that results at the end in a layered façade system. Other more developed industries, like car and airplane industries, are trying to enhance their products through more applying more integrated designs. The façade industry must adopt the same integration strategy in order to move forward. But how can the façade industry respond to such a strategy?

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The objective of this research is to enhance the building industry by proposing new integrated design strategies for solid facades. This will take place through investigating how the design and construction process in the façade section will respond to the integrated design approach than proposing methods that can be followed to implement integrated façade design solutions.

PROJECT INFORMATION
PhD Researcher: Ahmed Halil
In charge: Prof. Dr. Ing. U. Schröder
Second mentor: Prof. Dr. Ing. Herwig Reiter
Period: 2011-2015

RELATED PUBLICATIONS
Xella Technologie und Forschung

Systembauweise Energie Plus

Xella Systembauweise Energie was launched to conduct a scan of the potential of function integration in lime-sand brickwork and aerated concrete. It can be seen that a clear trend towards multifunctional solutions is visible. One of the reasons is that new requirements on energy savings ask for a more holistic building approach. Many other competitors focus on enhancing their product portfolio with integrated solutions on the component, whole-wall or house solutions. Even insulation manufacturers are developing products that include functions for load-bearing and weather tightness, and are pushing into the market that was traditionally reserved for massive building products.

The project aim is to develop concepts that will be used as a basis to develop a new multifunctional product solutions. These concepts can take place on a brick-element level or even target whole wall solutions. They will have a strong implication on the product performance, manufacturing as well as on the managerial side of the product including strategies for sales and warranty, etc.

Different competitors’ products have been analyzed in terms of their product levels (from simple elements to whole wall or building levels), their technical properties and constructional concepts (from massive single layered to complex multilayered) and finally, their functionality.

A number of product scenarios for the new generation of products have been developed and evaluated according to development trends, success potential and implementation effort.

Different developed concepts
Advection Based Adaptive Building Envelopes:
Component surface morphology and entropy management of a ceramic building facade

The Advection Based Adaptive Building Envelope is a ceramic based cladding system optimized to work with local climate conditions, absorbing or reflecting solar radiation by using variable surface morphology, colour and material properties, while vectoring energy via phonetic advection. The ABABE is designed to use this multivalent strategy to absorb, release, and redirect heat or coolth to conserve energy by managing entropy production.

Value Proposition of Managing Entropy Production
If ABABEs transport energy usefully in response to the dynamic loads of climate and occupation, then by controlling thermal transfer, in both time and length scales by vectoring phonetic advection, ABABEs will reduce the typical peaks and valleys of energy consumption associated with conventional building envelope typologies.

Building Envelope as Energy Transfer Function
The characterization of the building envelope as a transfer station for the capture, transformation, storage and distribution of energy is based on an ecological model of entropy management through the building matrix. It refines the typical approaches of energy mitigation or conversion that can be characterized as derived from the First Law of Thermodynamics (e.g., conservation of energy) to Second Law of Thermodynamics (e.g., entropy generation).

Bioanalytic Design Principles
The first principles of counter current heat exchange (e.g., rete mirabile), and surface modulation (e.g., caruncle), are directly related to thermoregulation across species (e.g., turkey vulture, lamnid sharks, etc.) and climates (e.g., hot and arid, continental, etc.) and provide a research platform from which to investigate the potential for the performance design of a multivalent envelope system. The principle of counter current heat exchange is the management of entropy through an advective working fluid. The principle of surface modulation is the control of the rate of energy gain or loss due to repurposes. By tinkering these two principles together in the design of a facade component, we can show significant effects on the energy profiles of the affected thermal zones, as well as propose the facade as a functioning ornament whose morphology reflects its use.

PROJECT INFORMATION
PhD Researcher: Jason Grant-Ovenden, RA
First Mentor: Prof. Dr. Ing. Ulrich Knaack
Prof. Dr. Ing. Tillmann Klein
Period: 2013-18

RELATED PUBLICATIONS
Roadmap Massiv
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- Full services and energy collection integrated in light massive enveloper
- Light massive envelope with separate and demountable cladding
- Light and fully demountable massive envelope
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Prof Dr.-Ing Ulrich Knaack
TU Delft / Chair Design of Construction – The Netherlands
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ADDITIVE GLASS MANUFACTURING
The potential of additively fabricated glass connections for façade applications

During the past two decades Additive Manufacturing (AM) which can be defined as the layered production from a 3D file, has been enhanced from a prototyping tool used mainly for product development to a fully independent production method. Whilst the direct fabrication of materials such as plastics or metals is by now a sophisticated technology, the additive fabrication of glass, perhaps one of the most fascinating building materials, is almost unexplored.

Glass is strong but brittle, heavy yet looks lightweight, and it is transparent. These properties have made glass an important component of our built environment. Several types of glass such as laminated and insulated glazing, coated, curved, and free-formed glass panes have been developed rapidly after the float glass process was invented.

Besides this progress in glass production, constructions have been further developed to increase a transparent architectural appearance. Current architecture is heavily influenced by digital media and modelling software, giving us the possibility to create almost anything. In turn, this has developed the need for glass of an overall higher performance.

Free-formed glass panes, each one different to the other, might fit perfectly together, but are singularly produced. At this point the question arises: why not use additive fabrication methods for glass production or processing? It would give us the possibility to produce free-formed transparent building components, without the complexity of the classical steps of production but with a wide range of performance adaptable to various conditions.
Rapid Prototyping

Materials:

ABS
Acrylate
Photopolymers
Polyamid
Epoxy
PVC-Foil
Polypropylen
Polystyrol
Polycarbonat
PMMA
Wax,
gypsum,
starch,
molding sand
Rapid Prototyping

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DUS Architects gaat 3D grachtenpand printen

In 1613, precies 400 jaar geleden, werd in Amsterdam gestart met de aanleg van de grachten. Dit was een van de belangrijkste projecten van de 17e eeuw. Nu wil DUS Architects een nieuw tijdperk aanbreken: dat van 3D ontwerp en printen. Ze willen een 3D-print van een historisch pand printen en dit kan de toekomst van architectuur betekenen. Deze technologie zal mogelijk tot nieuwe architecturale mogelijkheden leiden.

Door Chantal Caes - donderdag 14 maart 2013, 22:38 in categorie: Architectuur
1. Reliability/repeatability
2. Part quality/properties/size
3. Speed

**Diagram**

- Graph with points and lines
- Labels: 135, 18, 189
- Points at 1000 and 1900
construction oriented versus function oriented thinking
Rapid Prototyping in Facades

Research Project about the influence of Additive Layered Fabrication Processes on building technology and façades.

Rapid Prototyping, and in further evolution, Additive Layered Manufacturing (ALM) in the last years turned from a small niche application for Prototypes to a serious production Technology. Therefore the façade industry tries to adopt the new production principles to their range of products. In this project the first steps towards an enhanced use of the new ALM processes for free-form facades are taken. In cooperation between TU Delft and Kawneer-Alcoa this project develops from first sketches and ideas to live size mock-ups and upgraded products.

Introduction
Additive Layered Manufacturing is gaining importance not only in the aerospace, automotive and the medical industries, but the building industry is increasingly aware of the possibilities the this technology offers to create unusual structures and details.

Kawneer-Alcoa, an international company has been working with additive methods for some time. The main focus lies in enabling possibility to produce components that complement the standard products used in system facades. Against this background, the research project "Influence of additive processes on the development of façade construction" was established at the University of Applied Sciences Hohenstein-Ernstthal in Germany in cooperation with TU Delft. In addition to implementing research and education at the university with practical and groundbreaking activities, the results support the PhD work of the project leader Hodge Broues. As the Technical University Delft, chair Design of Construction under Prof. Dr. Ing. Ulf Knaack, Alcoa universities, new innovative design approaches can be developed and communicated between different faculties and areas of study. Student exchange between the Faculties of Architecture and Facades is also envisaged.

Research in cooperation with the Industry
To limit the number of potential results, the developments were divided into time periods. An initial time span of one to three years, where results are immediately realizable with existing technology, and a time span of five to ten years when results are realizable in the foreseeable future, and finally a time span of twenty-five to thirty years, which endorses ideas that will be realizable in the not distant future.

With help of this segmentation a direct correlation can be drawn between technology and future requirements for modern product design. What is envisaged is a more optimization of material components produced with current production methods, will, over the course of the project time, develop into a visionary approach for holistic façade solutions.

Outlook
The availability of Rapid Technologies, specifically the fast advancements of Direct Metal Fabrication with additive manufacturing methods, might make it possible that, in the near future free-form facades can be digitally designed and created and then "grown" as to convert digital as an enhancement of the building product.

The presented results are only the first steps of implementing additive processes into the building industry. Further exploration of the possibilities will offer even more options that will change our built environment.

Research process and ongoing examination of the possibilities is a first step and market demand will contribute to solving existing technical challenges.

PROJECT INFORMATION
Project Title: Rapid Prototyping in Facades
Funding: ALCOA
PhD Student: Vincent Stolper (TU Delft), Erik van der Velden (TU Delft), Hodge Broues (TU Delft), Marleen van der Meijden (Delft University of Technology)
Period: December 2009 - August 2011
Preparation: October 2009
Alcoa

Kawneer Alcoa

TU Delft
Delft University of Technology - Faculty of Architecture - Department of Building Technology
N-AM
The Future of Advanced Building Skin

Alamir Mohsen M.Eng.

Complex geometries are undeniable nowadays. According to the enormous progress in parametric software, giving a close-up of facade manufacturing will have prosperous results, look to the complex geometries; one can easily define the most critical points of any geometry, which are the connecting nodes. These represent a challenge for any project; based on severe limitations to be applied in facade industry. On the other hand, the question should be; how should facade engineers/manufacturers expand their horizons so they could get in to the process and start to trust and utilize.

The author claims what is missing is the tool that could connect the pieces and solve the puzzle. In reality, the problem is finding on what is present and ignoring what is absent, which is what the author considers is the tool. The tool from the author point of view is defined as the parametric node, which could adapt to any geometry condition. The first idea was to design a parametric node that could be manufactured with the traditional techniques of manufacturing. The idea achieved a good success reaching a point that approved that having a parametric node is conceivable. The challenge showed up in the kernel of the node as it only could work for a clear geometrical form, which presented a mind shifting strategy starting to look at additive manufacturing as the solution to be used to manufacture the node kernel. To get to that point using parametric software to get a realistic result is a must by trying to identify an algorithm that could compact the whole processes needed (ideal form, structural performance, etc.) to generate the node together in one step, which results in a final piece that could be directly printed and applied.

Main Determinants:
Delineating the process is a major challenge based on the wide range of branches that being involved, which is tending to a certain level. Accordingly, the process needs to be broken down as below:

- Meshing operation.
- Structural analysis.
- Topology optimization.
- Convenient additive manufacturing technique.
- The elite material.

Structural analysis:
The number of load cases that needs to be covered to grant sufficient strength of the whole system as such.

Topology optimization:
The process is comprehensively driven by other factors, which needed to be attentively observed to grant sufficient results.

Convenient additive manufacturing technique:
Each techniques of additive manufacturing have its own limitations, which needs to be clear not to interfere with the process.

The elite material:
Materials used in additive manufacturing vary in properties and the elite material have to be utilized to grant the completion of the whole process.

Kontakt:
Alamir Mohsen
mohsen@imi.tu-darmstadt.de
Technische Universität Darmstadt
Institut für Statik und Konstruktion
Franziska-Braun-Str.3
64287 Darmstadt, Germany
ADDITIVE GLASS MANUFACTURING
The potential of additively fabricated glass connections for façade applications

During the past two decades Additive Manufacturing (AM) which can be defined as the layered production from a 3D file, has been enhanced from a prototyping tool mainly for product development to a fully independent production method. Whilst the direct fabrication of materials such as plastics or metals is by now a sophisticated technology, the additive fabrication of glass, perhaps one of the most fascinating building materials, is almost unexplored.

Glass is strong but brittle, heavy yet looks lightweight, and it is transparent. These properties have made glass an important component of our built environment. Several types of glass such as laminated and insulated glazing, coated, curved, and free-formed glass panes have been developed rapidly after the float glass process was invented.

Besides this progress in glass production, constructions have been further developed to increase a transparent architectural appearance. Current architecture is heavily influenced by digital media and modeling software, giving us the possibility to create almost anything. In turn, this has developed the need for glass of an overall higher performance.

Free formed glass panes, each one different to the other, might fit perfectly together, but are singularly produced. At this point the question arises: why not use additive fabrication methods for glass production or processing? It would give us the possibility to produce free-formed transparent building components, without the complexity of the classical steps of production but with a wide range of performance adaptable to various conditions.

PROJECT INFORMATION
PHD Researcher: Lixi Ranlip
PI: M. Dr. Ing. Ulrich Knack

RELATED PUBLICATIONS
- Ranlip, L., Sheet Glass Fabrication from Glass with Additives Processes, in TUCO2012 Conference Proceedings, 06/2012, Sal Seabird, Spain
- Ranlip, L., Sheet Glass Fabrication from Glass with Additives Processes, in Challenging Glass 3 06/2012, Deodar
- Ranlip, L., Sheet glass fabrication in polycarbonate/Resin (EB2), Product Development and Architecture, Bielefeld, 2013
3-D Printing Breaks the Glass Barrier

Researchers have cracked the challenge of printing glass through a nozzle.

By Mike Orcutt on September 3, 2015

This object was built by a new 3-D printer that can work with melted glass.
More detail on those Chinese 3D-printed houses

Lloyd Alter (@lloydalter)
Design / Modular Design
April 24, 2014

Share on Facebook
Robotically Driven Construction of Buildings

ROBOTIC 3D PRINTING @ HYPERBODY

Project leaders: Henrietta Blec, Sina Mostafavi
Research & Continuous Variation Workshop
Sina Mostafavi, Ana Maria Anton, Serban Bodas
MSc 3 Coordinators and tutors: Kas Oosterhout, Henrietta Blec, Ninosch Bilieres, Vera Lazo
Utrecht, Week Bouw @ GEVEL / HAL4 / 9-13 of February 2015
Lecture session on Wednesday February 11, 13.00 - 13.30 @ the GEVEL Theater

The robotic 3D housing project will be presented at GEVEL as a part of Week Van De Bouw at Utrecht from 9th to 13th of February 2015.
Construction Week is for contractors, constructional engineers, retailers and suppliers. Renovate is aimed at clients and housing corporations. GEVEL is the event for architecture, design and building professionals. GEVEL is the most important trade show in the field of architecture and building.

The Robotic 3D Printing is a part of Robotic Building (RB) project at Hyperbody Group of TU Delft. The RB project is a part of the Dutch Research Program of Architectural Engineering and Technology (AI'T). The RB project implies both (A) physically built robotic augmented environments and (B) robotically supported building processes, whereas reconfigurable, robotic environments incorporating semi-autonomous mechatronic systems that enable buildings to adapt to their surroundings in real-time may require design to production, assembly, and operation chains that will be in part or as whole implemented by robotic means. Robotically supported building processes focus on processes only, namely on, seamless computer numerically controlled (CNC) and robotically supported building processes enabling implementation of robotically supported novel building construction techniques which transliteration to use. Such processes may require models, which are generated in virtual environments in collaboration with humans but also between robots and humans.

Robotic-Driven Construction of Buildings (ROB3D) funded and supported by 3TU.Bouw, DFR 1000 research office of B+D and ABB is distributing materials as needed and where needed.
CERAMIC MATERIALS IN AN AM PROCESS

Dennis de Witte M.Sc.

The building industry becomes more aware of its environmental impact. Over-construction becomes more aware of its environmental impact. Over-construction is not uncommon. Additive Manufacturing (AM) can be a solution to decrease the environmental impact and to increase the freedom in shape. But no formwork is needed efficient customisation can be achieved using an additive manufacturing method. AM of plastic is widely investigated. Moreover, ceramics are relatively new in the field of AM, even though they have high potential for the building industry. Most of the researches focussing on ceramics focus on non-structural art objects. The aim of the research is to extend the knowledge regarding the use of AM for ceramic materials in the building industry.

Additive Manufacturing (AM) is a technique used to make 3D-printing. There are different techniques. Among those, 3D printing (DP) and Powder Deposition Modelling (PDM). Those two are used to experiment with ceramics, due to their relative simple techniques.

As mentioned in the introduction, the building industry becomes more aware of its environmental impact. Facade elements are therefore highly standardised which makes customisation impossible. The formwork used to cast the facade elements determines the costs. When not using AM, there is no formwork needed anymore and all elements produced can be customised. AM of ceramic materials has great potential for facade elements and other building components (Figure 1).

AM uses only material where it is needed. The digital model can contain voids, but also information about the material composition at every location of the model. Optimising every single element to withstand the expected loads, is already possible, but a matching production technique is still missing.

As shown in my Master thesis “Concrete in an AM process” there are improvements needed to obtain a better:
- Surface quality
- Inter layer strength
- Tensile strength (Figure 2) and
- Reinforcement.

It is of great importance to match material and processing techniques in order to improve these characteristics.

Is a one phase production method the best solution? What are the steps and side effects when using a two phase production method to obtain the desired result? (Figure 3) Hybrid techniques can offer more flexibility but questions arise. Feasibility of a hybrid production technique regarding additive processing

Research focus and organisation

The focus is on the relation between production technique, material characteristics and form. This relation, if understood well, helps to increase the quality of the products.

To build elements that can be tested and evaluated, a 3D printer, that is capable of processing ceramic materials, will be built. This printer consists of a CNC controlled printhead in a frame and an extruder that processes the raw material to the printhead.

A printhead, extruder and process mechanism that can be used in multiple machines is most promising (Figure 4). Frames in which the CNC controlled printhead and extruder can move are available.

Next to the engineering of the printhead and extruder, a match between the processing techniques and the material needs to be found. It is not necessarily a compromise. New materials with beneficial characteristics that differ from well-known materials, can be used in an advantageous way. The material characteristics will be investigated and compared. There is a constant relation between material, production process and obtained quality. Before AM of ceramics can be used widely those relations need to be investigated.

Eventually the parameters obtained from a design will determine the matching material and production method.

Contact:

Dennis de Witte M.Sc.
dewitte@ist-darmstadt.de

Technische Universität Darmstadt
Institute of Structural Mechanics and Design
Fränkische Brau-Str. 3
64297 Darmstadt, Germany

28.06.2015
construction oriented versus function oriented thinking: craftsmanship 2.0
Massiv Construction 2.0
Prof Dr.-Ing Ulrich Knaack
TU Delft / Chair Design of Construction – The Netherlands
TU Darmstadt / Chair Facadetecholgy – Germany
http://facadeworld.com/
International Facade Master

TU Delft / The Netherlands
Hochschule OWL / Germany
Hochschule Luzern / Swiss
Universidad del Pais Vasco - San Sebastian / Spain
University of Bath / United Kingdom

Msc Façade Design
We bring façades to life!
The Future Envelope / Delft 18.06.2015
Facade2015 / Detmold 27.11.2015

Facade2015 – Conference on Building Envelopes
refurbishment, hightech – lowtech.

façade2015
Nov. 27th // COMPUTATIONAL OPTIMISATION

In the last few decades, information technology has brought about lasting changes to design and production processes. At the same time, our demands on design and building processes have increased in line with technical possibilities. Apart from unprecedented geometrical freedom, there is a vast potential to optimise functions, energy and performance of constructions, buildings and services. Big words like Big Data, Industry 4.0 and The Internet of Things already coalesce towards the next Digital Revolution. Simulating the entire life cycle of a building envelope and their planning and building processes “now” is an ever-increasing network of information contributive to an optimisation of today's designs and constructions?

These issues will be addressed at the conference façade2015 which will follow the same sequence, as the main phases of building environment planning, construction and operation. The potential, chances and risks of progressive digitalisation with respect to the building envelope will be the center of conference discussions.

8.30 Registration
9.00 Welcoming
Uta Pöltjljiess, Dean

9.15 Keynote #1 Planning
Marina Bauer, BarkowLeibinger; Berlin

10.00 Technical Possibilities
Uli Horner, AKT II Envelopes; London

10.30 Beyond the skin
Anthony Chen, Selley Technologies; Hong Kong

11.00 Coffee break

11.30 Keynote #2 Fabrication
Arnold Reis, design/production, Skidmore

12.15 Site to Factory: Parametric Facades
Patrick Gatterer, Schüco International KG, Bielefeld

12.45 Research
Paul Reissen Deitl, Priedemann Fassadenberatung GmbH, Berlin

13.15 Lunch break

14.15 Keynote #3 Operation
(T. Ho Herzog, Umweltbundesamt; Dessau)

15.00 Adaptive building envelopes
Suzanne Gosport, Lund university; Lund

15.30 Thinking Skins
Christian Matter, RWTH Aachen; Aachen

16.00 Final Discussion

Registration:
www.werkstatt-ermitte.de/weberliga/annmeldung
annmeldung@werkstatt-ermitte.de, deadline 11. November 2015
Changes or cancellations are subject to alterations by the organiser

Fees:
150,- € members German chamber of architecture
85,- € members Hochschule OWL / members ENF
25,- € students / partners of Hochschule OWL

Venue:
Casino, Campus Emilia, Emiliavenue 18, 37075 Detroit, Germany
www.h-ua.de/de/service/anfahrt-koestlich.html

Hochschule Ostwestfalen-Lippe
University of Applied Science
Detmolder Schule
für Architektur und Innenarchitektur

Hochschule Luzern
Engineering and Architecture
Journal of Façade Design and Engineering

Contact: jfde-bk@tudelft.n
Principles of Construction

Principles of Construction is a educational book series which provides young professionals and students with systematic structured principle knowledge of building technologies.

The amount of building construction related knowledge and the amount of existing constructional solutions are enormous. There is no point in attempting to create books that contains all this knowledge and all these solutions since this would lead to a voluminous, expensive and rapidly out of date product.

Moreover, it would not challenge or tempt students or young professionals to design their own constructional solutions because many solutions are already given. Thus, the concept is to describe problem types and solution types on an abstract level, suitable for a technical understanding. The main task is to identify and describe the typology of problems and solutions in a systematic manner. The aim is not to describe as much as possible, but as little as possible, to give the reader a theoretic foundation, that can be used for his/her own design.

A series of books was developed that organizes the principle of construction according to different themes and perspectives.

The following books are published:
Meija, Knaack: Components and Connections
Knaack, Klein, Blas: Advanced Facades

The following books are planned:
Knaack, Chung-Klates, Hasselbach: Systems
Knaack, Tchenu: Structures and function
Knaack, Klein: Material and Detail

Publisher:
Birkhäuser – Basel, Boston Berlin
All books are published in German and English.
Imagine 01 - Facades - 2008
Imagine 02 - Deflatables – 2008
Imagine 03 – performance driven envelope – 2011
Imagine 04 – rapids – 2009
Imagine 05 – energy – 2011
Imagine 06 – Reimagine facades – 2012
Imagine 07 – Reimagine housing – 2012
Imagine 08 – concretabel – 2015
Imagine 09 – efnMOBIL – 2016
Imagine 10 – rapids 2 - 2016
TU Delft / The Netherlands
Hochschule OWL / Germany
Hochschule Luzern / Swiss
Universidad del Pais Vasco - San Sebastian / Spain
University of Bath / United Kingdom
COST is supported by the EU Framework Programme Horizon 2020

Poster map – façade function vs. research area

Mind map prepared based on the contents of the posters, COST TU 1403, WG 4

<table>
<thead>
<tr>
<th>Facade function*</th>
<th>research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>simulation, prototypes</td>
<td>monitoring, assessment</td>
</tr>
<tr>
<td>create a durable construction</td>
<td>PV</td>
</tr>
<tr>
<td>allow reasonable building materials</td>
<td>advanced materials</td>
</tr>
<tr>
<td>provides a comfortable climate</td>
<td>facade glazing</td>
</tr>
<tr>
<td>responsible handling in terms of sustainability</td>
<td>facade shading</td>
</tr>
<tr>
<td>support the use of the building</td>
<td>control systems</td>
</tr>
</tbody>
</table>

* the function list based on Klein T., Integral Façade Construction, 2013

Dear participant, if any information is wrong or missing, please contact: marcin.brzezicki@pwr.edu.pl

The link determines the activity in more research areas.
Developing a flexible mould will encourage industrial companies to manufacture complex geometries in a cost efficient way.

The Kine-Mould develops a very simple mould system for industrial companies to manufacture complex geometries in a cost efficient way. The system is based on a flexible resin that can be shaped and hardened to form a mould. Once hardened, the mould can be used to cast a variety of materials, including concrete, glass, and other plastics. The system is designed to be easily handled and shaped, making it ideal for use in a wide range of industries. The flexible mould system opens up a wide range of possibilities for manufacturers, as it allows for the creation of complex, high-quality products with minimal effort and cost. This makes it an attractive option for companies looking to reduce their manufacturing costs and increase their production efficiency.
Questions for the national science agenda 2015
DE TOEKOMST WORDT GEBOUWD
JOURNAL OF FACADE DESIGN AND ENGINEERING

Nordpark cable railway – Zaha Hadid
The Nordpark cable railway is composed of four stations and a cable-stayed suspension bridge over the river Inn. Zaha Hadid Architects won the competition to create the railway stations in 2005. The project was completed in 2007.

Bucky Lab

BuckyLab intro-07
Marcel Bliow gives a small introduction about BuckyLab possibilities and activities – Part 07/07.
May 5, 2015 / Leave a comment

Glass Structures & Engineering

Climate Design and Sustainability Chair – TU Delft
Climate Design and Sustainability Chair – TU Delft. See the link here. With the leading role that building physics started to have for achieving sustainable building designs, the section Climate Design at TU Delft was inaugurated from a cooperation between TU Delft.
May 5, 2015 / Leave a comment

New Journal – Glass Structures & Engineering
New Journal – Glass Structures & Engineering A forum for developments in structural glass, offering a holistic approach to research, construction and engineering. Presents developments in structural glass research and their practical applications. Covers a wide range of research on April 28, 2015 / Leave a comment

facadeworld.com
Massiv Construction 2.0

Prof Dr.-Ing Ulrich Knaack
TU Delft / Chair Design of Construction – The Netherlands
TU Darmstadt / Chair Facadetechnology – Germany

http://facadeworld.com/