

efnMOBILIE 2.0

Ulrich Knaack / Uta Pottgiesser

Efficient
Envelopes

efnMOBILE 2.0 / Efficient Envelopes

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Ulrich Knaack / Uta Pottgiesser

Reviewers

Linda Hildebrand / Mikkel Kragh / Aleksandra Krstic-Furundzic

Design

Sirene Ontwerpers. Rotterdam

Cover image

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Editorial

Based on the experiences of **efnMOBILE 1.0** the hands-on student workshop activities and exhibitions took place in different environments and locations encouraging new technologies and methodologies. Like **efnMOBILE 1.0** the new workshop series **efnMOBILE 2.0** provides the **European Facade Network (efn)**, its conferences and the connected professional community with a local platform for communication, exhibition, innovative development and interaction. **efnMOBILE 2.0** is reaching out to be developed from a European communication and technology exchange instrument into an international tool to exchange with the global facade community

All events of **efnMOBILE 2.0** follow an overall theme: '**Efficient Envelopes**'. Focusing towards adaptive and transdisciplinary approaches to improve the building envelope's thus the building's performance through human-centered solutions in facade technology. The task is to inspire the upcoming generation of architects, designers and engineers to allow themselves to follow uncharted paths of development, think outside the box, to build showcase examples, and to come up with ground-breaking solutions – for a better design as it relates to climate, health and an overall building design approach. The concept is supposed to foster the dialogue around sustainable design and development and to increase awareness and actionable solutions for sustainable design.

In 2016 and 2017 **efnMOBILE 2.0** has been present at three annual conferences of efn: Lucerne 2016, Delft 2017 and Detmold 2017 and additionally at the glasstec fair 2016 in Dusseldorf (Germany), and in 2017 at the University of Antwerp and the ICBEST conference in Istanbul (Turkey). Each event includes a three-to-five-days-workshop on location – to inspire and innovate - followed by a period designated to design development and engineering, and concludes with a final presentation to the professional public at fairs, conferences or in the educational context.

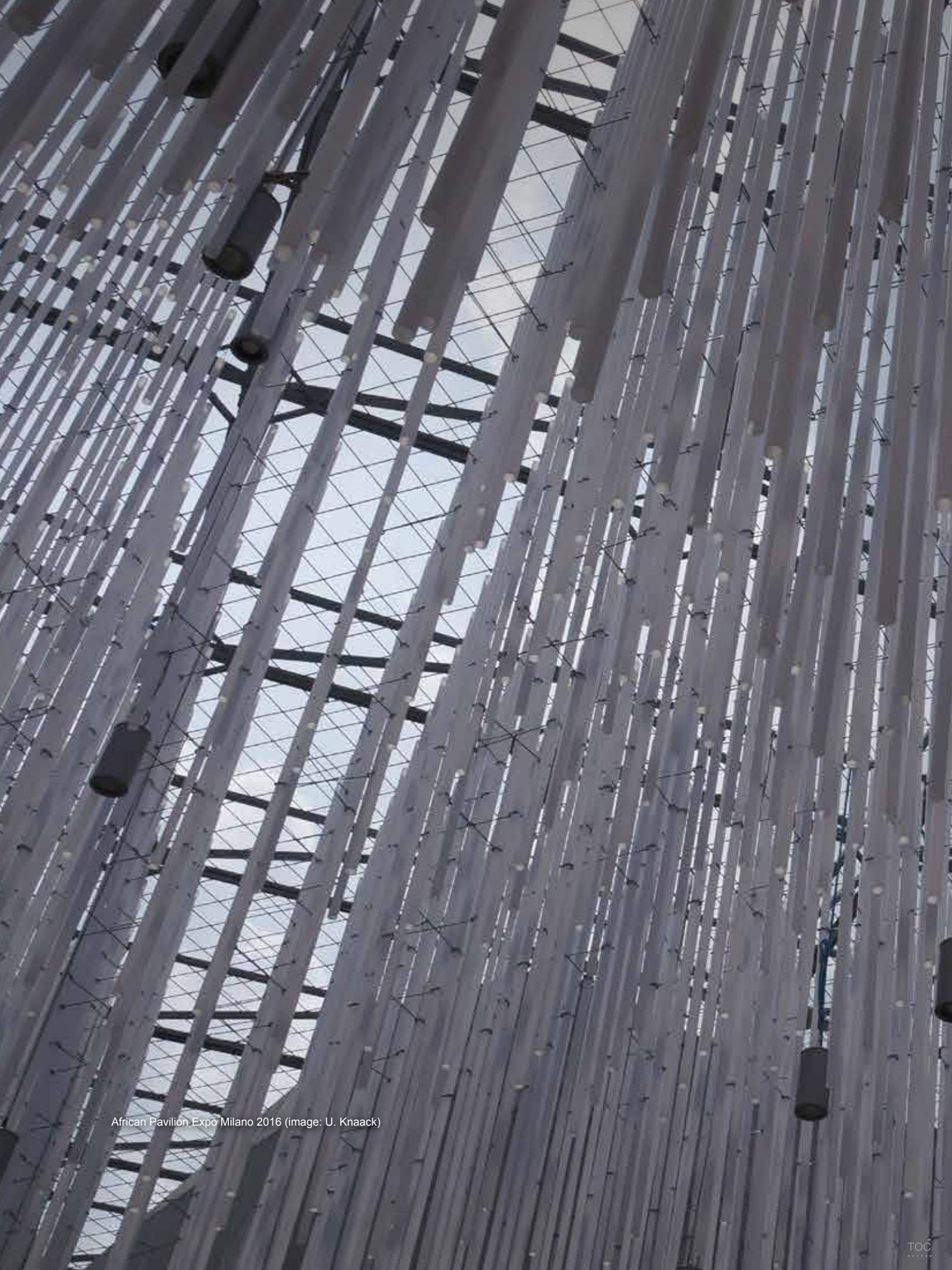
During each event, the participants build mock-ups of different scales, do field research or intercultural exploration. To reach this goal the project contributes with the following outcomes:

- 1 increased knowledge sharing between the various European research and education centres and between those centres and industry and further international actors.
- 2 development of novel concepts and technologies and/or the new combinations of existing technologies.
- 3 development of new knowledge such as effective evaluation tools / methods for adaptive facades.
- 4 start of new collaborations and research projects in the area of facade technologies.

This time **efnMOBILE 2.0** also included an international online survey on facade education with responses from more than 200 participants. The survey addressed practitioners and scholars and was focussing on the needs and expectations of facade industry and consultancy. The results of the survey will help to further improve the existing programs and to develop new programs overseas.

efnMOBILE 2.0 has been made possible through the funding of the ALCOA Foundation. The editors and the efn-members like to thank ALCOA Foundation for supporting this initiative to make building envelope design and connected educational programmes more efficient and successful by creating a platform for organized sustainable creative thinking

Ulrich Knaack, Uta Pottgiesser



African Pavilion Expo Milano 2016 (image: U. Knaack)

1 Global Facade Activities



FIG. 1.1 Toronto (image: U. Knaack)

1 Global Facade Activities

Uta Pottgiesser, University of Antwerp / HS OWL, Ulrich Knaack, TU Delft

In 2002 the European Commission announced for the first time the European Building Performance Directive (EBPD 2002) which was updated in 2010 and is still describing the ambitious goals of Europe to achieve 'Nearly Zero-Energy-Buildings' in 2020. Against this background the building envelope including facade design, construction and technology has become a crucial element and object in research and education – being identified as one of the key actors to improve energy efficiency and total building's performance. Before 2000 there were just singular activities in this field, most significant to mention the 'Center of Windows and Cladding Technology (CWCT)', founded in 1989 in Bath by Ted Happold, acting as a close to industry knowledge and information center and organiser of an postgraduate programme on facades.

The initiation of the Bologna Process in Europe in 1999 had led to new international programs on master and postgraduate level in general, but in particular in areas that were identified to be important, forward-looking or market-related. In the building sector this were topics dealing with energy savings and efficiency, new technologies or digitalisation. While most programs were designed for national needs and markets, some programs directly targeted international audience and labour markets.

In 2009 the efn was founded with 5 European institutions being active in education and research. In 2016 more than 10 European institutions are connected within the network with an increased number of activities joint and rotating conferences, a journal and different publications. As a next step the network is reaching out to other continents in North and South America and in Asia:

2016 was the year, when the first North American Facade Congress took place, organised by the Façade Tectonics Institute (FTI). 2017 was the year, when European and global façade activities merged for the first time during the ICBEST2017-Conference in Istanbul.

Next to these activities in education and research, the program efnMOBILE is very well linked to manufacturing and construction industry. As key factor and impulse for this program, the funding by the ALCOA Foundation is central. This is flanked by the local support of local facade manufactures of different braches / materials as well as the local facade construction companies – providing an local as well as international audience for the workshops. Key driver for the industry to participate is the interest in the development and understanding of the complexity of facades, their function for the building and their impact for the environment. This links well with the request and need for people, being able to develop, design and execute complex facade and to take these functions in engineering and industry. So, the program and the workshops support the interaction, the cooperation and – most importuned, the exchange between people.



Shop Hoofstraat Amsterdam (image: U. Knaack)

2 International Facade Education



FIG. 2.1 The facades and the details of the Löwenbräuareal in Zürich, Switzerland (by Gigon / Guyer Architects and Atelier WW) show the complexity of present building envelopes in materiality, construction and technology. (image: U. Pottgiesser)

2 International Facade Education

James Doerfler, Thomas Jefferson University, Uta Pottgiesser, University of Antwerp / HS OWL

Globalization in general and the construction industry in particular have brought about new demands for buildings and construction projects, new demands that still need to take into account local conditions. Moreover, digital technology has effected lasting changes to architecture, from planning and production right through to execution, and job requirements are getting more sophisticated accordingly.

This alliance of academia and industry will inform graduate programs at both institutions providing a unique educational model that merges theoretical and real world knowledge into frameworks for regenerative design. The existing European facade programs focus on qualifying architects and engineers for international interdisciplinary, and to a growing extent, digitally supported jobs. The facade programs attach special importance to the cooperation between university and external partners, to links between the universities and to planning offices, to construction industry and to software manufacturers. The complexity of the building envelope is defined by the aesthetic, constructive and physical requirements, the degree of the technical equipment and the repetition factor within a facade. The conception of a facade in the design and construction phase with the graphical representation of master and connection details and the project supervision with the examination of the facade specific execution requires special know-how of integrated architectural planning. Facade technology is the leading discipline within the building sector in terms of technical complexity and systems integration as well as having an impact on the public aspect of the building. This technologically leading role is earned by the need for integrating energy savings, improved indoor environmental quality and sustainability. Due to the goals of the architecture facade, design and technology play a key role in improving sustainability and in developing a sustainable design approach for the building envelope. This approach is increasingly needed for new designs and retrofitting existing buildings in the developed countries. Both should be designed with regard to the needs of the users combining aspects of layout, lighting and acoustics, ergonomics and materiality. Refurbishment is a key activity of the building sector in Europe and in the USA and other metropolises where a lot of 20th century high-rise, office and residential buildings need to be improved or modernised. Existing buildings and their envelopes will develop different solutions related to energy-savings and well-being that need to be clarified for different facade typologies and different base building needs. In the 21st century computer- and information technology are a basic technology that allows all partners in planning and realisation of architecture to communicate easily. Computer-based building and production processes via CAD-CAM-interfaces to CNC-mills and rapid prototyping-procedures expands the occupational profile of the building professions into fabricating. The integration of planning data into consistent 3D-models, the implementation from the digital model into the building through machine-based production processes are characteristics of new building technologies. The students are trained in the consequent and efficient use of digital tools and are qualified in the interdisciplinary exchange with experts from industry and other universities. These changes result in an increased use of integrated, often innovative and non-regulated building elements and materials, an increased degree of prefabrication and an optimised assembly.



FIG. 2.2 Facades are expression of the classical principles in architecture: construction, fuction and aesthetics. (image: U. Pottgiesser)

2.1 International Survey on Facade Education. Improvement of Education and Training

Uta Pottgiesser, University of Antwerp / HS OWL, James Doerfler, Jefferson University, Philadelphia

To gain a more detailed knowledge of the requirements for facade education from the spectrum of professionals involved in facade design, a worldwide online facade survey has been executed within the facade and building construction communities – mainly in North America and Europe with different standards and building traditions.

The survey has been designed in 2016 by the authors as a cooperation of the European Facade Network (efn) and the Facade Tectonics Institute (FTI) in the USA. It is seen as a first action to raise awareness among the stakeholders and to collect more information about the educational needs of academic and professional environments in the field of facade education. The analysis will help to understand and optimize processes in the building and facade sector in the different fields and for different target groups. The survey was composed of 24 questions subdivided into the four fields: general Information, facade design and technology, facade construction and education and training.

The survey was launched in the USA in Fall 2016 via surveymonkey and collected about 100 responses until the end of the year. In 2017 the survey was distributed in Europe through different channels. In July 2017 more than 200 responses were available that are being presented for the first time in this book. The aggregated results will be made available to the networks and to the public and will be further discussed among the stakeholders during the next meetings and conferences to find their way into the educational programs worldwide. First direct impact will be the design of the new facade program at the Thomas Jefferson University in Philadelphia, USA, being the first facade program in North America.

It can generally be said that the majority of questions was answered by more than 200 participants, the rate of skipped answers is very low with an average of 2-10 participants that were not or not correctly answering the questions. The highest rate on unanswered questions we find at questions Q12 followed by Q13 asking for the future personnel needs expressed in estimated numbers and likelihood.

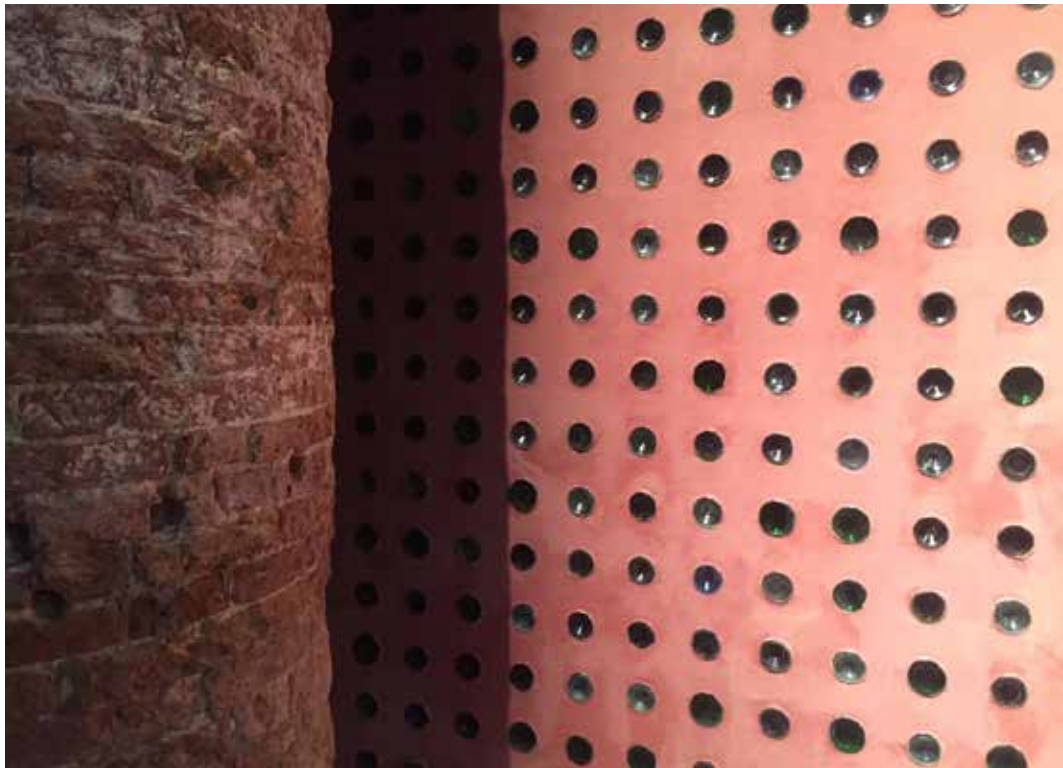


FIG. 2.3 At the Venice Architecture Biennale 2016 the curator Alejandro Aravena put into focus vernacular principles and techniques in architecture to remind scholars and practitioners “that the advancement of architecture is not a goal in itself but a way to improve people’s quality of life”. A concern that should be also crucial for facade design and technology. (image: U Pottgiesser)

Participants of the World Wide Online Survey

The first field of general information was aiming to classify the participants of the survey according to their age (Q1), experience (Q2) and gender (Q3). It also collected information about their main field of occupation or the company’s focus (Q4), the organisation’s size (Q5), the specific position in the organisation (Q6) and current work experience in that position (Q7) and the country of origin (Q8).

Looking at Q1-3, we can consider that the majority of the participants is aged from 36-65 (67%), has a master degree (61%) and is male (79%). It is significant to mention that only four participants (2%) went through a professional formation (apprenticeship) and that in total 98% have an academic background. The professional background in Q4 shows mainly architects (30%) followed by facade consultants (16%), facade manufacturers (15%), engineers and metal manufacturers (each 8.5%). In total the professional field is dominating with 86.5%, educational field is represented with 11% and associations with 2.5%.

Interesting is to look at the size of the participant’s enterprises in Q5. The majority are SME (41%), followed by huge enterprises (23%) and large enterprises (20%). There is also a significant number of micro enterprises with less than 10 employees (17%). In line with the age and degree structure it is evident that most of the participants are in higher and responsible positions (38%) or even in management positions (29%). 26% are normal team members and less than 8% are students or interns.

Q7 shows that there is disparity between the age and position structure and the time being in the current position: nearly 57% of the participants are working in their positions for less than 9 years, app. 24% are active between 10-19 years and only 19% work in the field for more than 20 years. This may indicate that there has been an increase of work in the field of facades in the last 10 years, but it may also indicate the distribution of different positions within the companies and institutions, investigated in Q6. The majority of participants (38%) works in a responsible position as project leader or in the academic field, 28% of the participants are in leading management positions and 26% act as professionals and team members; less than 8% are students, interns or apprentices.

The survey was first distributed in the USA, though among an international target group. At that time Q8 was not included in the survey and only added for the second distribution round in Europe and the USA again in 2017. This explains why there are only 103 answers available. Surprisingly the second distribution round through in Europe and the USA shows a dominant participation from the USA with 57%, followed by Germany (13%), Greece (6%), Spain and Italy (4%), Canada (3%) and the UK (2%). Further participating countries are Australia, Colombia, Costa Rica, Denmark, Dominican Republic, India, Ireland, Mexico, Netherlands, Slovakia, Switzerland and UAE each with 1%.

Educational Needs of the Labour Market (Questions 9-13)

The second field addresses the educational needs of the building and facade sector related to specific study and training programs (Q9) and the course formats (Q10). Q11 personally addresses the participants if they were interested in pursuing a master program and Q12 and Q13 asked for the estimated need for master graduates in their companies and organisations in the next year (Q12) and over the next five years (Q13). The answers of Q9 show significantly that the market looks for graduates with master degrees in facade design and technology (76%) but even more for specific staff trainings and courses (90%). Q10 indicates a trend for short- and part-time offers rather than full-time programs, which may indicate that it is important to keep the staff members involved in the business during their further education. This will be further evaluated and published in upcoming papers.

Q11 (pursuing a master program) shows extreme (yes-no) answers that are further evaluated in more depth related to the participants background. Crossing Q11 with Q4 we will see which employment field is tending to pursue a specific master program in facade design and technology. Metal and facade construction companies and facade consultants rank first with 47% and 44% to pursue a specific facade program, followed by engineers, facade manufacturers and architects with app. 36% each. Other construction companies it as important (50%) but are only represented with 1% among the participants. Looking at a connection between the company size and the specific staff requirements, it was our hypothesis that larger enterprises have a higher interest in a degree in facade design and technology. Crossing Q5 with Q11 we can confirm that 91% of the employees of huge enterprises (more than 1.000 employees), and 81% of those from large enterprises (more than 500 employees) find it very likely to pursue a facade program. Surprisingly also 85% of the employees from small enterprises (10-49 employees) consider this as very likely.



FIG. 2.4 The Media TIC-Building by architect Enric Ruiz Geli from Cloud 9 in Barcelona is not only expression of digital architecture and CAD-CAM fabrication processes but of the changing needs of the labour market. (image: U. Pottgiesser)

We can see in Q13 that in the near future of five years more staff with graduate degrees in Facade Design and Technology (M.S Architecture, FDT), in Architecture (M.S. Architecture, not specified) and in Engineering will be needed. Approximately 80% of the participants consider this as likely or even very likely in all three fields. The highest urgent demand (49%) is identified for degrees in Engineering, followed by Architecture (44%) and then Facade Design and Technology (39%). Crossing Q7 with Q13 and looking at a connection between the years of experiences and the specific staff requirements in the companies, it could be seen that a degree in engineering and also a not specified degree in architecture were generally higher ranked to be very likely than a specific degree in facade design and technology.

This will be content of further evaluations and investigation in the near future. We will also need to prove the hypothesis that there are significant differences between the countries depending on the educational traditions and the marketshares of facade consultants and manufacturers. In our case can only refer to the USA and Germany as only countries with a significant number of participants. We also would like to distinguish if certain professions have a higher tendency to employ staff with graduate degree in facade design and technology or architecture. Here, it has to be taken into consideration that the architecture profession by itself already demands a master degree in nearly all countries worldwide and that this might reduce the need for another master program after the architecture degree. This means that we will take a closer look into the professional field that is less facade specific to see if there is a higher demand for a graduate degree in facade design and technology and if this could be seen as a general sign for a higher market demand in this field.

Specifications for Facade Design and Technology Professions (Questions 14-20)

In this third part of the survey we were asking for specific knowledge and competences that are used in the current staff and those that need to be acquired from existing or future staff. Q14 refers to aspects in Facade Design and Technology, Q15 asks for the information sources in the field. With Q16 and Q17 we want to know about the character of the participant and their attitude related to well-being and the user. Q18 wants to explore knowledge related to facade performance, Q19 the working methods and Q20 the importance of the daily work.

In Q14 the importance of certain aspects in the field that were distributed randomly in the questionnaire is evaluated. But in fact the 10 aspects can be categorized in three major groups:

- **Design:** visual design/appearance, corporate design/public impact, high quality and branded products
- **Technology:** innovative/new materials, sun control, wheather resistance/durability, commissioning/maintenance
- **Sustainability:** natural ventilation, sustainable materials, energy modelling/performance.



FIG. 2.5 The sequential wooden roof construction of the Arch_Tec_Lab building at ETH Zürich demonstrates the work of the hosted ITA-Institute: all design, dimensioning and fabrication processes were done consequently digitally and the assembly in 2016 was done by a roboter. (image: U. Pottgiesser)

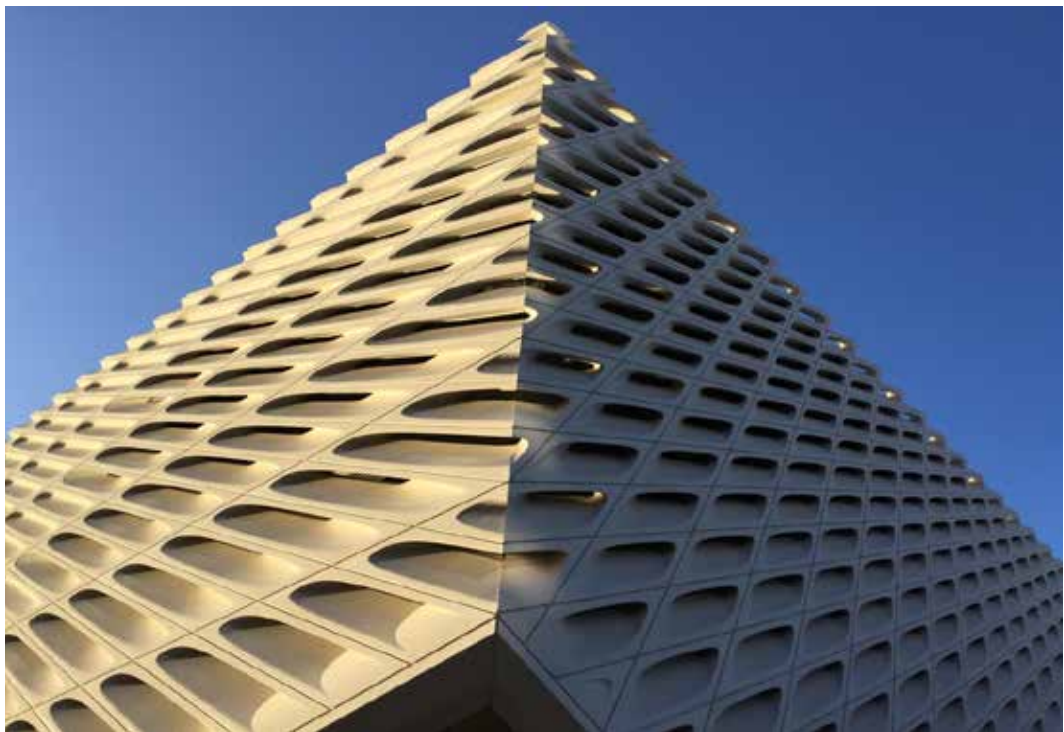


FIG. 2.6 The new contemporary art museum The Broad in Los Angeles by the architects Diller Scofidio + Renfro was finished in 2016: the innovative airy, honeycomb-like structure covers the interior gallery and provides it with provides filtered natural daylight. (image: U. Pottgiesser)

We see from the survey that aspects of technology and sustainability are much more the focus; lead by weather resistance / durability (70.5%) and energy modelling / performance (61%) and followed by effective sun control and innovative / new materials (53% each). The single aspects are displayed in individual diagrams for a better overview in the following pages. If we compare these aspects (Q14) with the position of the participants in the companies (Q4), it becomes evident that weather durability is highest ranked in the management and sustainable and innovative materials among the younger staff.

The answers of Q15 clarify that facade companies and fabricators are seen as perceived having the highest level of competence and the first source of information, 58% of the participants agreed on this. Of course this is dependent on the participants position in the field and a closer look shows that architects have lower preference of 47% than associations, engineers, consultants, facade and metal manufacturers who generally refer to a high level of 54-88% to facade companies and fabricators.

With the Q18-20 we wanted to get a more detailed picture of the daily routines and activities in the field of facade professionals and asked for knowledge, working methods and areas of work with a specific focus on content, methods and time. Just looking at Q18 the following knowledge is of huge importance for: fabricator / installers qualification (87%), national standards, guidelines and codes (86%) and simulation tools (85%). When looking at the field of occupational field, it becomes clear that there are differences between the professions, mainly to mention that architects together with engineers and associations consider Building Information Modelling (BIM) with 41% for an important knowledge while facade consultants and manufacturer rank it significantly lower with 19% and 17%.

Looking at working methods in Q19 it is significant that bilateral communication and teamwork within the company and with external partners is crucial in the facade business with an overall importance from 85-92%. Also important is the area of individual concentrated work and the combination of different digital tools with 73-75%. When looking at the field of occupation, it becomes clear that there are differences between the professions, mainly to mention that architects and engineers consider teamwork within the company to a lower degree (58%) for the most important. Facade consultants and manufacturers rank this as very important with 72-82% in their daily work. On the other side architects consider Building Information Modelling (BIM) as very important in their daily work (45%).

With asking in Q20 about the areas of daily work we wanted to get an understanding about the time spent with certain facade and project related activities. In general we find a relatively broad distribution of the answers, only the area of national standards, guidelines and codes (81%) stands out, followed by international standards, guidelines and codes (69%), costs and cost estimating and scheduling (65%).

In order to understand our participants from the facade community better, we created Q16 and Q17 asking for their character and attitude related to well-being and the user because we expected that this may show certain preferences and differences related to practical and educational work. The participants consider themselves in the majority as progressive (44%) followed by pragmatic (26%) and functional (22%); the categories refined only was chosen from 5%, classic and rustic only from 1.4% each. We liked to see if there is a correlation with a general attitude and the specific expected knowledge and if the characteristic is depending on the professional background. Significant is that participants who considered themselves as functional were those who consider with 37% a very huge impact on well-being; progressive and pragmatic personalities rate this impact only with 19% as very huge; a huge impact is seen to a quite similar share of 53-58% in those groups.



FIG. 2.7 Since 2000 the Institute for Advanced Architecture of Catalonia (IAAC) in Barcelona offers specialized master program in advanced architecture which is collaborating with the Barcelona FabLab as a huge workshop. (image: U. Pottgiesser)



FIG. 2.8 Merge installation in Philadelphia showing architecture students and glaziers in the workshop pre- installing the components of a multidisciplinary project. (image: J. Doerfler)

Demands on Education and Training (Questions 21-24)

In the last sequence of questions we were directly asking for the concrete academic requirements of education for architects and engineers (Q21) and for construction workers and installers (Q22). Q23 and Q24 are looking at the target groups of authorities and institutions and in Q24 to the qualities for somebody graduating from a facade program.

First the education fields were evaluated individually and show very clear preferences. In Q21 71% of the participants demand for an increased awareness of details and constructability, 58% the ability to work in teams, 48% an increase of competence in technology and 41% consider a sustainable construction knowledge as very important. In Q22 59% of the participants demand for more ability to work in teams 56.5% for an increase of practical training and 46% for an increase of competence in technology and 35% consider communication competences and competency based qualifications as very important. Both questions were compared with specific views of professions and company's sizes.

Depending on the occupation we can see some differences between the professions: the ability to work in teams is considered as very important above the average of 58% from facade manufactures (67%), architects (63%), and associations (60%).

The competence in technology is considered as very important above the average of 48% from other consultants (57%), metal and facade manufactures and engineers (52%) and from architects (51%).

The view on a sustainable construction knowledge varies widely. It is considered as very important above the average of 41% from other consultants with 71%, from associations with 60% and from higher education with 59%. But also the different construction companies and manufacturers rate it with 50% as very important. Facade consultants and the professional education field rate it with 20% as very important, but give a high percentage of 60% in the category of important.

Also the company size has an influence on the estimation of educational demands: Huge, large and larger companies rank the ability to work in teams slightly with 60-67% higher than the average of 58%. Huge and larger companies rank the competence in technology slightly with 52-55% higher than the average of 48%. Again huge and larger companies rank the sustainable construction knowledge with 51% and 43% higher than the average of 41%.

In Q23 we were also interested in the requirements of education for members of public authorities and institutions as important partners of building practitioners. Again the education fields were evaluated individually and show very clear preferences. In Q23 75% and 74% of the participants expect technical knowledge and construction and assembly knowledge followed by material knowledge (64%) and the ability to work in a team.

In Q24 we finally liked to compare the results of earlier questions related to the qualities and competencies for somebody graduating from a facade program. The individual education fields show very clear preferences. In Q24 45.5% of the participants demand for an increased sustainable construction knowledge, 41% for more communication competences and 37% an increase of competence in technology.



FIG. 2.9 Robots are part of the fabrication facilities in the Department of architecture at MIT. (image: J. Doerfler)



FIG. 2.10 Merge installation in Philadelphia showing architecture students and glaziers on site assembling the components of a multidisciplinary project. (image: J. Doerfler)



FIG. 2.11 The Comcast Building in Philadelphia (2016) shows a high degree of prefabrication with unitized facade elements that allow for a faster assembly but also need an efficient logistic and in time delivery. (image: U. Pottgiesser)

Conclusion and Outlook

With more than 200 participants from 19 countries this survey can validate our impressions gained in the past with our educational programs and in discussions with practitioners.

Facade companies and fabricators are seen as the primary resource for information about facades (Q15 58%) and we see a need to clarify the role of facade consultants in this field. It is also important to study the biographic dynamics and professional carriers in the facade sector that has not seem to have clear roots in the certain professions but so far individual pathways. Interesting in the transcontinental perspective will be the comparison of academic and professional education as a basis for high-quality facade design and construction.

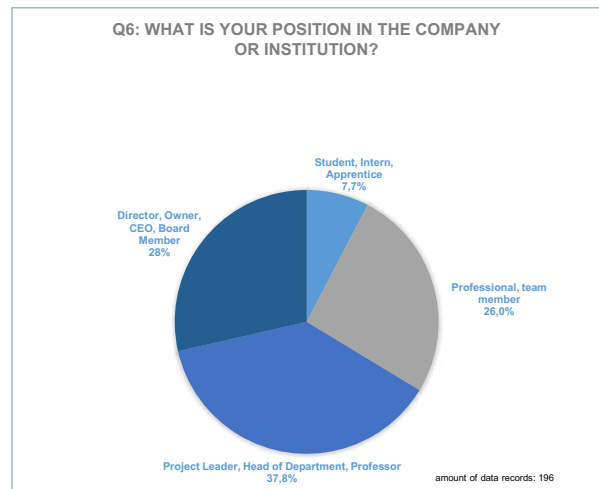
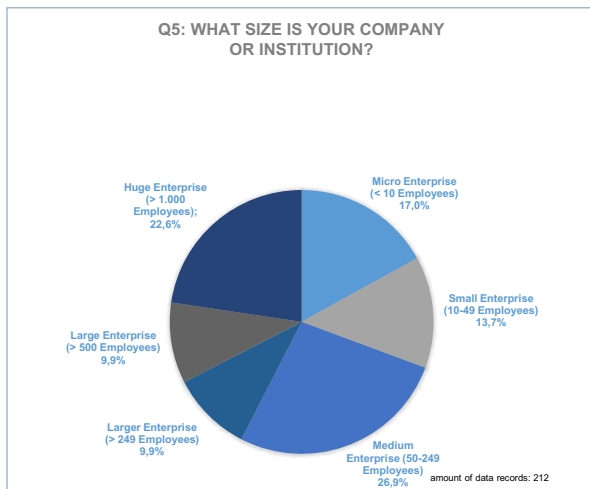
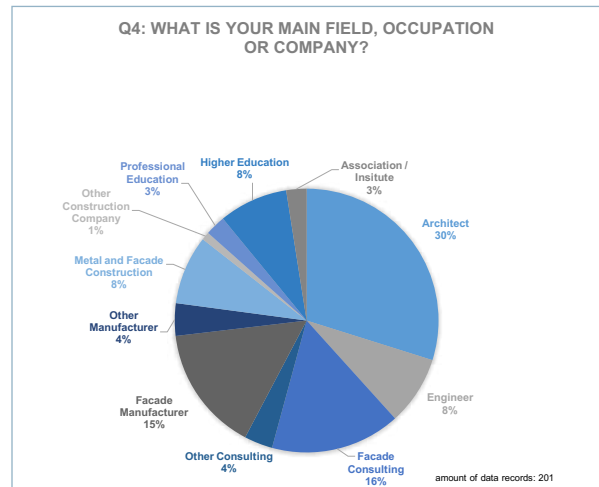
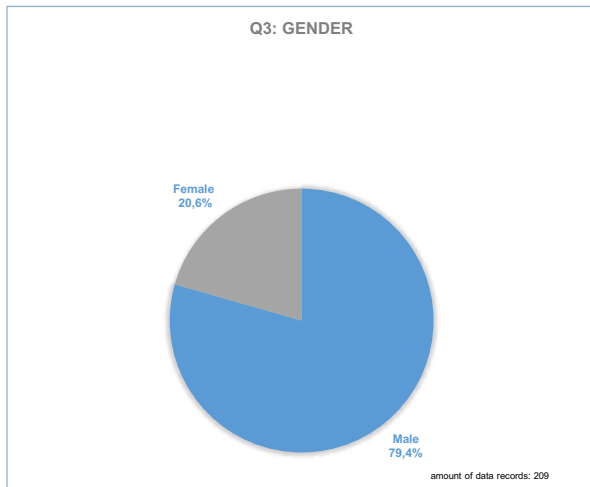
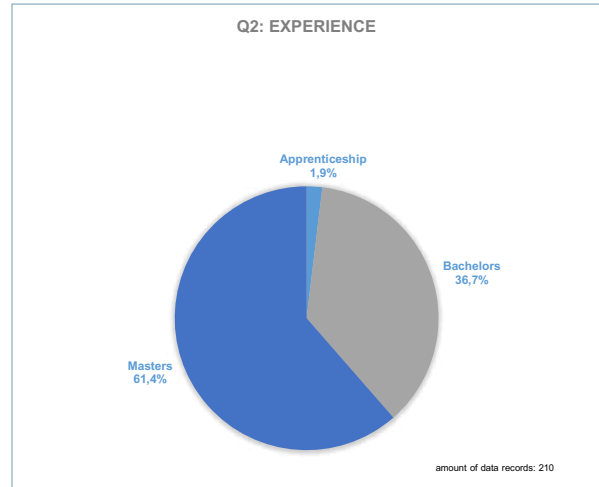
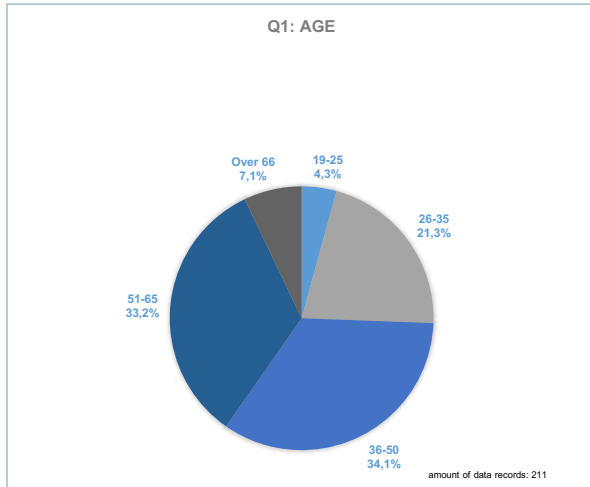
Teamwork is an important trait for the facade designer and manufacturer. The answers to Q19 with 62% saying that teamwork within the company was very important and 50% teamwork with external partners was very important. We also see that Q21 shows us that the ability to work in teams was very important for 58% of the respondents and Q22 with 59% and Q24 also has a 62% very important response for the ability to work in teams. Due to the complexity of facade design and the need to communicate outside your discipline to other members of the design team, it would be important for a facade design education program to include multidisciplinary teamwork as an experience and learning outcome for the program.

Coming from the survey, another important learning outcome for a facade program is the inclusion of simulation tools (Q18 41%) and increase of competency in technology (Q21 48%, Q22 46%, Q23 38%). The introduction and initial use of these tools would also be a desired learning outcome for a facade design program. Across the spectrum of the design team there is a need to understand a high level of technology for energy, daylight control, ventilation and other aspects of performance. This is effectively done using digital tools to simulate the conditions and make design decisions. The facade programs must work closely with the facade industry and be informed by typical facade design disciplines, such as engineers, architects, material scientists, etc. how the modeling tools are used in the professional world. It is important to keep the facade programs connected to real-world consultants to be up to date on the latest tools.

After this first evaluation of the survey's result we do see the need of further investigate certain aspects in more detail and with a specific focus to countries and disciplines. This will be done in the near future and be presented in upcoming conferences and articles within the existing facade networks and in follow-up surveys.

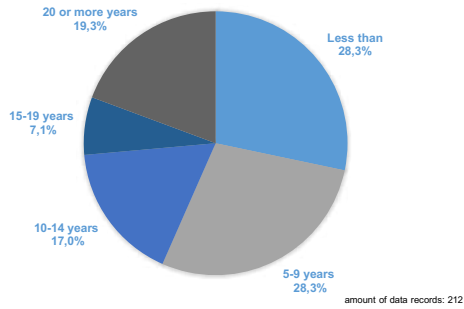
We would like to thank the participants in this survey for taking the time to give us useful information for improving the existing programs and for developing effective new facade programs for the industry, consultancy and design sector. It is important to get feedback from the future employers across the many industries and professions that make today's complex building envelope systems. It is a relatively new discipline in the built environment that is still evolving and growing into an influential discipline that will help to shape new and old buildings into the future.

INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

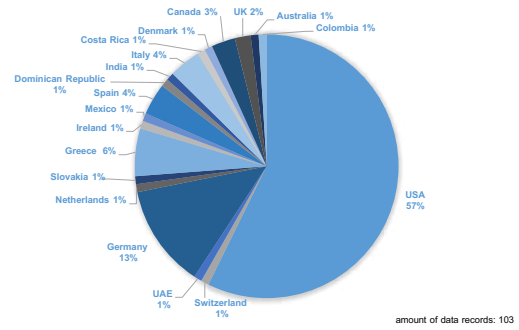


INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

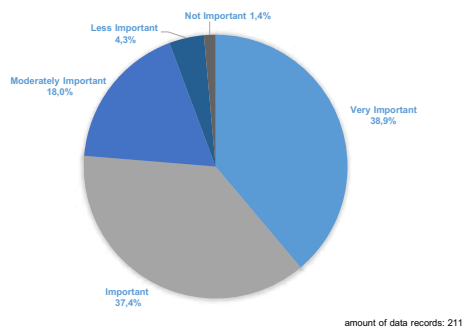
Q7: HOW MANY YEARS HAVE YOU BEEN IN YOUR CURRENT POSITION?



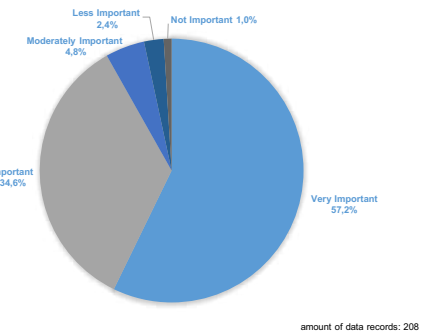
Q8: WHAT COUNTRY ARE YOU FROM?



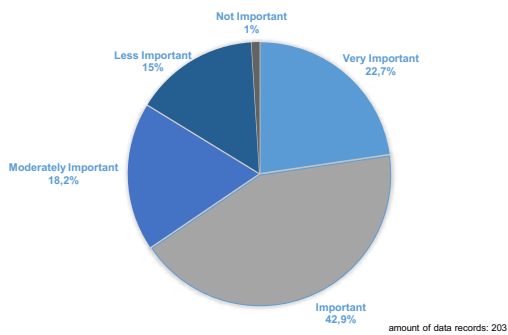
**Q9: WHAT IS YOUR ASSESMENT OF THE NEED IN THE INDUSTRY FOR:
1. A MASTER'S PROGRAM IN FAÇADE DESIGN AND TECHNOLOGY?**



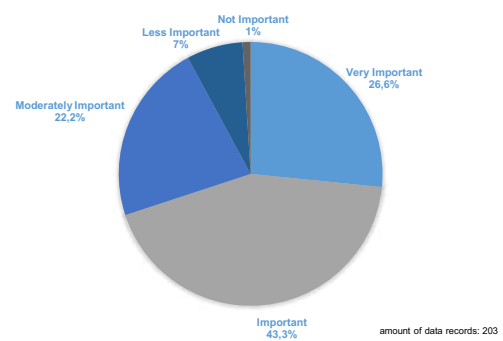
**Q9: WHAT IS YOUR ASSESMENT OF THE NEED IN THE INDUSTRY FOR:
2. SPECIALIZED TRAINING OR COURSES FOR STAFF IN FAÇADE DESIGN AND TECHNOLOGY?**



**Q10: HOW IMPORTANT ARE THE FOLLOWING ASPECTS OF A GRADUATE PROGRAM IN FAÇADE DESIGN AND TECHNOLOGY?
1. FULL TIME PROGRAM FOR STUDENTS (1 YEAR)**

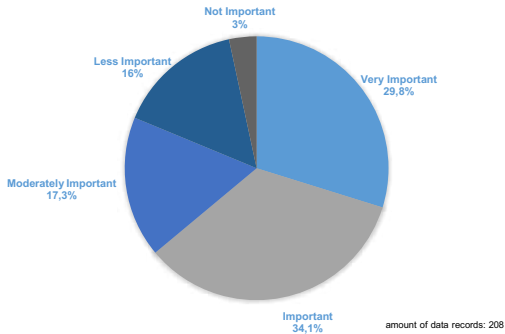


**Q10: HOW IMPORTANT ARE THE FOLLOWING ASPECTS OF A GRADUATE PROGRAM IN FAÇADE DESIGN AND TECHNOLOGY?
2. PART-TIME PROGRAM FOR STUDENTS (2-3 YEARS)**

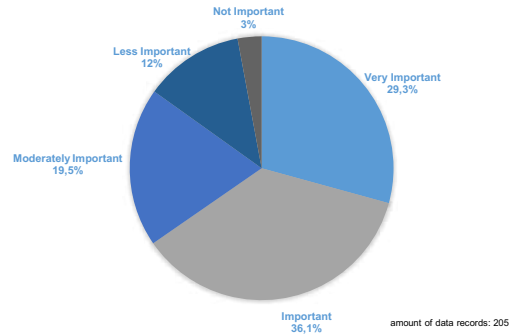


INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

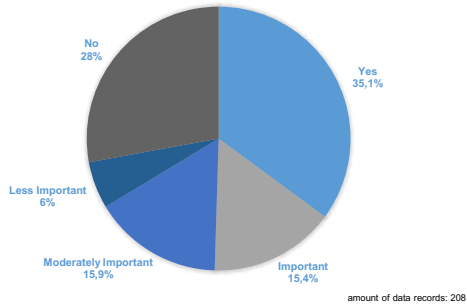
Q10: HOW IMPORTANT ARE THE FOLLOWING ASPECTS OF A GRADUATE PROGRAM IN FAÇADE DESIGN AND TECHNOLOGY?
3. EVENING COURSES



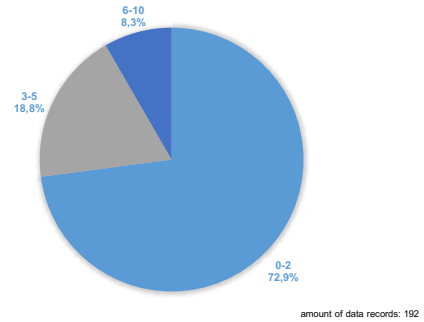
Q10: HOW IMPORTANT ARE THE FOLLOWING ASPECTS OF A GRADUATE PROGRAM IN FAÇADE DESIGN AND TECHNOLOGY?
4. GROUP OF COURSES THAT FORM CERTIFICATE



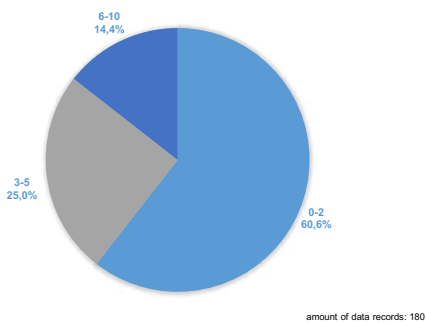
Q11: WOULD YOU CONSIDER PURSUING A MASTER'S DEGREE IN FAÇADE DESIGN AND TECHNOLOGY?



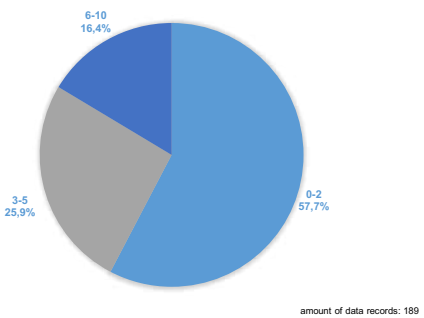
Q12: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE ESTIMATE THE NUMBER OF FAÇADE PROJECT STAFF YOUR FIRM EXPECTS TO HIRE WITH THE FOLLOWING DEGREES IN THE NEXT YEAR:
1. GRADUATE DEGREE IN FAÇADE DESIGN AND TECHNOLOGY (M.S ARCHITECTURE, FDT)



Q12: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE ESTIMATE THE NUMBER OF FAÇADE PROJECT STAFF YOUR FIRM EXPECTS TO HIRE WITH THE FOLLOWING DEGREES IN THE NEXT YEAR:
2. GRADUATE DEGREE IN ARCHITECTURE (M.S ARCHITECTURE, NOT SPECIFIED)

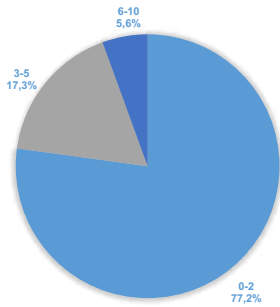


Q12: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE ESTIMATE THE NUMBER OF FAÇADE PROJECT STAFF YOUR FIRM EXPECTS TO HIRE WITH THE FOLLOWING DEGREES IN THE NEXT YEAR:
3. GRADUATE DEGREE IN ENGINEERING



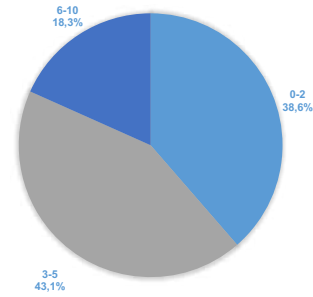
INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

**Q12: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE ESTIMATE THE NUMBER OF FAÇADE PROJECT STAFF YOUR FIRM EXPECTS TO HIRE WITH THE FOLLOWING DEGREES IN THE NEXT YEAR:
4. GRADUATE DEGREE IN BUSINESS (M.B.A)**



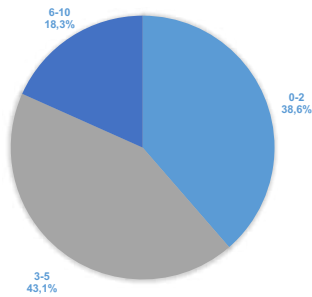
amount of data records: 162

**Q13: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE INDICATE THE LIKELIHOOD THAT YOUR FIRM WILL HIRE STAFF WITH THE FOLLOWING DEGREES OVER THE NEXT FIVE YEARS:
1. GRADUATE DEGREE IN FAÇADE DESIGN AND TECHNOLOGY (M.S ARCHITECTURE, FDT)**



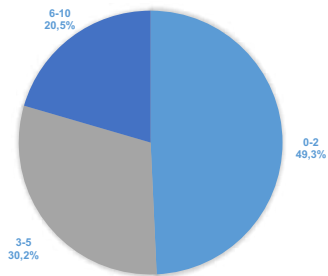
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**Q13: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE INDICATE THE LIKELIHOOD THAT YOUR FIRM WILL HIRE STAFF WITH THE FOLLOWING DEGREES OVER THE NEXT FIVE YEARS:
2. GRADUATE DEGREE IN ARCHITECTURE (M.S ARCHITECTURE, NOT SPECIFIED)**



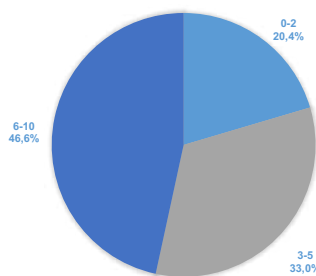
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**Q13: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE INDICATE THE LIKELIHOOD THAT YOUR FIRM WILL HIRE STAFF WITH THE FOLLOWING DEGREES OVER THE NEXT FIVE YEARS:
3. GRADUATE DEGREE IN ENGINEERING**



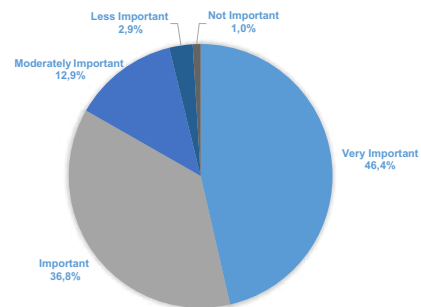
amount of data records: 205

**Q13: THINKING ABOUT YOUR FIRM'S PERSONNEL NEEDS; PLEASE INDICATE THE LIKELIHOOD THAT YOUR FIRM WILL HIRE STAFF WITH THE FOLLOWING DEGREES OVER THE NEXT FIVE YEARS:
4. GRADUATE DEGREE IN BUSINESS (M.B.A)**



amount of data records: 191

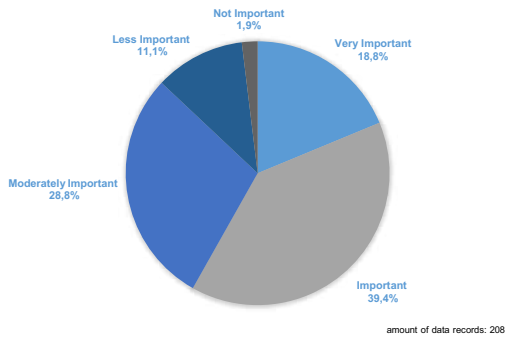
**Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
1. VISUAL DESIGN / APPEARANCE**



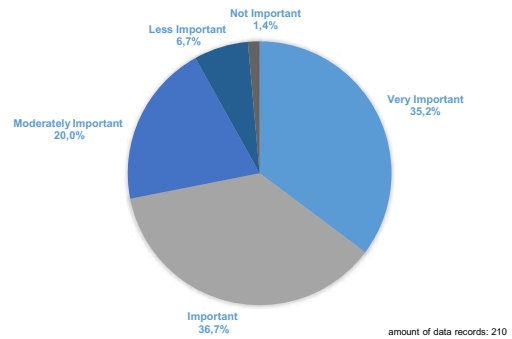
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INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

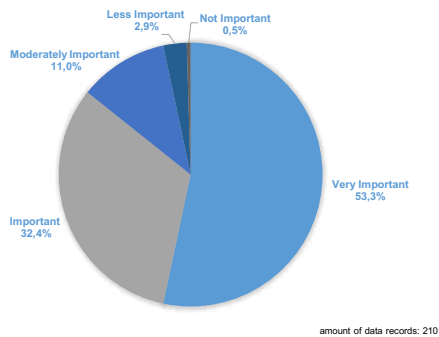
Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
2. CORPORATE DESIGN / PUBLIC IMPACT



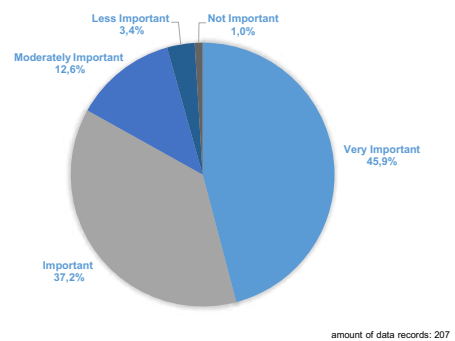
Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
3. NATURAL VENTILATION THROUGH OPENINGS



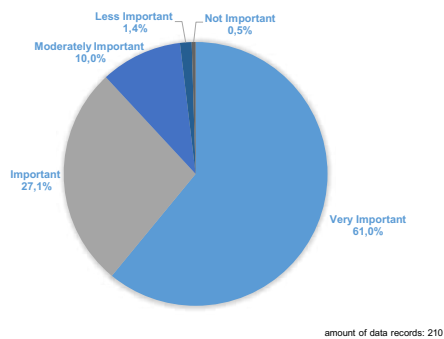
Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
4. EFFECTIVE SUN CONTROL



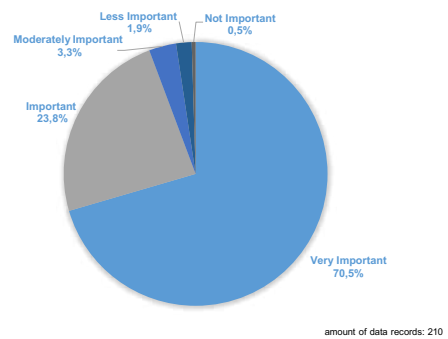
Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
5. SUSTAINABLE MATERIALS

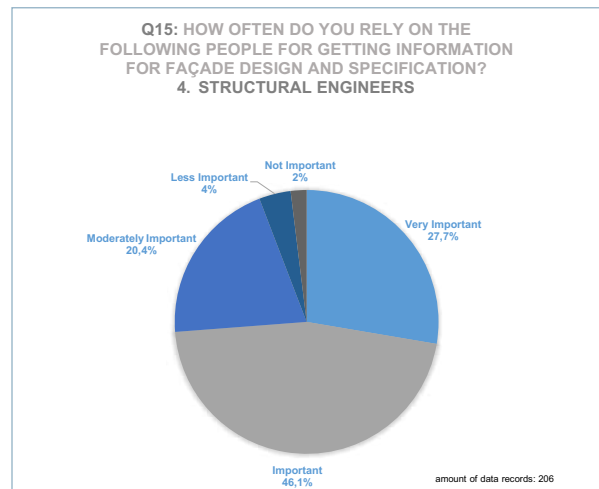
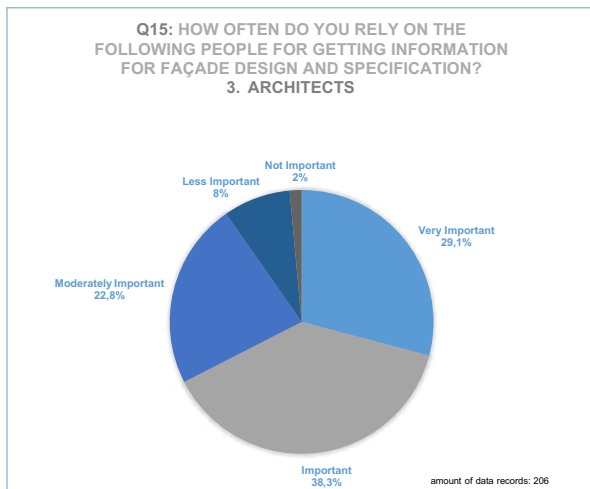
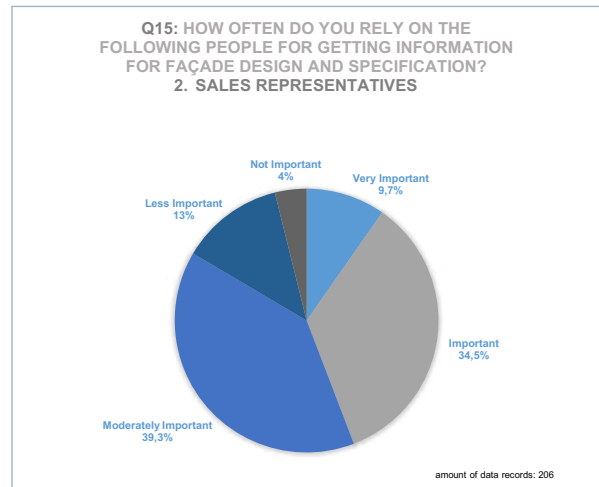
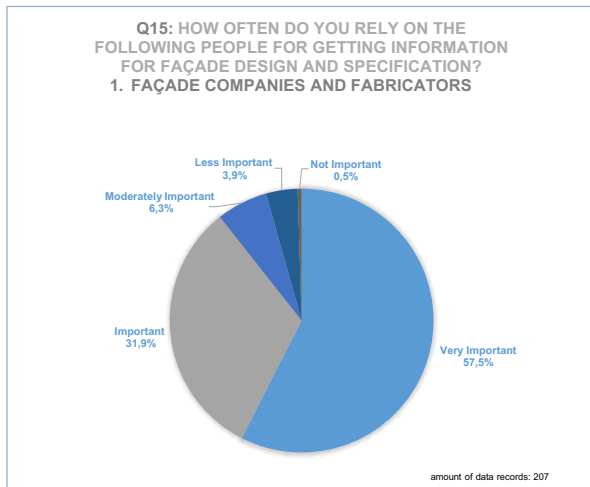
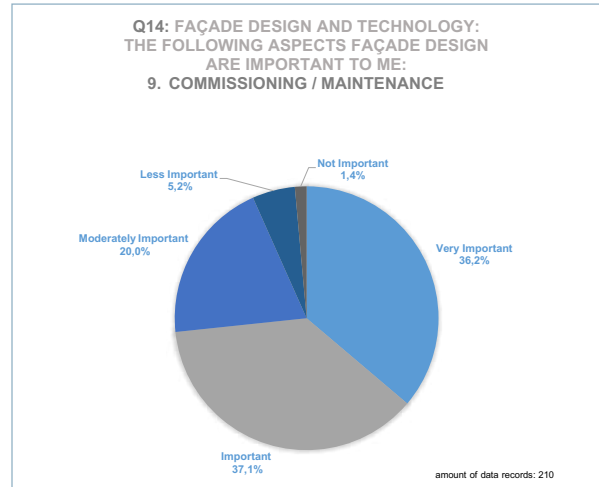
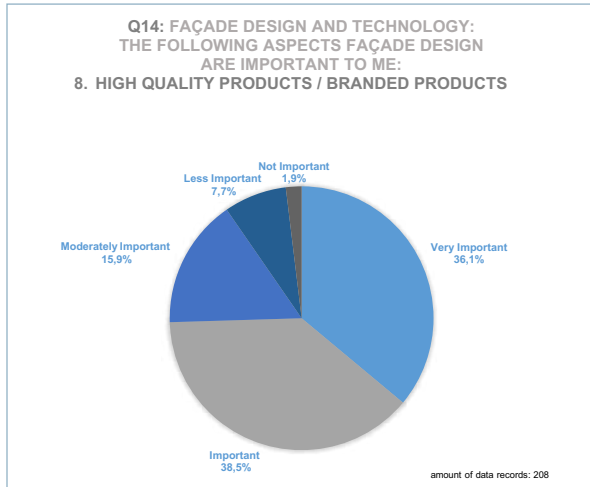


Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
6. ENERGY MODELLING AND PERFORMANCE



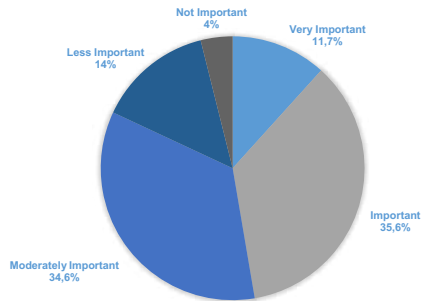
Q14: FAÇADE DESIGN AND TECHNOLOGY: THE FOLLOWING ASPECTS FAÇADE DESIGN ARE IMPORTANT TO ME:
7. WEATHER RESISTANCE / DURABILITY





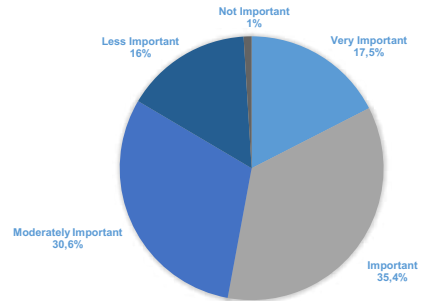
INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

**Q15: HOW OFTEN DO YOU RELY ON THE FOLLOWING PEOPLE FOR GETTING INFORMATION FOR FAÇADE DESIGN AND SPECIFICATION?
5. BUILDING SERVICES ENGINEERS**



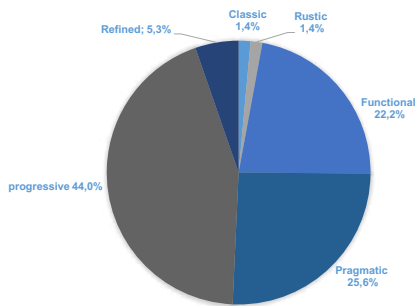
amount of data records: 205

**Q15: HOW OFTEN DO YOU RELY ON THE FOLLOWING PEOPLE FOR GETTING INFORMATION FOR FAÇADE DESIGN AND SPECIFICATION?
6. INDUSTRY ASSOCIATIONS / INSTITUTES**



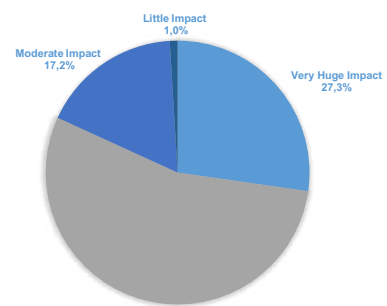
amount of data records: 206

Q16: CHOOSE ONE THAT DESCRIBES YOUR CHARACTER THE BEST.



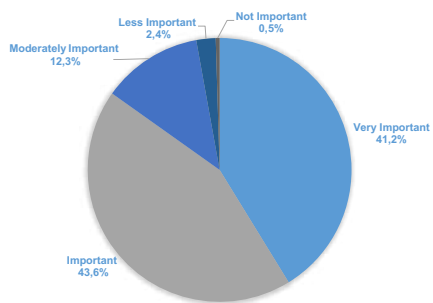
amount of data records: 207

Q17: HOW DO YOU CONSIDER THE IMPACT OF FAÇADE DESIGN ON THE WELL-BEING OF THE USER?



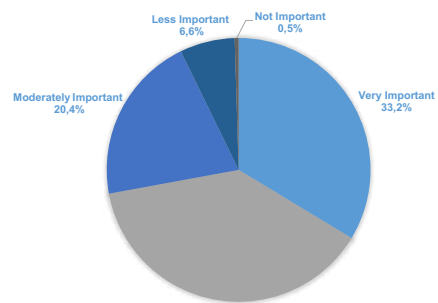
amount of data records: 209

**Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
1. SIMULATION TOOLS**



amount of data records: 211

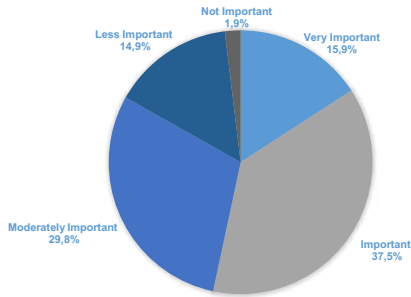
**Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
2. MATERIAL PROCESSING**



amount of data records: 208

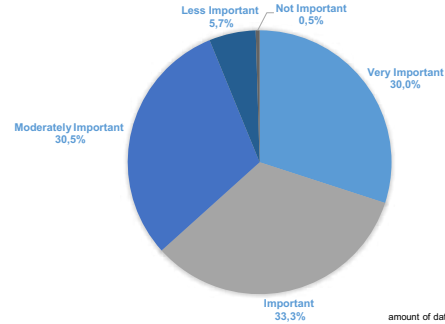
INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
3. QUANTITIES AND TAKE OFFS



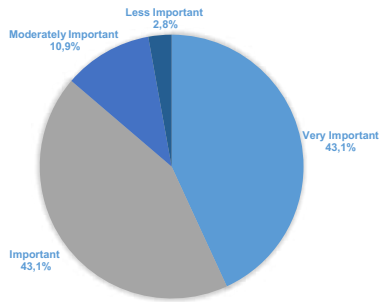
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Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
4. BUILDING INFORMATION MODELLING



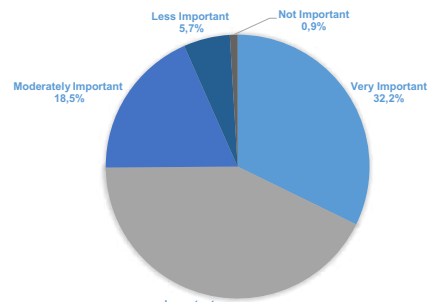
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Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
5. NATIONAL STANDARDS, GUIDELINES AND CODES



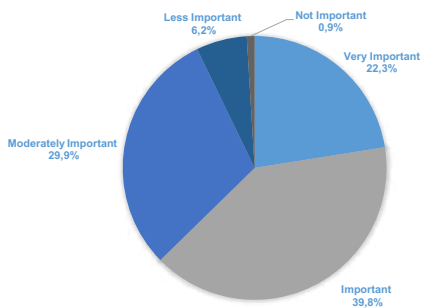
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Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
6. INTERNATIONAL STANDARDS, GUIDELINES AND CODES



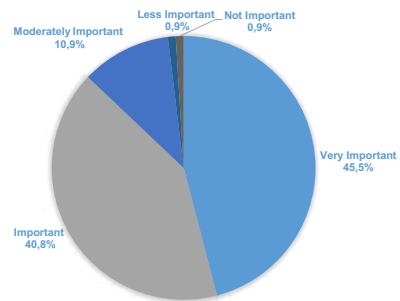
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Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
7. INFORMATION AND AUTOMATION TECHNOLOGIES



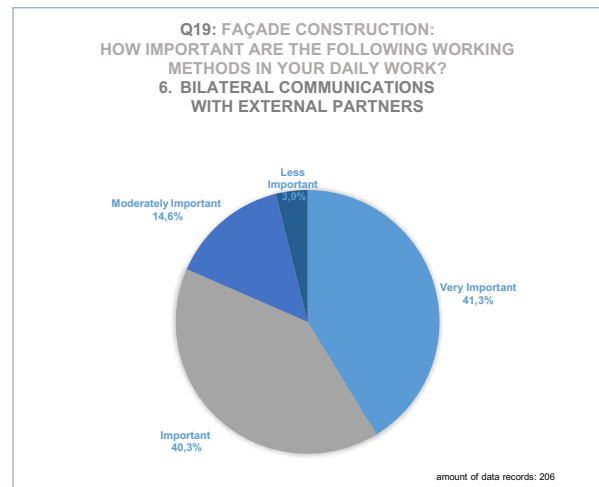
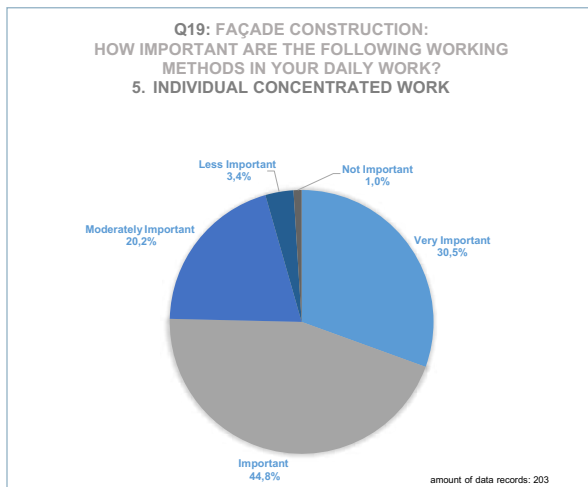
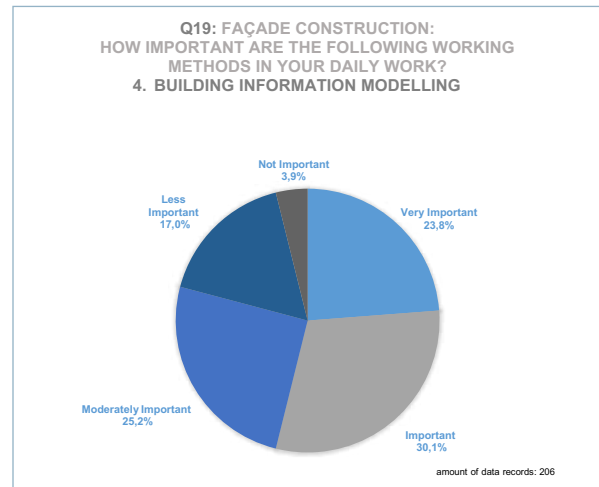
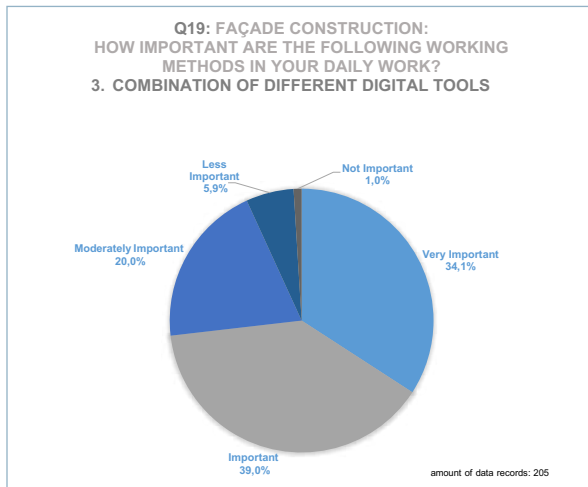
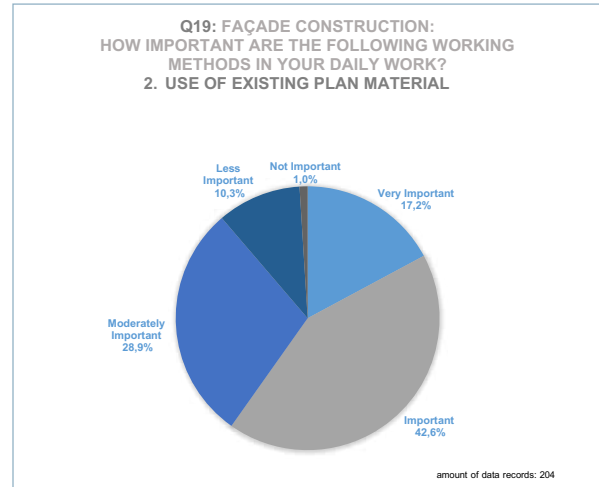
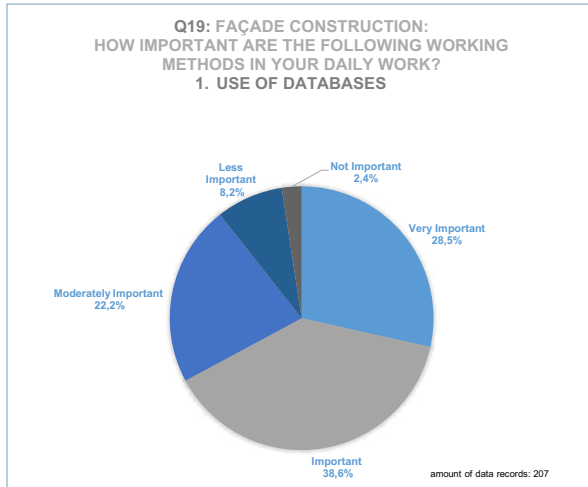
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Q18: HOW IMPORTANT IS THE KNOWLEDGE IN THE FOLLOWING AREAS FOR FAÇADE PERFORMANCE?
8. FABRICATOR / INSTALLER QUALIFICATIONS

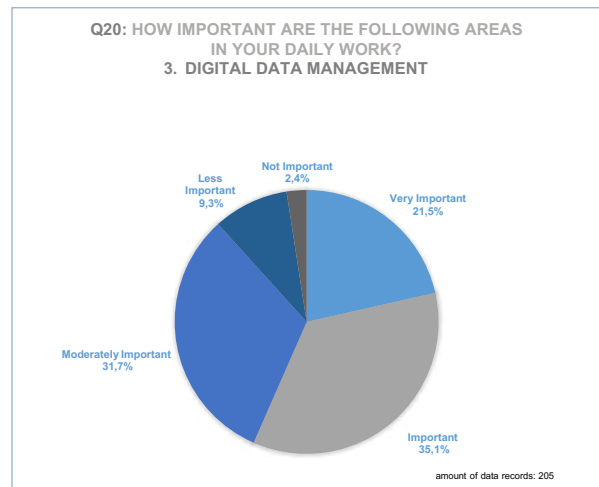
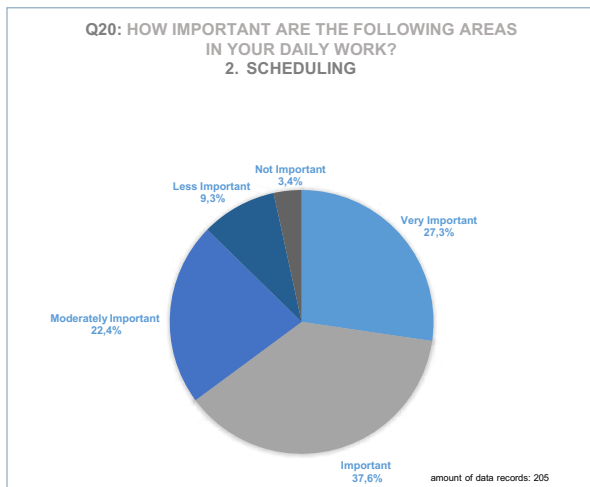
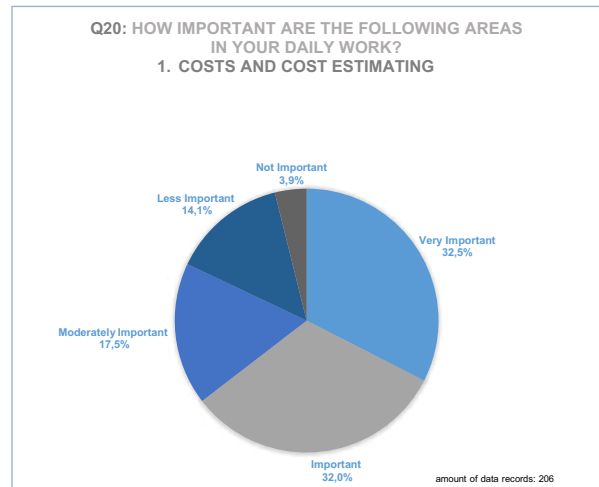
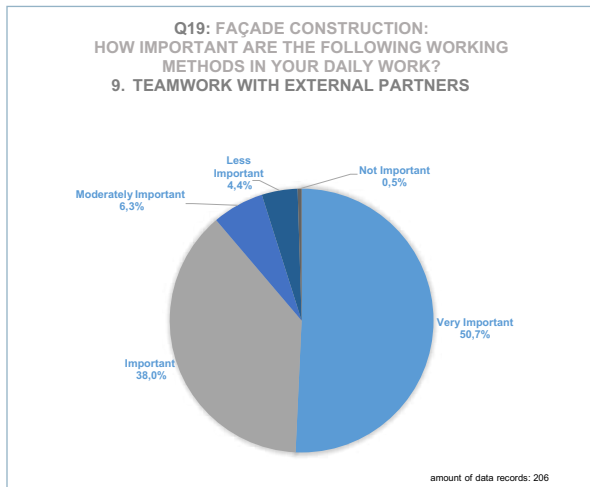
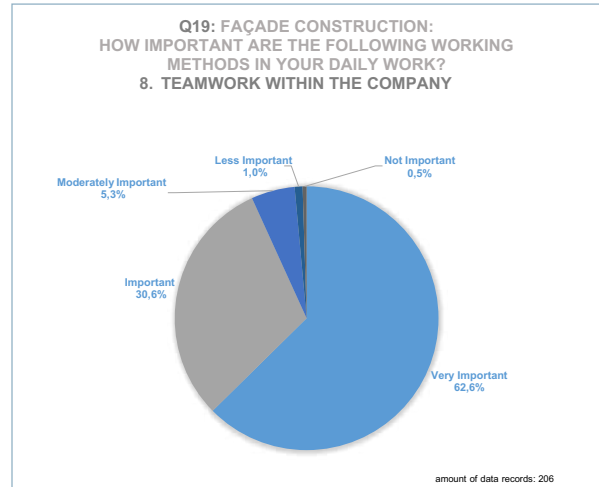
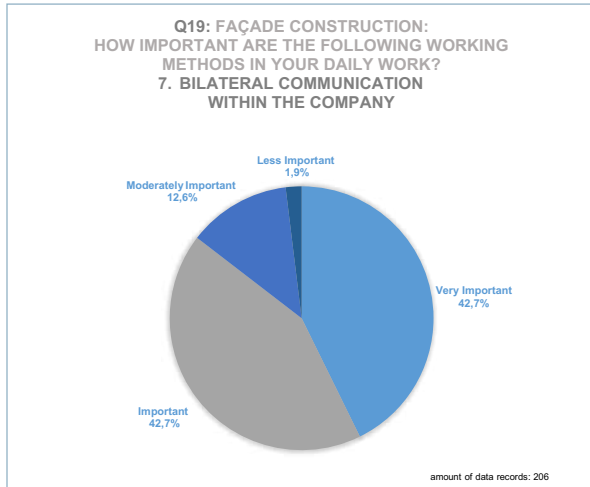


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INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

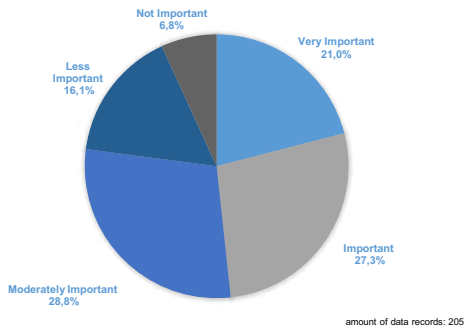


INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

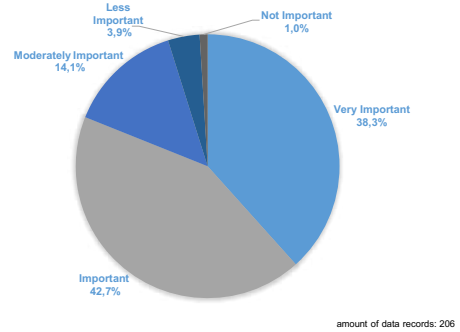


INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

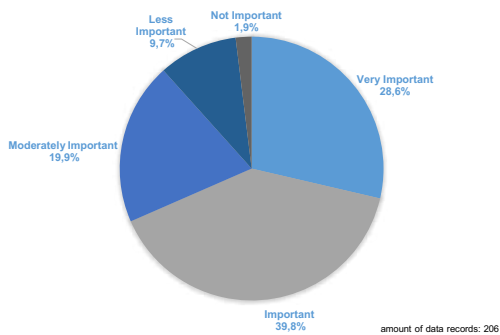
Q20: HOW IMPORTANT ARE THE FOLLOWING AREAS IN YOUR DAILY WORK?
4. BUILDING INFORMATION MODELLING



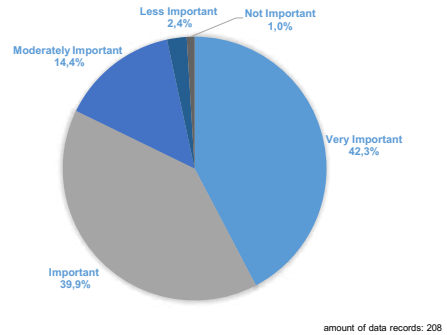
Q20: HOW IMPORTANT ARE THE FOLLOWING AREAS IN YOUR DAILY WORK?
5. NATIONAL STANDARDS, GUIDELINES AND CODES



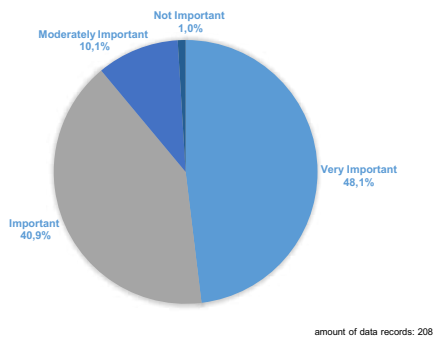
Q20: HOW IMPORTANT ARE THE FOLLOWING AREAS IN YOUR DAILY WORK?
6. INTERNATIONAL STANDARDS, GUIDELINES AND CODES



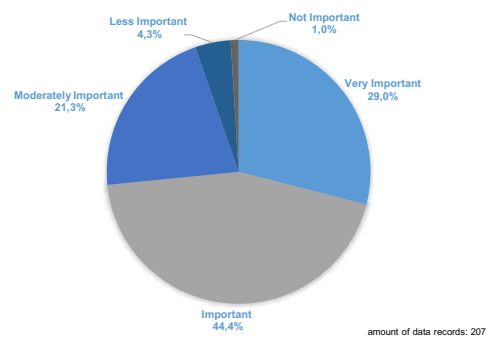
Q21: EDUCATION AND TRAINING: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF ARCHITECTS AND ENGINEERS?
1. NEW RESEARCH AND DEVELOPMENT



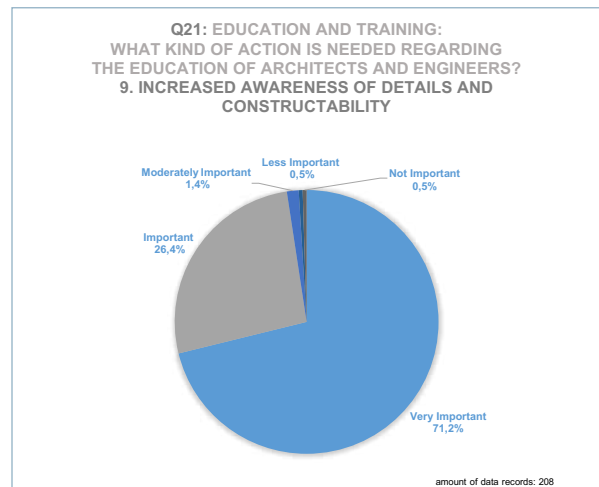
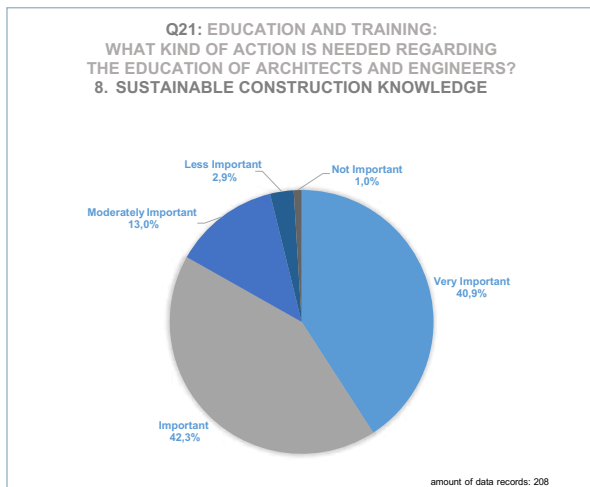
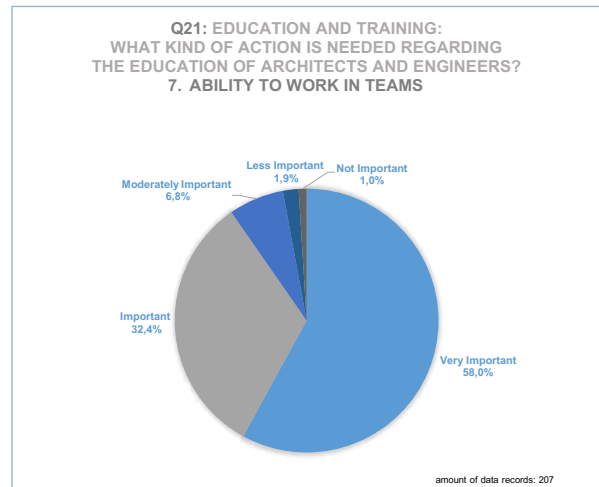
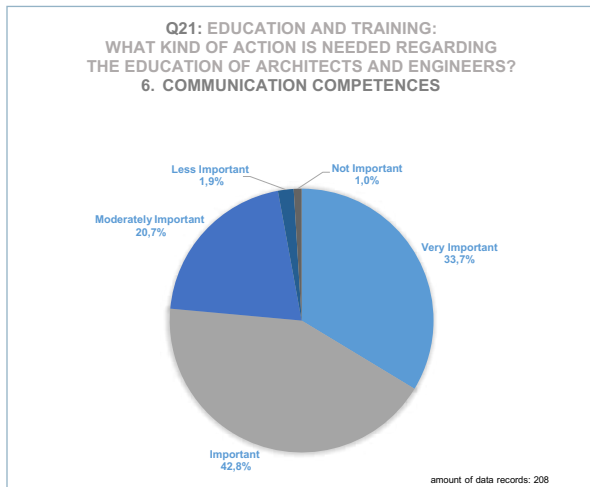
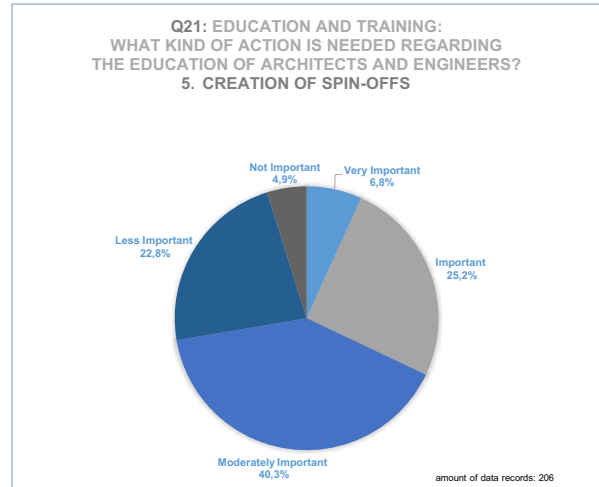
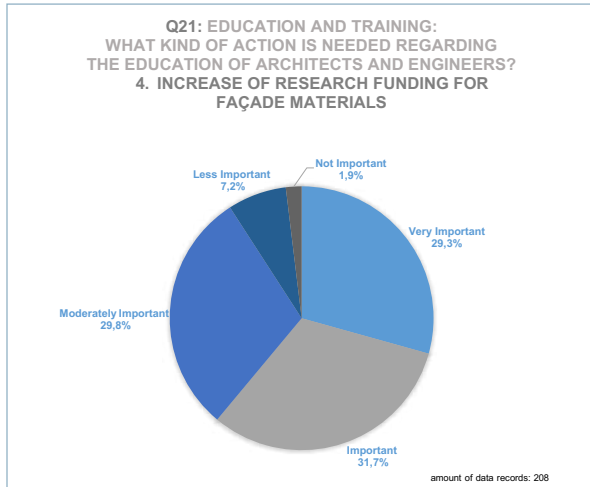
Q21: EDUCATION AND TRAINING: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF ARCHITECTS AND ENGINEERS?
2. INCREASE OF COMPETENCE IN TECHNOLOGY



Q21: EDUCATION AND TRAINING: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF ARCHITECTS AND ENGINEERS?
3. INCREASE OF APPLICATION ORIENTATION

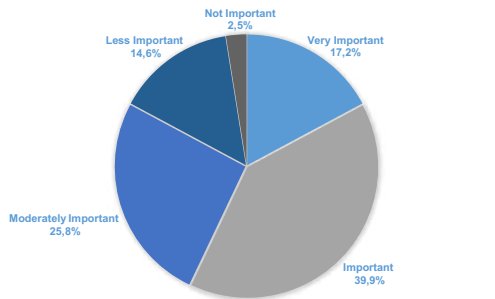


INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES



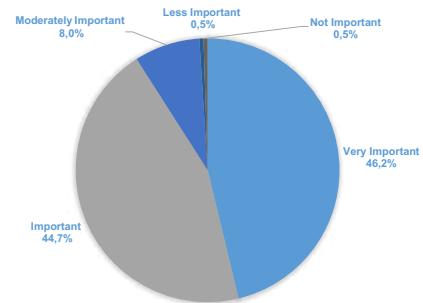
INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES

**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
1. INCREASE OF EMPLOYES**



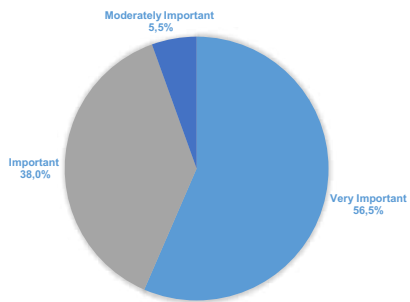
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**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
2. INCREASE OF COMEPETENCE IN TECHNOLOGY**



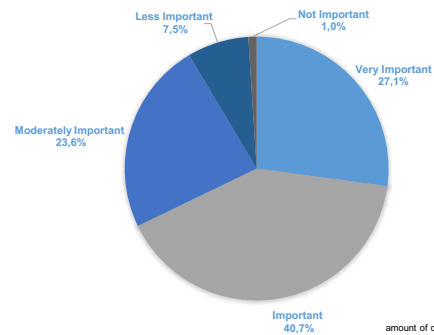
amount of data records: 199

**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
3. INCREASE OF PRACTICAL TRAINING**



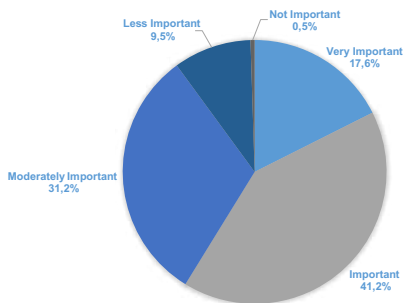
amount of data records: 200

**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
4. INCREASE OF THEORETICAL KNOWLEDGE**



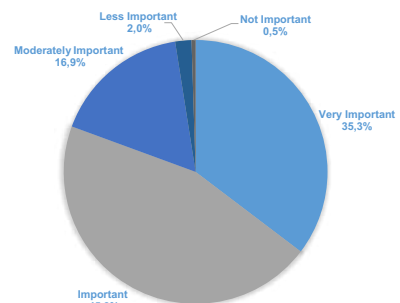
amount of data records: 199

**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
5. INCREASE OF COMPUTATIONAL TRAINING**



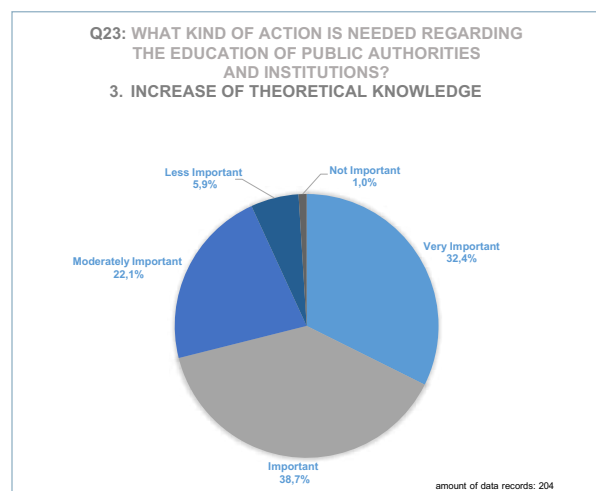
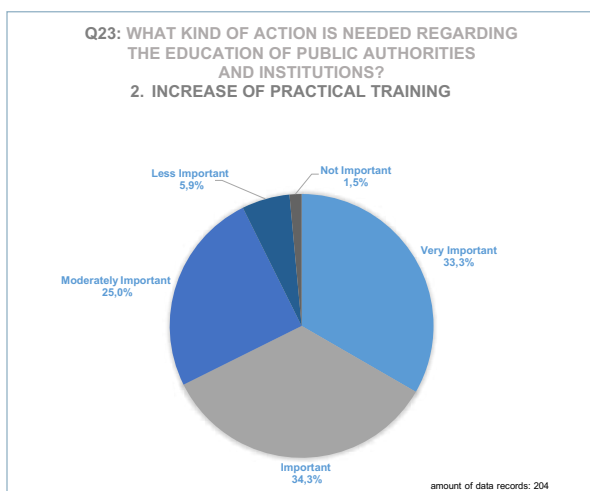
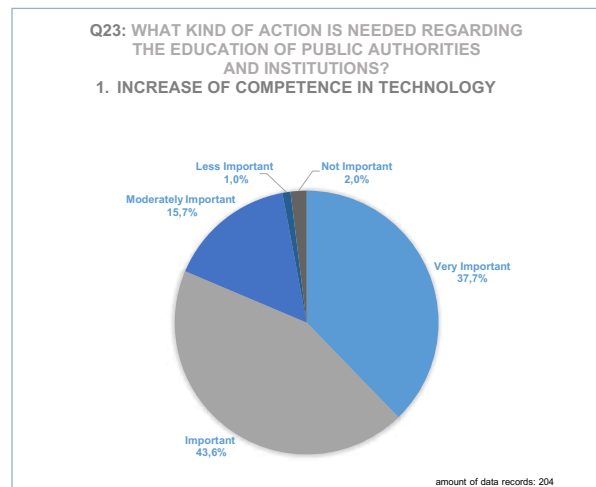
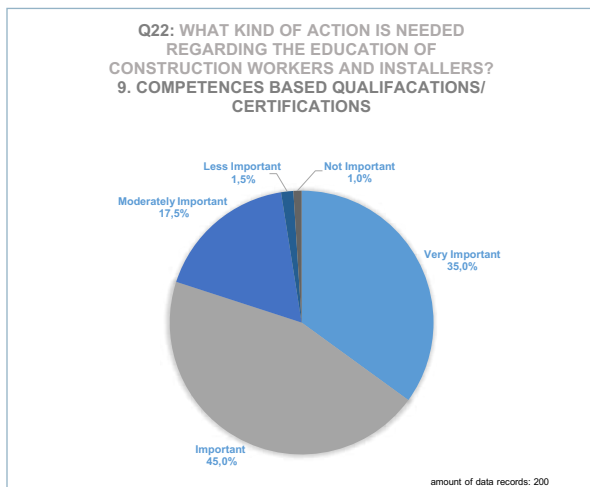
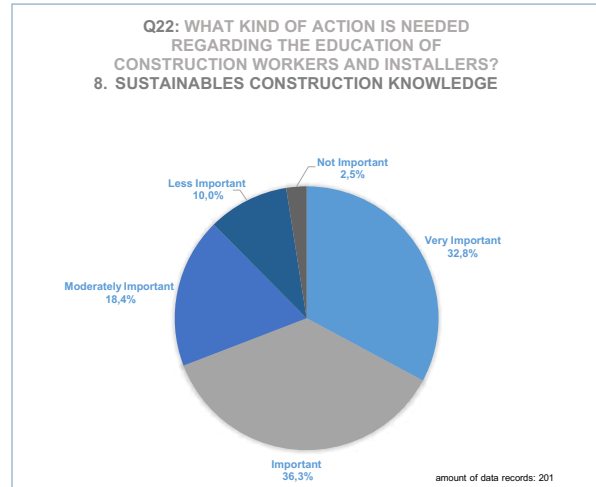
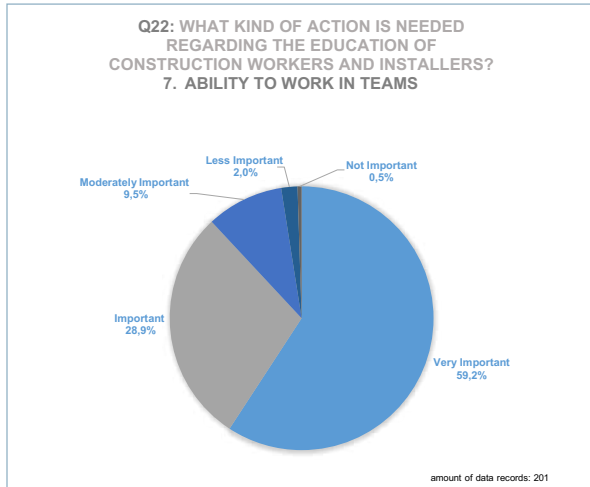
amount of data records: 199

**Q22: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF CONSTRUCTION WORKERS AND INSTALLERS?
6. COMMUNICATION COMPETENCES**



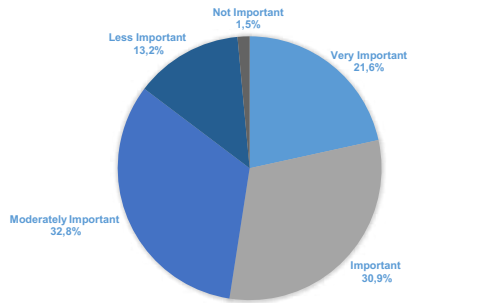
amount of data records: 201

INTERNATIONAL SURVEY ON FACADE EDUCATION – FACTS & FIGURES



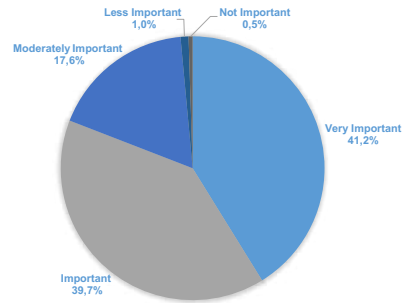
INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

Q23: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF PUBLIC AUTHORITIES AND INSTITUTIONS?
4. INCREASE OF COMPUTATIONAL TRAINING



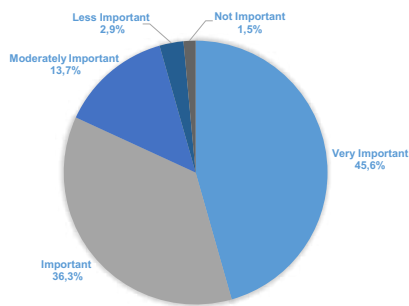
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Q23: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF PUBLIC AUTHORITIES AND INSTITUTIONS?
5. COMMUNICATION COMPETENCES



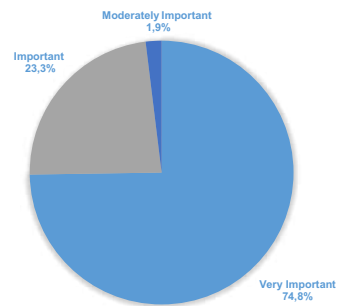
amount of data records: 204

Q23: WHAT KIND OF ACTION IS NEEDED REGARDING THE EDUCATION OF PUBLIC AUTHORITIES AND INSTITUTIONS?
6. SUSTAINABLE CONSTRUCTION KNOWLEDGE



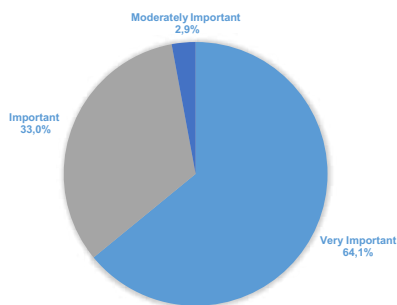
amount of data records: 204

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
1. TECHNICAL KNOWLEDGE



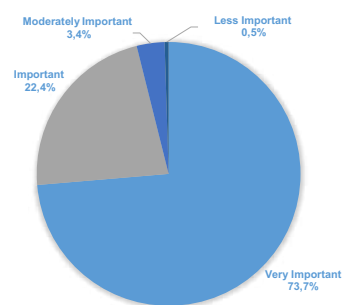
amount of data records: 206

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
2. MATERIAL KNOWLEDGE



amount of data records: 206

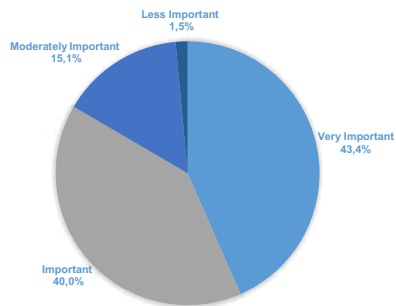
Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
3. CONSTRUCTION AND ASSEMBLY KNOWLEDGE



amount of data records: 205

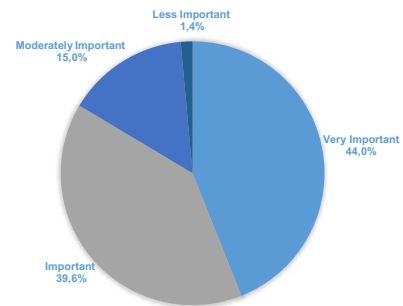
INTERNATIONAL SURVEY ON FAÇADE EDUCATION – FACTS & FIGURES

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
4. COMMUNICATION COMPETENCES



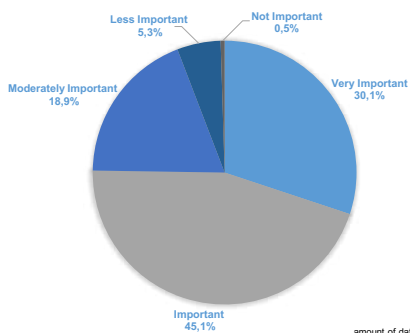
amount of data records: 205

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
5. DRAWING AND VISUALISATION SKILLS



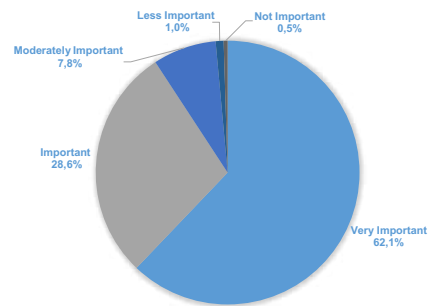
amount of data records: 207

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
6. PRESENTATION TECHNIQUES



amount of data records: 206

Q24: HOW IMPORTANT ARE THE FOLLOWING QUALITIES AND COMPETENCES FOR SOMEBODY GRADUATING FROM A FAÇADE PROGRAM?
7. ABILITY TO WORK IN TEAMS



amount of data records: 206

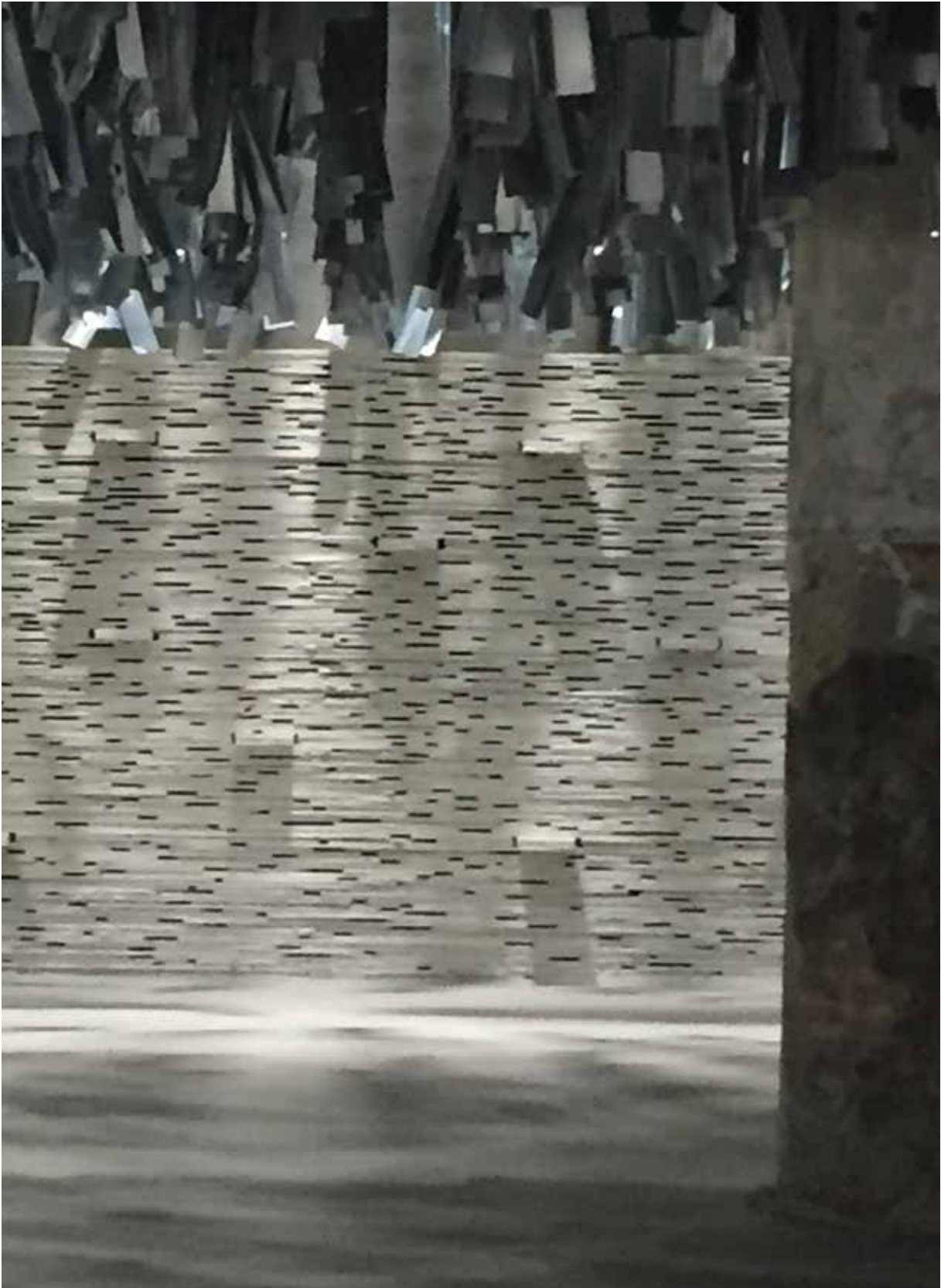


FIG. 2.12 The two entrance rooms of the Venice Biennale 2016 were built out of 90 tonnes of waste from Art Biennale 2015 to sharpen our eyes for the importance of embedded energy, recycling and the principles of a circular economy. (image: U.Pottgiesser)

2.2 Educational Concepts and Programs

Uta Pottgiesser, University of Antwerp / HS OWL

The nine existing international European masters programs teach theoretical and practice-oriented skills of digital analysis-, design-, planning- and production methods and detailed overview of the latest technological developments in facades. They are either linked to architectural or to civil engineering programs and faculties and differ largely in format, duration, degree and language. The majority of them prepares for international projects in international markets. Therefore, teamwork and presentation skills have a fixed place in most curricula.

Before 2000 the master program at Bath University in collaboration with the 'Center of Windows and Cladding Technology (CWCT) was known for its facade focus and graduates in the field. Since then innovative facade concepts and designs shaped the architectural landscape boosted by demands energy efficiency at the first hand and by new material trends on the other hand. In 2009 the European Facade Network (efn) was founded in Brussels with 5 European institutions being active in both education and research. In 2016 efn had grown to 12 European partners and is reaching out to other national and international networks in other continents, such as: the Facade Tectonics Institute (FTI) in the USA and the community of the International Conference of Building Envelope Systems and Technologies (ICBEST) and organisations in Asia.



FIG. 2.13 Members of the European Facade Network (efn) in 2017. The twelve partner institutions in Europe run in total nine educational programs on master level or as postgraduate certificates. (image: efn)



MSc Façade Engineering

Centre for Window and Cladding Technology
& University of the West of England, Bristol



The only UK course to specialise in façade engineering, this industry-led masters degree is delivered as a close collaboration between the Centre for Window and Cladding Technology (CWCT) and The Department of Architecture and the Built Environment, UWE Bristol.



Façade engineering is a discipline in its own right. Most large-scale commercial, industrial, educational and even residential buildings are now constructed using a frame and an envelope and many engineering firms have their own façade engineering departments.

This is a unique course is designed specifically for the industry - overcoming a severe skills shortage and making it easier for companies to find the staff they need. Our graduates are highly sought-after.

You will learn why façades are one of the most complex, technically challenging and trans-disciplinary parts of a building, how to design and develop façades that perform technically and develop an architectural expression.

Programme Leader:
Andrew Peters ARB Andrew.Peters@uwe.ac.uk

Further details:
<http://courses.uwe.ac.uk/K90D1/facade-engineering>

Applying theory to practice, you'll cover key topics including façade materials and components, thermal performance and analysis, weathertightness, fire performance, structural analysis and procurement.



MSC FAÇADE ENGINEERING – UWE BRISTOL

UNIVERSITY	University of the West of England, Bristol
FACULTY	Architecture and the Built Environment
DEGREE / LANGUAGE	MSc. – English
DURATION	12 – 18 months full-time; 24 – 36 months part-time
SPECIALISATIONS	Façade Engineering
ADMISSION FOR	Honours degree in an engineering, built environment or architecture related degree; professional experience
KEY CONTENTS	Façade materials, structural performance, building physics, weathertightness, procurement
COORDINATORS / TEAM	Andrew Peters – UWE, David Metcalfe – CWCT

PROFILE

This is a unique course, working closely with The Centre for Window and Cladding Technology (CWCT) and designed specifically for the industry – overcoming a severe skills shortage and making it easier for companies to find the staff they need. After nearly 20 successful years based at the University of Bath, a refreshed course moves to the University of the West of England in 2017.

Students will learn why façades are one of the most complex, technically challenging and trans-disciplinary parts of a building, how to design and develop façades that perform technically and develop an architectural expression.

The technology of building envelopes applied to non-traditional commercial building facades has changed rapidly in the closing decades of the twentieth century. Today the technology of advanced building envelopes is more complex than that of simpler traditional construction. This technology is, furthermore, applied to an ever-greater proportion of buildings. However, the training of building professionals has not kept pace with these changes.

The course aims to provide a broad view of façade engineering and create individuals with an appreciation of all aspects of façades and the relevant processes of procurement, design and construction.

The course may be undertaken as either full- or part-time study. The part-time route allows industry professionals the flexibility required to study whilst continuing employment. This benefits both the student and the employer and they are able to put their new found knowledge and skills into immediate practice. Individual units may also be taken as CPD. A research dissertation is undertaken in the final semester.

For further details see <http://courses.uwe.ac.uk/K90D1/facade-engineering>

JOB PROSPECTS

Our graduates are highly sought after. This course offers so much potential for architects, engineers, project managers, and construction professionals. Façade engineering expertise is increasingly sought-after in industry, academia, training and consultancy, and this course can lead to a variety of career options. We're creating the next generation of façade engineers ready to work with technical professionals on project teams in façade design, manufacture or installation.



MASTER PROGRAM ARCHITECTURE, URBANISM, AND BUILDING SCIENCES, TRACK BUILDING TECHNOLOGY – DELFT

UNIVERSITY	Delft Technical University
FACULTY	Faculty of Architecture, Department Architectural Engineering + Technology
DEGREE / LANGUAGE	M.Sc. / English
DURATION	2 Years / 4 Semesters
SPECIALISATIONS	Accredited focus
ADMISSION FOR	B.Sc
KEY CONTENTS	Building_function
COORDINATORS / TEAM	Prof.Dr. Ulrich Knaack, Dr.-Ing. Tillmann Klein, ir. Arie Bergsma

PROFILE

The Building Technology track is one of the five tracks within the Architecture, Urbanism and Building Sciences master program. Within this track, students can specialize on Façade Design. The track focuses on research, technological design and innovation, dealing with the newest technology and interacting with the current market. This program offers a balance between applied research and design of buildings and building elements.

It encompasses a broad spectrum of engineering and architectural design skills that lead to one of the dominant professions of the future: the sustainable designer. The emphasis of this programme is on the design of innovative and sustainable building components and their integration into the built environment.

What you will learn

Through focusing on structural, façade and climate design, students learn how to contribute to smart buildings that are sustainable, comfortable and environmentally intelligent. This programme stands out internationally because of its integration of architectural design with technical disciplines, filling the niche between architecture and engineering. Rather than focusing on one or two specialisations, students investigate the whole breadth of building technology, looking at climate design, façade design and structural design, producing designers that know how engineers work.

Prospective students must show both technical and architectural skills, interest and understanding. The programme is well suited to architectural graduates looking to strengthen their technical qualifications and those with a technical background that want to strengthen their design abilities.

JOB PROSPECTS

Building technology graduates and façade specialists are in high demand as the construction industry is lacking designers that bridge this gap between the architectural and engineering disciplines. Given that graduates can make decisions based on calculations and integrate them into architecture, they can direct structural engineers and manage complex processes. Graduates are sought after for architectural offices, engineering offices and specialised façade manufacturers.

Graduates of the Building Technology programme can expect to find generalist and specialist positions in engineering and architectural firms, and excellent opportunities in the business supply, contracting and project development sectors. Others opt to begin their own businesses or to pursue further studies at the doctoral level.



Hochschule Ostwestfalen-Lippe
University of Applied Sciences

Detmolder Schule für Architektur
und Innenarchitektur

MASTER INTEGRATED DESIGN (MID)

facade design
computational design



MASTER INTEGRATED DESIGN (MID) - DETMOLD

UNIVERSITY	Ostwestfalen-Lippe, University of Applied Sciences, Germany (HS-OWL)
FACULTY	Detmold School of Architecture and Interior Architecture – FB1
DEGREE / LANGUAGE	M.Eng.; accredited and internationally recognized degree that qualifies for senior public service and for PhD programmes / English
DURATION	2 Years / 4 Semesters
SPECIALISATIONS	Facade Design (MID-FD) / Computational Design (MID-CD)
ADMISSIONS	Bachelor / Diploma of Architecture, Architectural Engineering, Civil Engineering or similar studies or additional professional experience; Application with Portfolio
KEY CONTENTS	Facade Design, Computational Design, Components and Construction, Digital Tools and Programming, Scientific Methods and Communication
COORDINATORS / TEAM	Prof. Dr. Uta Pottgiesser, VProf. Daniel Arztmann; Prof. Hans Sachs, Prof. Jens-Uwe Schulz / M. Arch. Anica Dragutinovic; M.IA. Jan Kahre Heidemann

PROFILE

The Master of Integrated Design (MID) focuses on qualifying architects and engineers for interdisciplinary, international and to a growing extent digitally supported jobs. Special emphasis is laid on the cooperation between university and external partners, linking to other universities, planning offices, the construction industry and to software manufacturers. Globalisation in general and in the construction industry in particular have brought about new demands on buildings, building components and construction projects. Moreover, digital technology has effected lasting changes to the planning, production, construction and operating phase. Job profiles are getting more sophisticated accordingly. The MID-programme therefore teaches in particular theoretical and practice-oriented skills of digital analysis-, design-, planning- and production methods and gives a detailed overview of the latest technological developments. It includes operative aspects of information technology, new developments in building materials and scientific work as part of the architectural education.

The MID-programme is linked with the degree programme Master of Integrated of Architectural Design (MIAD) and offers the two specialisations Facade Design and Computational Design. Both specialisation have joint courses and collaborate in the project modules. The standard study period are four semesters as a 2-years full-time course and is organized through the four module blocks: Core Modules are common for the both specialisations and teach theory and scientific methods, communication, construction and different tools. Project Modules are studio-based, with different focus within the specialisations. Through experimental design students gain practice-oriented skills. The Specialised Modules students deepen knowledge in their chosen specialisation, such as climate, comfort, materials, safety, planning and production or digital fabrications, computational optimisation and simulations. Elective Modules can be taken individually. The fourth semester is reserved for the Master thesis.

Module Compulsory modules/Compulsory subjects	Reference	Sum SWS	CR	Semester / SWS							
				1	2	3	4	1	2	3	4
Core Modules											
Topic 1	MID C 1	4	4	2	2						
Construction and Dimensioning	MID C 2	4	4	2	2						
Topic 2	MID C 3	4	4			2	2				
Theory and Scientific Methods	MID C 4	4	4			2	2				
Confidence and Communication	MID C 5	1	2							1	
Project Modules											
Facade Design and Construction	MID P 4	5	12		1	4					
Integrated Building Design	MID P 5	5	12			1	4				
Contextual Design	MID P 6	5	12					1	4		
Specialised Modules											
Climate and Comfort	MID S 4	4	4	2	2						
Planning, Detailing and Production	MID S 5	4	4			2	2				
Materials, Surfaces and Safety	MID S 6	4	4					2	2		
Elective Modules											
Elective from catalogue	MID E 3-6	4	4					1	3		
Master thesis, presentation and colloquium	MID T		30								x
Sum SWS		44									
Sum CR			120								

Module Compulsory modules/Compulsory subjects	Reference	Sum SWS	CR	Semester / SWS							
				1	2	3	4	1	2	3	4
Core Modules											
Topic 1	MID C 1	4	4	2	2						
Construction and Dimensioning	MID C 2	4	4	2	2						
Topic 2	MID C 3	4	4			2	2				
Theory and Scientific Methods	MID C 4	4	4			2	2				
Confidence and Communication	MID C 5	1	2							1	
Project Modules											
Computational Architectural Design	MID P 7	5	12		1	4					
Integrated Building Design	MID P 8	5	12			1	4				
Contextual Design	MID P 9	5	12					1	4		
Specialised Modules											
Programming and Simulation	MID S 7	4	4	2	2						
Digital Fabrication	MID S 8	4	4			2	2				
Computational Optimisation	MID S 9	4	4					2	2		
Elective Modules											
Elective from catalogue	MID E 3-6	4	4					1	3		
Master thesis, presentation and colloquium	MID T		30								x
Sum SWS		44									
Sum CR			120								

Curriculum MID: Specialisation Facade Design (left) and Specialisation Computational Design (right)

JOB PROSPECTS

The MID-programme qualifies graduates for positions in the private commercial sector as well as for the public sector. Job sectors include in particular architectural offices, engineering and planning offices as well as the construction industry, research institutes and universities. Other possibilities are also in specific technological fields, such as studies in software application and simulation technology, the research in new manufacturing methods, of construction or material innovation; these areas are covered in particular in the specialised modules with changing themes and best-practice examples.

Lucerne University of
Applied Sciences and Arts

HOCHSCHULE LUZERN

Technik & Architektur
Institut für Bauingenieurwesen



Studienrichtung Gebäudehülle
www.hslu.ch



BACHELOR AND MASTER PROGRAMME - LUCERNE

UNIVERSITY	Lucerne University of Applied Science and Arts
FACULTY	Lucerne School of Engineering and Architecture Institute of civil engineering
DEGREE / LANGUAGE	Bachelor and Master degree/ German
DURATION	3 year (Bachelor)/ 3 Semesters
SPECIALISATIONS	Bachelor and Master in Civil Engineering with an area of studies in Facade Engineering
ADMISSION FOR	All with a higher education entrance qualification or a subject-linked university entrance qualification
KEY CONTENTS	Components and Construction, Façade Design, Metal construction, Building physics, Simulation, Structural Glass, Energy efficiency, Materials, Testing, Structural design, Execution
COORDINATORS / TEAM	Prof. .Dr. Andreas Luible, Prof. Dr. Klaus Kreher

PROFILE

The Lucerne University of Applied Sciences and Arts is a university of applied sciences that is supported by the six cantons of Central Switzerland. With 6,200 students attending bachelor's and master's degree programs, almost 4,600 students attending continuing and executive education programs, and 416 new projects in research and development, it is the largest educational institution in this region, the heart of Switzerland.

The Bachelor and Master program in Civil Engineering with an area of studies in Facade Engineering at Lucerne School of Engineering and Architecture is a full time program that focuses on the basic theoretical and practical aspects in civil and structural engineering as well as façade engineering (40%). The program, which was initially focused on metal construction, is running since 1993 and has continuously been adapted to the needs of the industry and the development of new technology. The façade engineering program at Bachelor level consists of 10 lecture courses, 3 project courses and 1 diploma theses. The lecture topics are components and construction of facades, façade systems, façade design, metal construction, steel construction, structural glass, building physics, simulation, testing, energy efficiency, daylight, materials, execution of facades, light weight building envelopes, etc.

The education program is support by the Competence Center for Building Envelope, a research group with 14 researchers. The competence center is running an accredited test laboratory for facades and offers a wide range of research facilities. Research topics are the use of photovoltaics in architecture , colored PV modules, daylight control systems, adaptive facades, bio composites, structural glass, energy efficient facades, green facades, etc..

JOB PROSPECTS

This diploma qualifies graduates for positions at manufacturers, façade consultants, general contractors, engineering offices, engineering and architectural offices dealing with design, certification, fabrication and installation of the building envelopes.



MASTER DE
ARQUITECTURA EN
**FACHADAS
LIGERAS**
WWW.MASTERFACHADASLIGERAS.COM

I EDICION



CURSO 2017



LIGHT FACADES MASTER (MFL) – MADRID & DONOSTIA-SAN SEBASTIAN

UNIVERSITY	Universidad Politécnica de Madrid & University of the Basque Country
FACULTY	Higher Technical School of Architecture
DEGREE / LANGUAGE	Professional Master, Spanish.
DURATION	1 Year / 2 Semesters
SPECIALISATIONS	Façade consultancy, Façade design, Façade manufacture and assembly.
ADMISSION FOR	Bachelor/Diploma of Architecture or Engineering.
KEY CONTENTS	Façade design, simulation, calculation, manufacture, construction and assembly.
COORDINATORS / TEAM	Prof.Dr. Gabriel Ruiz Mujica, Prof. Zigor Marroquin, Prof.Dr. Jose Miguel Rico Martínez, Prof. Xavier Ferres, Prof.Jesus Cerezo.

PROFILE

The need for specialized knowledge on building envelopes completing the traditional university profiles of architects and engineers led to the creation of this Façade Master which supplies with all the skills necessary for the professional design of modern facades.

The master integrates practical skills guaranteed by a large teaching team formed by architects, engineers and company-specialists from the façade sector.

The main objective of this master is to strengthen the knowledge on façade technology and create façade experts with the following skills and knowledge:

- Materials, components and façade systems.
- Relation between project, industry and assembly.
- Façade-technologies applicable to many industrial fields.
- Risks and concepts about material and product interactions.
- Law, regulations and quality control.
- Constructive-design
- Practical experience
- Computer aid and laboratory tools for the assessment, simulation and the definition of performance.
- Economic, planning, administrative and organization aspects related with building envelopes.

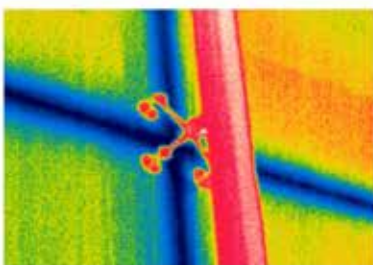
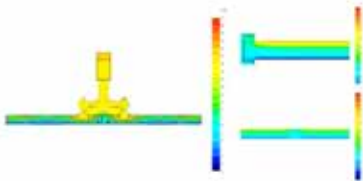
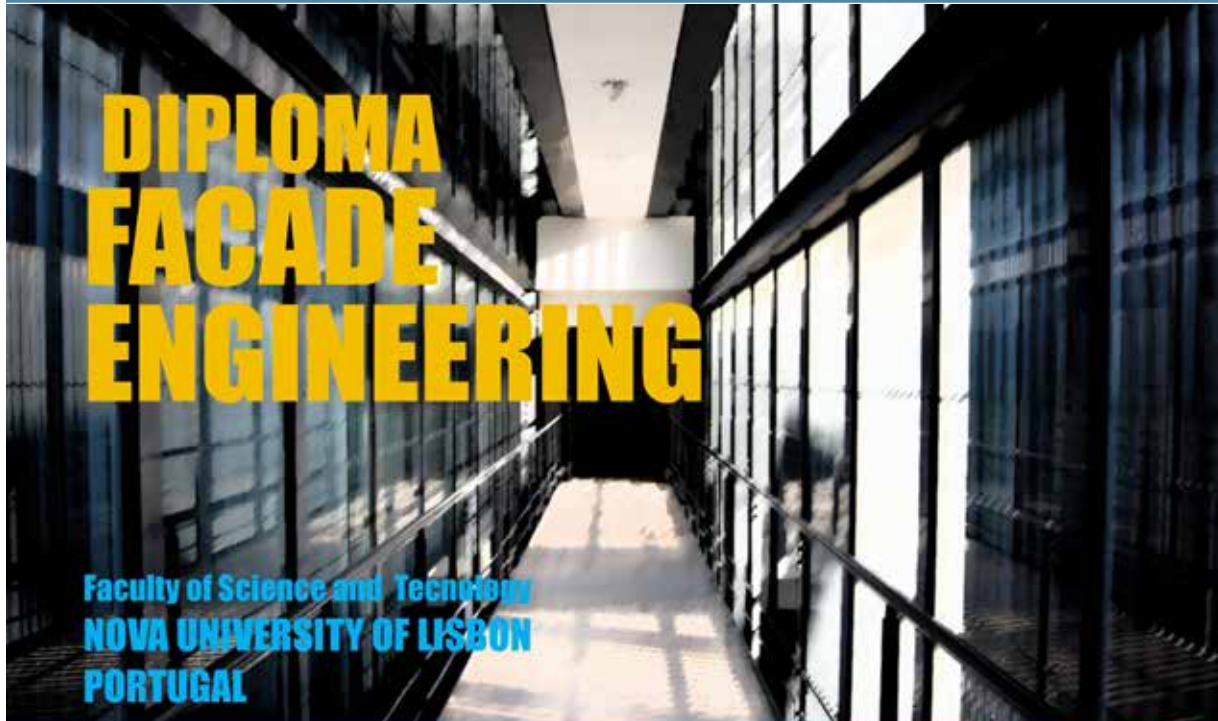
JOB PROSPECTS

The industry of light façade passed, in only two decades, from being almost an industry of artisan elaboration, to be a sector in which the development of the machinery has facilitated the serial work of many of the different components. Profiles, glass, silicones, etc., have adapted to new forms of production.

New technologies, as well as changes in business management systems, are requiring changes and new personnel needs to adapt to these new techniques and knowledge, which are not covered in terms of training.

This is why the sector suffers a lack of training both in terms of knowledge about materials, components, systems and their specifics, as well as their technology of transformation, the uses and applications in appropriate conditions of a product. In short, this Master aims to deepen the preparation of future building technicians, specialists in light facades.

The students of this master will become qualified professionals able to carry out his work in the field of building envelope design, manufacture, transformation, assessment and assembly in companies, research or consulting centers, in areas such as planning, projects, design, management, organization, control, supervision and training, as well as education.



POST GRADUATE DIPLOMA – LISBON

UNIVERSITY	NOVA UNIVERSITY OF LISBON
FACULTY	Faculty of Science and Technology, Department of Civil Engineering
DEGREE / LANGUAGE	Post Graduate Diploma (No degree)/ Portuguese and English
DURATION	1 year/ 2 Semesters
SPECIALISATIONS	Facade Engineering
ADMISSION FOR	Bachelor / Diploma of Architecture, Architectural Engineering, Civil Engineering or similar studies or additional professional experience; Application with Portfolio
KEY CONTENTS	Components and Construction, Façade Design, Building Simulation, Scientific Methods
COORDINATORS / TEAM	Prof. .Dr. Daniel Aelenei, Prof. Dr. João Viegas, M. Arch. João Ferreira

PROFILE

The Postgraduate Diploma in Façade Engineering at the Nova University of Lisbon is a part-time program that focuses on the theoretical and practical aspects of building façade design of topics such as energy and comfort, protection and maintenance and sustainability, technology and innovation. With more than 19,000 students 100 master programs spread between 9 schools, Nova University offers a diverse and stimulating space for students of the Façade Engineering program to thrive in. It responds to a palpable need for greater understanding of the multi-functional nature of the building envelope and the need for holistic design of façades. To orient research and education activities towards the needs of society and bring expertise from wide ranging fields in industry and research, the Diploma was launched in cooperation with other two key partners, the National Laboratory of Civil Engineering (LNEC) and the National Association of Manufacturers Efficient Windows (ANFAJE). LNEC is an advanced technological institution with several expertise in civil engineering that comprises the design, construction and maintenance of civil engineering works whereas ANFAJE represents the entire Portuguese sector of windows and facades in Portugal, since manufacturers of efficient windows to complementary product companies (window frames, fittings and accessories solutions, glass solutions, silicones and mastics, shading solutions, etc.).

The post graduate program relies on 4 core courses to provide the façade engineering students with the fundamentals aspects of façade design, namely “Structural Behavior of Facades”, “Thermal Performance of Façades”, “Weather Performance and Ventilation” and “Façade Materials and Technologies”. In addition to these four courses, an overview of the main technological and architectural aspects of façades is given in the “Introduction to Façade Technology” while aspects such as procurement routes, supply chain, forms of contract and contract law are taught in “Façade Procurement and Quality Management”. To gain practice-oriented skills, workshops are promoted with invited industry professionals and project leaders from leading companies on practical projects relating to specific topics such as natural light, sound transmission, integration of renewables and fire performance. Finally, each the diploma program is concluded with an independent research study to nurture the student’s abilities to pursue a topic of specialized interest. The students are encouraged to present the results of their research studies at international events or at the annual symposium dedicated to façades and organized with participants from both academia and industry.


Course	Ref	L	LP	PL	F	S	T	AT	Total	ECTS
Introduction to Façade Technology	I	6				6		3	15	0,5
Structural Behavior of Facades	CE		24					52	76	3
Thermal Performance of Façades	CTF		42					42	84	3
Weather Performance and Ventilation	DAM		40	3				42	85	3
Façade Materials and Technologies	MTF		22	3				52	77	3
Seminars	SVC				8	15		28	51	3
Façade Procurement and Quality Management	GC					18		24	42	1,5
Scientific work	AC	7					8	70	85	3

L – Lectures; LP – Lectures-practical; PL – Practical and laboratory; F – Field work; S – Seminars; T – Tutorials; AT – Autonomous work

JOB PROSPECTS



This diploma qualifies graduates for positions in companies dealing with design, certification, fabrication and installation of the building façades with regards to the performance of materials, aesthetic appearance, structural behavior, weather tightness, safety and serviceability, security, maintenance and build ability.

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

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SEKTÖREL BAĞLANTILAR

FAÇADE DESIGN AND TECHNOLOGY – ISTANBUL TECHNICAL UNIVERSITY

UNIVERSITY	Istanbul Technical University
FACULTY	Educational Institution, Department, Study
DEGREE / LANGUAGE	M.Sc. / English - Turkish
DURATION	1 year / 3 Semesters
SPECIALISATIONS	Façade design
ADMISSION FOR	Bachelor / Diploma of Architecture, Engineering, Urban Planning
KEY CONTENTS	Facade design, Construction, Performance,
COORDINATORS / TEAM	Prof.Dr. A. Nil Turkeri, Assist. Prof. Dr. M. Cem Altun

PROFILE

The Façade Design and Technology program is a graduate program under the Department of Architecture at ITU Graduate School of Science, Engineering and Technology. Applications to the program are accepted from persons who have completed a bachelor's degree in architecture or engineering or persons who have worked in the façade sector for at least two years with a bachelor's degree in interior architecture or landscape architecture.

The program aims to educate professionals from the construction sector into "façade all-rounders". The education oriented program consists of three semesters, each lasting 11 weeks. The curriculum consists of 13 courses and one term project. The offered courses are in the fields of façade design, façade manufacturing/assembly, façade performance and management of all processes. The courses in the field "façade design" are focusing on façade materials, holistic façade design and detailing of façade systems. "Façade performance" courses are comprising the topics; structural performance, acoustical performance, hygrothermal performance, air- and watertightness performance, performance related to daylighting, and fire protection.

Courses in the "management" field are comprising the topics façade design and construction management and production management. The given lectures are supported by visits and observations at the ITU Environmental Control Laboratory, ITU Structural and Earthquake Engineering Laboratory and Avrasya Façade and Window Frame Testing and Technology Center. The term project comprises research work and integral design of façade systems.

The program cooperates in numerous fields with its partners from the façade industry, namely; Asaş Alüminyum San. ve Tic. A.Ş., Dekoral Alüminyum San. ve Tic. A.Ş., Fibrobeton A.Ş. Rheinink Türkiye, Schüco Türkiye and Trakya Cam San. A.Ş.

JOB PROSPECTS

The Façade Design and Technology program aims to equip its graduates not only with theoretical knowledge in fields of design, manufacturing, assembly, performance evaluation and management of façade systems but also with skills to translate theory into practice with a creative and innovative mentality. In this context the program will sufficiently prepare graduates for the fast growing façade industry. Career opportunities for graduates of the program include, but are not limited to: façade consultancy firms, façade system/component manufacturing companies, façade contractor companies.

FACE

Façades Architecture Construction Engineering



FACE | FAÇADES ARCHITECTURE CONSTRUCTION ENGINEERING – BOLZANO

ORGANISATION	IDM South Tyrol & EURAC research – Bolzano, Italy
DEGREE / LANGUAGE	CEUs for professional architects and engineers / English – Italian
DURATION	120 hours + individual project work + final event
SPECIALISATIONS	Façade Design + Construction + Maintenance
ADMISSION FOR	Bachelor / Diploma of Architecture, Architectural Engineering, Civil Engineering or similar studies or additional professional experience; Application with CV
KEY CONTENTS	Façade Technology, Façade Physics, Façade Construction and Operations
COORDINATORS / TEAM	Prof. Ing. Angelo Lucchini, Prof. Ing. Paolo Rigone, Ing. Roberto Lollini, Ing. Carlo Battisti

PROFILE

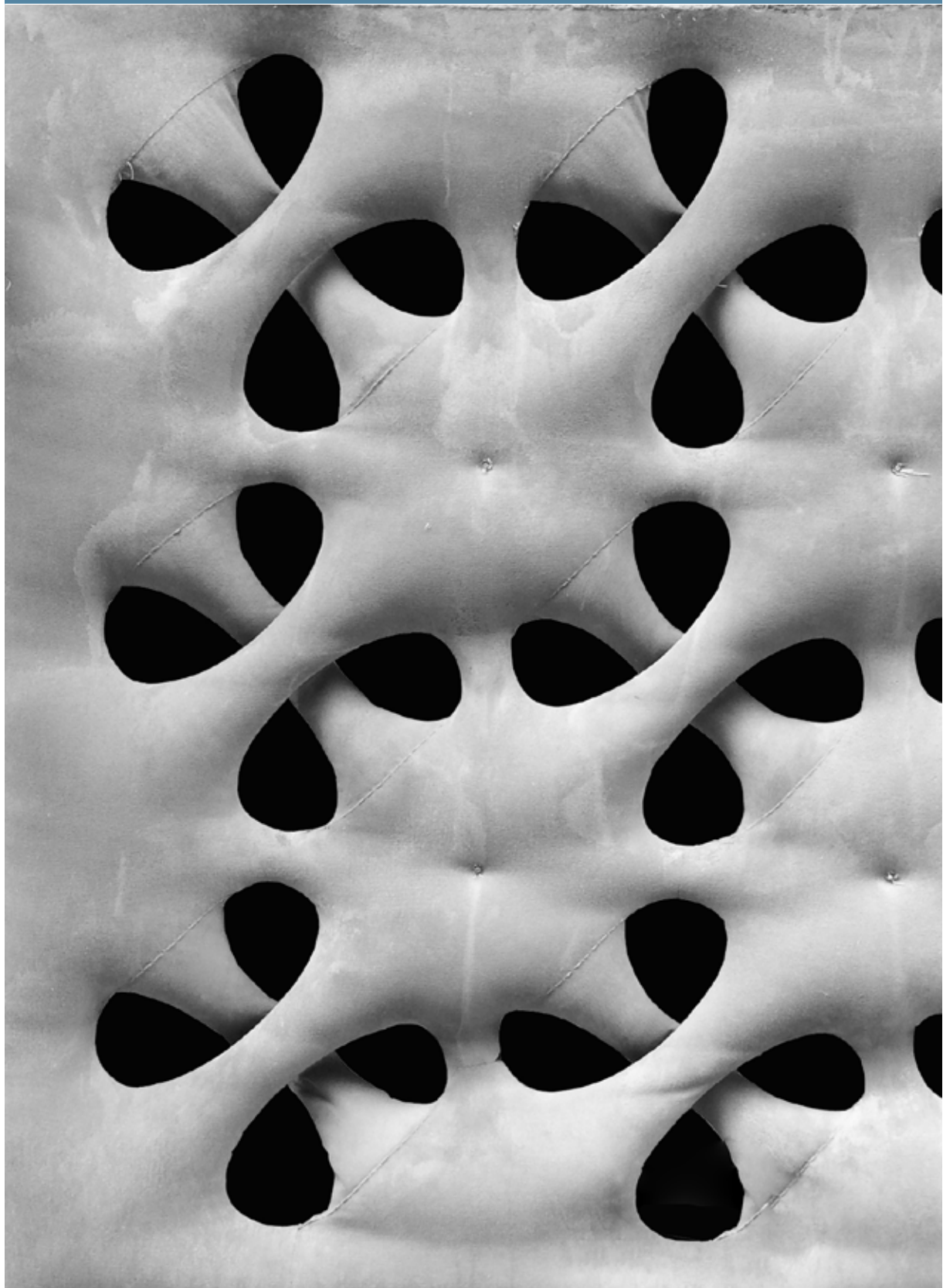
IDM South Tyrol and EURAC research offer a training course aimed at increasing the know-how of companies and freelance professionals operating in the field of complex technological building façades. The course aims to transfer to freelance professionals and technical staff of construction companies, concepts and innovative methods in the sector of complex technological façades. The educational program has a complete structure regarding the covered topics, to provide innovative concepts, tools and methods, while stimulating the growth of local skills in the construction sector, increasingly subject to environmental and energy regulations and severely affected by the global economic crisis. Through this course, the aim is to increase the specific know-how of companies and freelance professionals operating in the field of façades and to build a network of technical operators and specialized people who can work in the market with quality and competence, to reach important goals in terms of positioning and revenues. The course is divided into 6 units, for a total of 15 days. It is characterized by a strong orientation to practice with the participation of experienced speakers, well-known for their skills in the field. All contents have been conceived and designed to address the main themes of concept, design, calculation, production, installation and maintenance of complex building facades. A study trip to Milan is planned to closely analyze significant examples of technological innovation in the field of façades. **Expected results:** 1. Increase of the level of expertise of technicians (free professionals and technical-operating staff of companies) in the sector of complex technological building facades. 2. Ability to design, develop and manage a complex Project Work, thanks to skills and concepts that can be directly replicated in everyone's own professional situation.

Contents

<p>Unit 01 / FAÇADE TECHNOLOGY (basic) <i>Design</i></p> <ul style="list-style-type: none"> • Conventional and advanced facades • Solving of critical technology nodes • Visit to a façade company 	<p>Unit 04 / FAÇADE PHYSICS (advanced) <i>Performance checking</i></p> <ul style="list-style-type: none"> • Daylighting • Ventilation • Acoustics • Façade shielding systems • Façade tour – project in South Tyrol
<p>Unit 02 / FAÇADE PHYSICS (basic) <i>Energy performances</i></p> <ul style="list-style-type: none"> • Thermal analysis and condensation risk of critical nodes • Integrated optimization of building performances • Solar radiation • Façade systems modelling and simulation • Visit to façade testing laboratories 	<p>Unit 05 / FAÇADE OPERATIONS (advanced) <i>Construction and regulatory contest</i></p> <ul style="list-style-type: none"> • Envelope commissioning • Project Management • Maintenance, cleaning, diagnosis • Lean Construction
<p>Unit 03 / FAÇADE OPERATIONS (basic) <i>Construction and regulatory contest</i></p> <ul style="list-style-type: none"> • Façade statics • Glass statics • Regulations and CE marking • Façade tour – projects in Milan 	<p>Unit 06 / FACADE TECHNOLOGY (advanced) <i>Design</i></p> <ul style="list-style-type: none"> • BiPV • Multifunctional façades • Double-skin and punctual façades • Free-form façades • Practice exercise and visit to façade laboratories

JOB PROSPECTS

The aim is to train a new skilled professional who can master the technical and management know-how needed to make the most of the potential of the building envelope, from the design phase to the correct assembly.



MASTERPROGRAM GLASS & FAÇADE STRUCTURES – DARMSTADT

UNIVERSITY	Technische Universität Darmstadt
FACULTY	Faculty of Civil and Environmental Engineering
DEGREE / LANGUAGE	M.Sc. / English
DURATION	2 Years / 4 Semesters
SPECIALISATIONS	Civil Engineering with a focus on Glass and Façade Engineering
ADMISSION FOR	B.Sc
KEY CONTENTS	Façade materials, structural performance
COORDINATORS / TEAM	Prof. Dr. Ulrich Knaack, Prof. Dr. Ing. Jens Schneider

PROFILE

As part of the Civil Engineering track of the Faculty of Civil and Environmental Engineering MSc program a specialisation of façade engineering is made available. Within this track, students can specialize on Façade Engineering. The track has a broad intake with a standard civil engineering MSc program and is focusing in the specialisation “glass + façade structures” at materials, structural and computational engineering as well as facades and glass construction. Problem solving at an engineering level, combined with a close understanding of technical and physical parameters of facades are in the focus of the education. Engineering and design skills are trained in an project oriented program. The program is closely linked to research within the faculty and interacts with the partner programs within the European network.

What you will learn

Façade as one of the most complex parts of a building act as the border of Indore and outdoor environment: An education to engineer the requires a deep understanding of the mechanical, material and building physics related aspects. In this program thesis aspects are integrated in theoretical and experimental courses. Project related parts of the programm will train the understanding of engineering and design processes.

JOB PROSPECTS

Civil engineering graduates da have a large variety of job opportunities: working in the engineering and construction industry as well as being active in the manufacturing industry are general opportunities. But due to the lake of skilled people in the façade industry the specialization “Glass and Façade Structures” will allow alumni’s to become active as specialist in consulting, engineering and manufacturing / construction within the field of façade.

Graduates of the “Glass and Facades structure” program can expect to find engineering or specialist positions in engineering or manufacturing firms as well as contracting and project development sectors. The program also allows to continue further studies at the doctoral level.

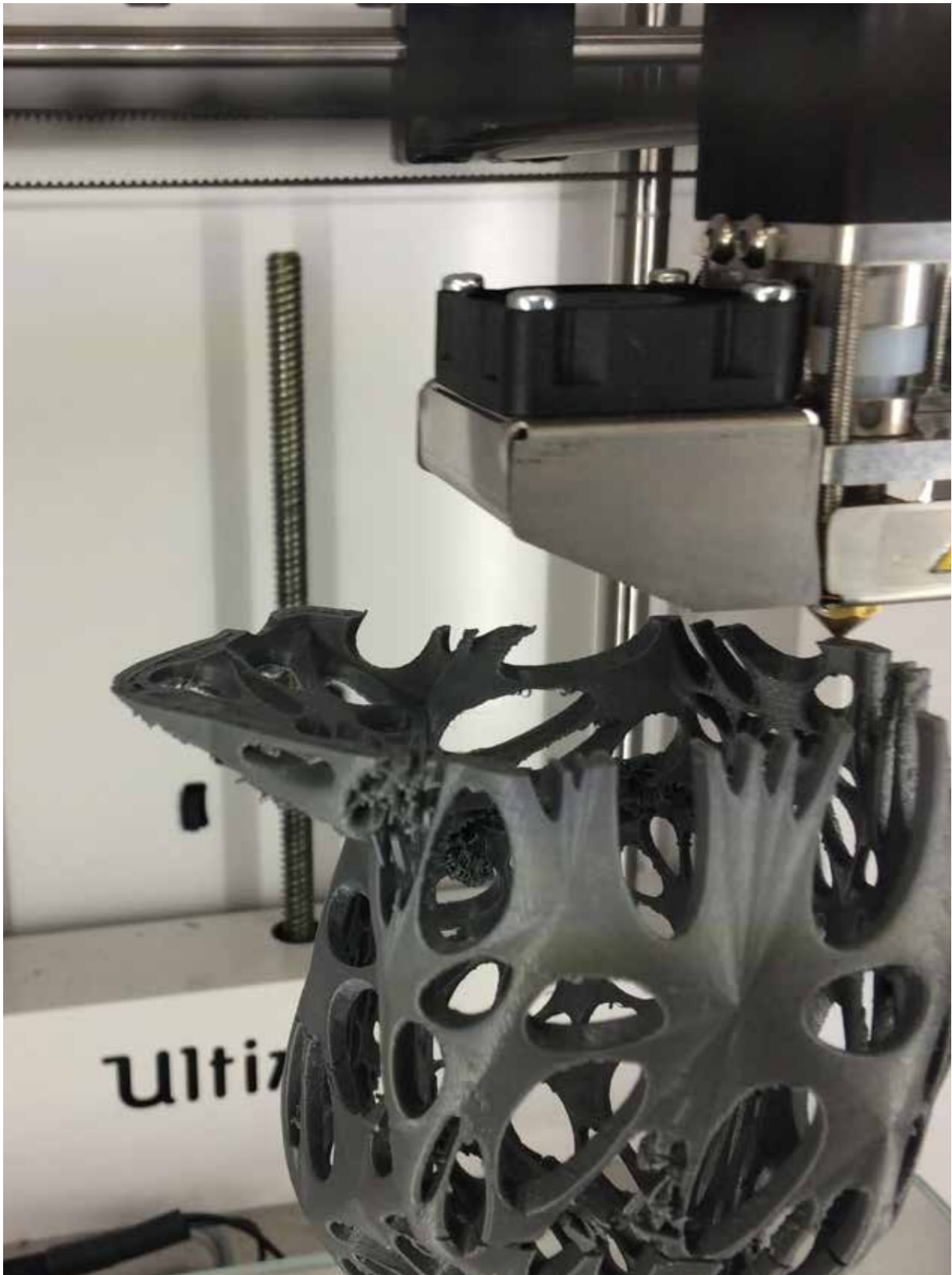


FIG. 2.14 Digital design and fabrication is becoming a standard approach in design and fabrication and part of the architecture and engineering education. Students from Prof. Ku's design studio study the typology of the "column" using a 3D printer at Thomas Jefferson University Architecture. (image: J. Doerfler)

2.3 Designer's and Fabricator's Knowledge on Building Envelopes

Uta Pottgiesser, University of Antwerp / HS OWL

While other industry sectors are largely digitalised and automatised, in the building sector a lack of understanding about technology, fabrication, design integration and the “physical making of things” within the academic education of both architects and engineers can be identified. This also applies to the professional area of contracting and manufacturing companies to a certain extent. The consequence is a misunderstanding and/or a limited exploitation of the potentials of the building envelope for more sustainable results in the design, fabrication, assembling and maintenance process. Experience in research and education shows that this can be improved and maybe finally solved by “making of experiences with 1:1 mock-ups” in workshops and on site.

Coming from a long-term, experience based and slowly developing tradition building design and construction has been challenged during the 20th and 21st century with increasing numbers and spread of innovations in the field of materials, technologies and design tools. Due to its diverse character and organisation along the value chain and complex decision making processes and responsibilities the building sector has shown more difficulties to adapt to rapid changes and knowledge growth. This means that education and training generally “demand new approaches to architecture, engineering, and construction (AEC) education” (Becerik-Gerber et. al., 2011). And Burcin-Gerber and Kensek (2009) state that “The 21st century engineer and architect must be able to deal with a rapid pace of technological change, a highly interconnected world, and complex problems that require multidisciplinary solutions.”

As one approach the efn partners deal with this challenge and have introduced new workshop formats with the efnMOBILE 1.0 and 2.0 series, the latter are presented in the following pages. The practical experiences will be further analysed and compared with the results of the recent Online Facade Survey to further improve the knowledge basis, the interaction of explicit and tacit knowledge and the cooperation of the disciplines and stakeholders.

References

- 1 Becerik-Gerber B, Gerber D J, Ku K (2011). The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula, ITcon Vol. 16, pg. 411-432.
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- 2 Becerik-Gerber B, Kensek K (2009). Building Information Modeling in Architecture, Engineering, and Construction: Emerging Research Directions and Trends, Journal of Professional Issues Engineering Education and Practice, Vol. 136, Issue 3, pg. 295-302.
To link to this article: [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000023](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000023)

2.3.1 Form Finding Fabrication

The workshop 'Form Finding Fabrication' and the integrated symposium 'Digital Methods' in the context of the Workshop series 'Digital Crafting' at the Glasstec 2016, Düsseldorf have been co-organized and held by Prof. Hans Sachs, Prof. Dr. Uta Pottgiesser, Susann Kreplin B.A., and Dipl.-Ing. (FH) David Lemberski

Introduction

In recent years, the use of digital media, computational tools and methods has not only vastly influenced the way architects and interior designers work, it has also significantly altered the design language, and the appearance and perception of architecture. The computer is probably the most comprehensive and dynamic medium that the architect ever had available for the development and realization of spatial concepts. To benefit from this potential, one needs to understand the computer as an interactive and creative instrument and to use its artificial intelligence as an extension of possibilities in various directions.

In this context, the cross-referenced series of lectures and seminars 'Digital Crafting' at the professorship of CAAD at the Detmold School of Architecture and Interior Architecture is mainly about dynamics, changeability and adaptability in architectural design and its development processes. The focus lies on the architectural simulation, presentation and visualization as well as on the iterative design development process, which we know from software development strategies. This iterative development process represents a circular metamorphosis in the sense of making design and architecture instead of just 'drawing' a plan.

Practically, students were tasked to develop concepts for 1:1 installations in the field of art and architecture with the integrative use of digital tools and methods as well as considering material properties and behavior by working at the intersection of physical and virtual models. On the foundation of semester sub-tasks, the students were guided by three key topics of computational architectural design, applying a collection of digital tools and methods:

- 1 3D modelling / digital prototyping
- 2 Generative design and digital fabrication
- 3 Visualization / Animation

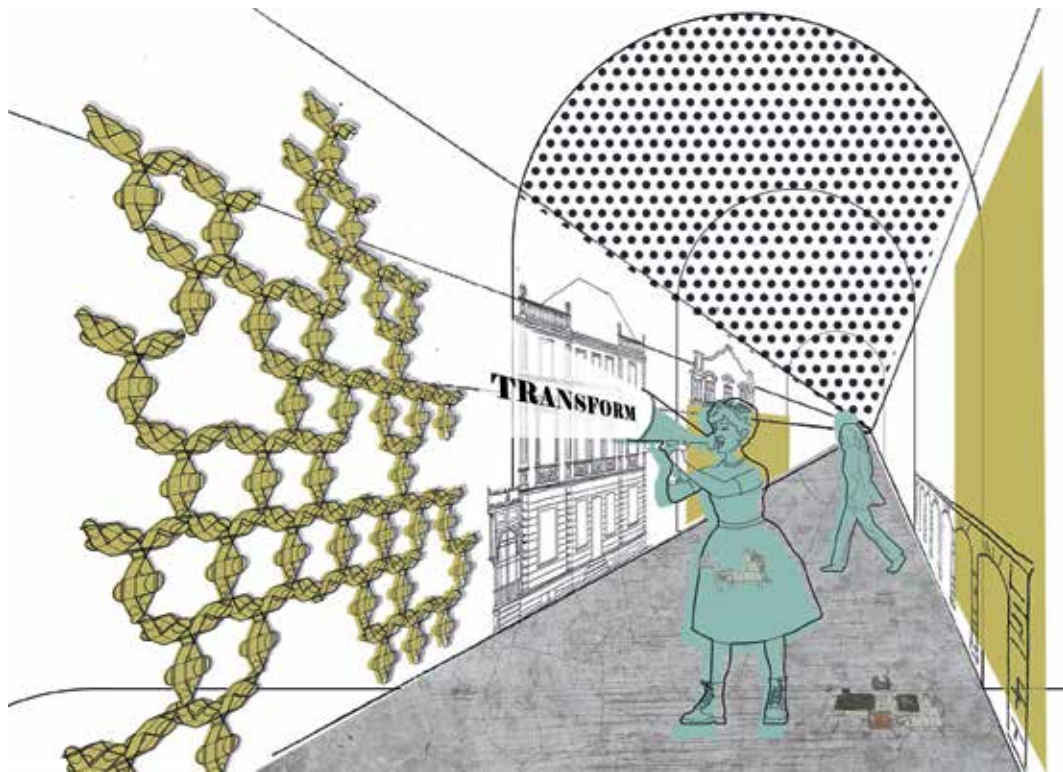


FIG. 2.15 Photoshop Collage based on workshop results, C1 Tools & Methods. (image: T. Hütte)

The goal of the educational workshop series ‘digital crafting’ is to explore and reflect the important links between form, function, material and fabrication. The interconnection of these main aspects of creation is particularly driven by the raising prominence of computational tools in the context of design and fabrication. Hereby the focus is especially on two points: the – even in real time – implementation of data in example user data which strongly relates to the concept of ‘Open Innovation’ (see chapter below in this article). On the other hand it is about the ‘crafting inspired’ approach of a comprehensive integration of material properties, its behavior and traditional processing techniques, into the design development process.

The here presented workshops and both the processes and resulting works are basically rooted in the interconnection of ‘3D modeling’ and ‘digital fabrication’ techniques for model making. At the same time it is strongly related to the principles of the open ‘maker movement’ or ‘culture’, which “in general supports open-source hardware and. Typical interests enjoyed by the maker culture include engineering-oriented pursuits such as electronics, robotics, 3-D printing, and the use of Computer Numeric Control tools, as well as more traditional activities such as metalworking, woodworking, and, mainly, its predecessor, the traditional arts and crafts”¹. In addition the workshop series ‘Digital Crafting’ is led by the concept of mass customization, which is a method of “effectively postponing the task of differentiating a product for a specific customer until the latest possible point in the supply network”².

This article thus aims to present the main background and drivers of the workshop series followed by a more detailed explanation of the digital crafting workshop ‘form finding fabrication’ at the glasstec 2016.

“The modern material world could not exist without the marvels of CAD. It enables instant modeling of products from screws to automobiles, specifies precisely their engineering, and commands their actual production”³ says Richard Sennett in his comprehensive book ‘The Craftsman’. But even though computers and software have developed significantly during the past decades, the way of developing architectural and industrial design with CAD is still widely misinterpreted and partly misoperated.

On the one hand, the computer has been and still is widely used as a technical drawing assistance for conventional 2D plans and documentation in terms of architectural building production. In line with the understanding that refers to CAD as ‘Computer Aided Drawing’ software, digital design rather bases on the concept of 2D documentation, industrially standardized processes and industrial production.

Richard Sennett also compares the general application of CAD in architecture to the crafting related principles of problem solving and discovering in the open source software development. While the development of LINUX, as well as processes in traditional crafting focuses on problem solving and finding, ‘CAD is often used to hide them’⁴. In addition, the importance of material mostly finds itself in a secondary position in this process. In her article ‘Material Computation’ Oxman says, “[...] it is due to the priority of geometrical representation over physical material considerations, a phenomenon that has led to stream-lining the design process: form first, material later.”⁵

On the other hand, we experience a strong contradiction in architectural design when it comes to design research and practice. Although widely preached as integrative design and processing, the use of digital technologies in mainly digitally developed design and architecture is limited to the implementation of highly complex but mostly formal design concepts. In her book ‘Writing About Architecture’, Alexandra Lange refers to a formalized architecture whose “primary emphasis is on the visual – the building or the object’s form.”⁶ This formal criticism is strongly referred to Ada Louise Huxtable, one of the most important critics in architecture, who “approached architecture criticism from a holistic point of view, not solely considering a building’s formal and aesthetic features.”⁷ Even today Chup Friemerts architectural critics in his book ‘Die gläserne Arche’ (1984) on the Crystal Palace in London are of strong significance as the main focus in architecture and design remains on the finished object or building, the final ‘image’. “It almost seems as if the fence in the history of architecture still exists today: its main interest is still directed to the finished building, but hardly on the process of construction”.⁸

A significant advantage and still largely undeveloped potential of CAD and digital processes in this context is the comprehensive integration and interactive processing of complex and variable information in virtual models and simulations – even in real time. A high degree of variation, adaption and responsiveness can be integrated into the design, development and production process and leads to “a digital continuum from design to production.”⁹ Historically, when it comes to fabrication, especially physical – material, process and function related parameters and constraints effectively outline the design of an object. Digital processes represent and provide the necessary infrastructure, the foundation for the development of new tools that push forward the connection of design related media and materials. As Bob Sheil and Ruari Glynn (Interactive Architecture) put it in their book ‘Fabricate: Making Digital Architecture’: “the exchange of information between design and fabrication is no longer a slow chain of vulnerable links, but a rapid flow of data, where design and making can be a simultaneous process.”¹⁰ In this sense digital techniques are (re-) strengthening a correspondent relation between form, material and function.

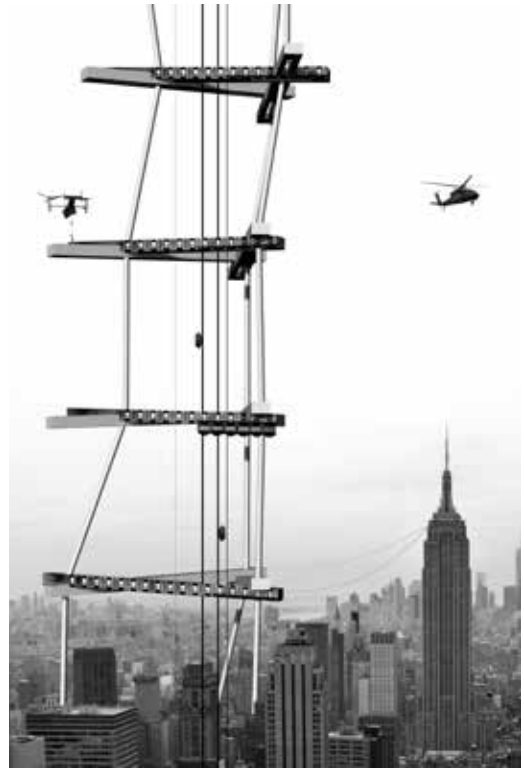


FIG. 2.16 'From making to drawing', fictitious architecture diagrams developed based on 'Digital Crafting' workshop prototypes. (images: Y. Kweon and T. Mena)

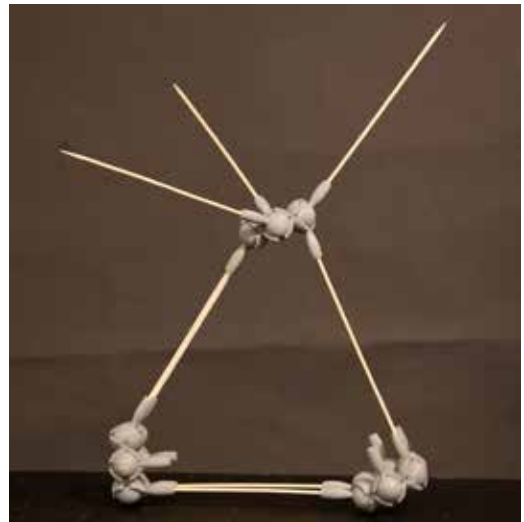


FIG. 2.17 'Flex node' / connector study, Onurcan Kurt, MID, Glasstec 2016. (images by O. Kurt)

Digital Fabrication

Similar to the 18th and 19th century industrial revolution, we are today in a process of societal change that, among other factors, significantly influences architecture and design. This proceeding digital revolution 'refers to the advancement of technology from analogue electronic and mechanical devices to the digital technology available today'¹¹. But while information technology and digital, rule-based, robotic processes already dominate large parts of our private and business live, 'traditional' industrial processes still primarily govern the production of consumer goods.

FabLabs

The potential of digital processes in manufacturing is currently thoroughly investigated and applied in various areas. So-called 'Fab Labs' are exploring the themes of interdisciplinary, searching and applying more 'democratic' methods through collaboration and the open exchange of production knowledge. In this context, "A 'Fab Lab' (short for 'fabrication laboratory') is an open [...] high tech workshop providing fabrication techniques for one-off pieces to private individuals"¹².

In these open laboratories, individual design objects and technical products are created, for example by using 3D printers that people have built themselves and some of which are self-replicating by also using CNC machines, laser cutters and even discarded industrial robots. Based on the principles of open source, CNC production data is distributed and further developed via the Internet and new knowledge regarding "materialization" is being shared. Ideally, production knowledge is shared using Creative Commons licenses and a global network of mini factories "... is created with these networked, digital production methods"¹³. The FabLabs most likely represent only forerunners of new product development practices and concepts in the future. Under the banner "Open Innovation" this movement of sharing, linking and reflecting creational knowledge and product data is getting more and more relevant in companies' design, innovation and marketing strategies.



FIG. 2.18 Prototypes and form studies at the 'Innovation Space & FabLab Berlin', 2017. (image: H. Sachs)

Generative Modelling: From Objects to Sequences of Operations

The concept of an optimized and highly integrative project and product development in architecture is based on adaptive and informed modeling and fabrication processes. The method of generative modeling – ‘the generalization from objects to operations: A shape is described by a sequence of processing steps, rather than just the end result of applying operations’¹⁴ – inevitably pushes towards new concepts of design making and thinking and subsequently leads to new design aesthetics. Hereby the computer extends the principles of traditional crafts by numerous options such as simulation, generation and the connection and controlling of production processes.

In his new readings Bernhard Cache directly connects contemporary architecture with historical tradition: “Parametric design and mechanics are not new in architecture: they were actually there from the very beginning of the written sources of our discipline. To understand this, we must return to classics such as works by Euclid, Plato, and Vitruvius.”¹⁵ The ‘Tower of the Winds’ in Athens, built around 100 B.C., mentioned in Vitruvius’ multi-volume work on engineering and architecture, is based on adaptive modeling techniques integrating sun positions for eight differently oriented sun dials besides water pressure, and wind direction. Around 16 centuries later Albrecht Dürer explored various concepts of generative form finding in his work ‘Underweysung der Messung [...], i.e. with the ‘Schneckenlinie’ or the ‘Der Vergleicher’ and ‘Gesichtsproportionen’ (Dresdner Skizzenbuch)¹⁶. ‘The Vergleicher’ represents the foundation for a mathematical, truly adaptive modeling method to find the ideal proportions for the construction of fortifications. “Rather than showing geometrical figures, Dürer often shows mechanical instruments that are intended to be used to draw curves. These instruments take on so much importance that sometimes the curves themselves are not even represented.”¹⁷

In the 20th century, Antonio Gaudi and Frei Otto experimentally developed adaptive physical models in order to achieve an optimized interaction of material and construction. “Antoni Gaudi invented not only unusual organic forms, but also rational methods used to develop these forms in the same manner and to optimize as do today’s architects.”¹⁸



FIG. 2.19 ‘Free form’ experimental compact workshop with soapbubbles and fabrics inspired by ‘Frei Otto’, M-CDC, IFDC 2015. (images: H. Sachs)

Fabrication: From Standard to Non-Standard

"[...] Digital fabrication implies that making drawings and making buildings are now inseparable entities – their interdependency has become a connected circumstance rather than a negotiable one"¹⁹. With a drastic increase in the availability and development of digital techniques, new integrative design methods, techniques and tools evolve. The final geometry of an object is no longer dependent on static, mechanic tools for fabrication. Generative design and modeling in combination with digital fabrication lead to a liberation from the dogma of mechanic, repetitive fabrication. The intelligent control and automation of processes break up the strong limitation of variation in material, structure and form in the traditional industrial production. Already in 1995, Bernard Cache argues in his book 'Earth moves: the furnishing territory' as follows: "We no longer apply a pre-set form on inert matter, but lay out the parameters of a surface of variable curvature. A milling machine that is commanded numerically does not regulate itself according to the build of the machine; it rather describes the variable curvature of a surface of possibility. The image-machine organization is reversed: the design of the object is no longer subordinated to mechanical geometry; it is the machine that is directly integrated into the technology of a synthesized image."²⁰

Liberation of geometry

Significant advantages of digital design and production processes are that numerous local and global factors relating to the product context can be integrated and processed individually during the design and development processes. The same goes for structural requirements such as the final use, structural engineering and various technical functions. Thus a higher degree of adaptivity can be integrated in the design, development and production process and the subsequent use of an object. Thus when it comes to materialization, especially physical parameters and constraints dominate the design of an object. There is a strengthened and more correspondent relation between the development and fabrication process combined with a higher flexibility considering the geometry: in the phase of design and manufacturing but also in the final shape.

A British research group, for example, has shown that 3D printing may well trigger a revolution in production techniques of airplanes. The group "EADS Innovation works" aims to use this technique to produce whole aircrafts in the near future. Individual connection elements printed from metal are already being in use in Airbus airplanes and can be easily modified in any individual airplane model. In addition the 3D printing method provides great opportunities to save material and weight.

Process- and material driven design

But although industrial production still dominates the world of products and consumption, digital techniques have helped – even if mostly exemplarily – in reinstating basic principles of craft production in design and architecture " [...] in which material and form are naturally intertwined into a tradition of making [...]"²¹. The principles of digital design and manufacturing processes are rather linked to a way of craft production than industrial processes as they emphasize the qualities of the materials used and provide higher flexibility during the development and production process. The connection of digital design and digital manufacturing can be resumed as 'Digital Crafting', which describes the combination of work techniques typical of craftsmen with computer-supported processes²². As previously stated, the computer extends the principles of traditional crafts by numerous options such as simulation, generation and the connection and controlling of production processes. Combined with the potentials of generative modeling – 'the generalization from objects to operations: A shape is described by a sequence of processing steps, rather than just the end result of applying operations'²³(9) – it inevitably pushes us towards new concepts of design making and thinking and subsequently leads not only to new design aesthetics but also new methods of development and creation.

With the comprehensive integration of software-based tools in the design development and fabrication process, the boundaries between those become increasingly blurred. The methodology changes, the design development phase can reach up to the last produced model in a product series, while the serial production cycle already starts with the first prototype as it is already produced with high, computational precision.

Open Innovation

“ It’s the little things that make all the progress”²⁴

Open innovation is based on communication and social interaction. It is “[...] a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology”²⁵(2). Excellent examples of open innovation, combined with parametric model based product configuration by the customer, in the business context are the Open Logo Project of Spreadshirt.com (a provider for individual clothing), the “Wikihouse” project (www.wikihouse.cc/), where costumers respectively users use and further develop a CNC-production based housing system or the Sketch Chair study by Greg Saul, with which the customer can create his own chair design based on a construction template embedded in a configurative web application. These examples have in common that they put the customer at the heart of value creation. Furthermore they induce playful synergies resulting from a constant dialogue between designer and user, object and function.

With the workshop series ‘Digital Crafting’, also the enabling powers of such participative design strategies are to be explored. The concept of “interactive value creation”²⁶(4) is about the active role of the customers, an external actor who leaves his marks or even inventively contributes to the design and development process of a product or object. “Customers are no longer just passive receivers and consumers [...]”. They represent much more a collaborator to the designer or producer in the creation of value, in the development but also the evaluation of a product.

Design and architecture is creation, and it is creative. The main goal of the concept of ‘Digital Crafting’ in an architectural context is to activate a playful experience and to forge a constant dialogue between designers, developers and even users. ‘Playful’ means the direct interaction with the environment, personal engagement, material properties and production knowledge. This process helps strengthening the relationship of an object and its function, allowing for engagement, growth and change. Even the user himself has a constant impact on his immediate environment, resulting in continuous transformation and interaction. This demands a process of participation where the user is deliberately asked for input and engagement. Participation thus means that designer and user join forces in a playful act of creation. Therefore the digital tool studies generally leave elements of design open to encourage users to participate with their own input. Hereby products do not even function to their full extent unless the targeted user becomes actively engaged. The research’s design approach is thus playful in both conceptualization and the use of computational applications as well as in the attitude towards design referred to as the art of manufacturing. The manufacture is equally process and product comprising designer and user as producers of space and creative energy.



FIG. 2.20 Trade fair booth 'efn mobile' with 'form finding fabrication' workshop and exhibition at the Glasstec 2016. (image: S. Kreplin)

In this concept, which can be perfectly referred to the architect Frei Otto's slogan 'Denken in Modellen' (thinking with physical models) the design development is rather driven by the process of making than pure strategic thinking. On the contrary to industrial production – also in architecture – in this concept of 'making', a wide range of data about form, function, material, processing and individual user demands are constantly and repeatedly intertwined. The way of honoring material and its strong – but ever changing – relation to manufacturing processes leads not only to **new design aesthetics** but also to a new, crafting oriented way of design thinking. "Every good craftsman conducts a dialogue between concrete practices and thinking; this dialogue evolves into sustaining habits, and these habits establish a rhythm between problem solving and problem finding"²⁷. With the integration of computation into these processes of making and thinking these method of creation can be applied in a much wider context regarding developers and collaborative users. Thus such tools are certainly not only questioning traditional top down planning methods in various fields but also the concept of mass production and consumption in general.

Workshop and Symposium 'Form Finding Fabrication' at the Glasstec 2016

From September 20th to 23rd the European Facade Network (efn) in cooperation with the Detmold School of Architecture and Interior Architecture (HS OWL) and the TU Delft have hosted the workshop 'Form Finding Fabrication' and the Symposium 'Digital Methods' at the glasstec 2016 trade fair in Düsseldorf.

Workshop and symposium served as the semester kick-off for Detmold's new master students and were led by Prof. Dipl.-Ing. Hans Sachs and Dipl.-Ing. (FH) David Lemberski. More than 80 students in the field of architecture (Master Integrated Architectural Design – MIAD) and interior architecture (Master Innenarchitektur-Raumkunst – MIAR) developed a huge variety of digital and physical prototype wall and roof structures in an cross-disciplinary and interactive design and modeling process.

The focus of this experimental workshop has been on the interconnection of analogue and digital modeling and fabrication techniques by using 3D printers, two CNC laser cutters, a CNC wire bender and cutting plotters. Within this setup our international and national 'newcomer students' interconnected greatly at an early stage of their studies and immediately learned to use and integrate innovative modeling and prototyping techniques in the design development process.

The symposium "Digital Methods", which took place on September 21st 2016 at the EFN trade booth at the 'Glasstec', brought together eight experts from various universities and companies and allowed them to present their strategies, concepts and methods of design and development processes in a digital context. The symposium had a focus on future strategies, techniques and (working- and development-) methods that emerge from the application and interconnection of various kinds of arising digital tools.

While coming from different disciplines such as architectural design, urban planning or from innovative digital (industrial) production processes (Industrie 4.0), all speakers had a focus on digital techniques and working methods. Hereby a great variety of possible applications of digital tools and methods, not only in an architectural context but also at the intersection to other product related disciplines was presented. The workshop and symposium have been supported by the ALCOA Foundation through the project "efnMOBILE.Efficient Envelopes", by the glasstec fair and by internal grants of HS OWL.

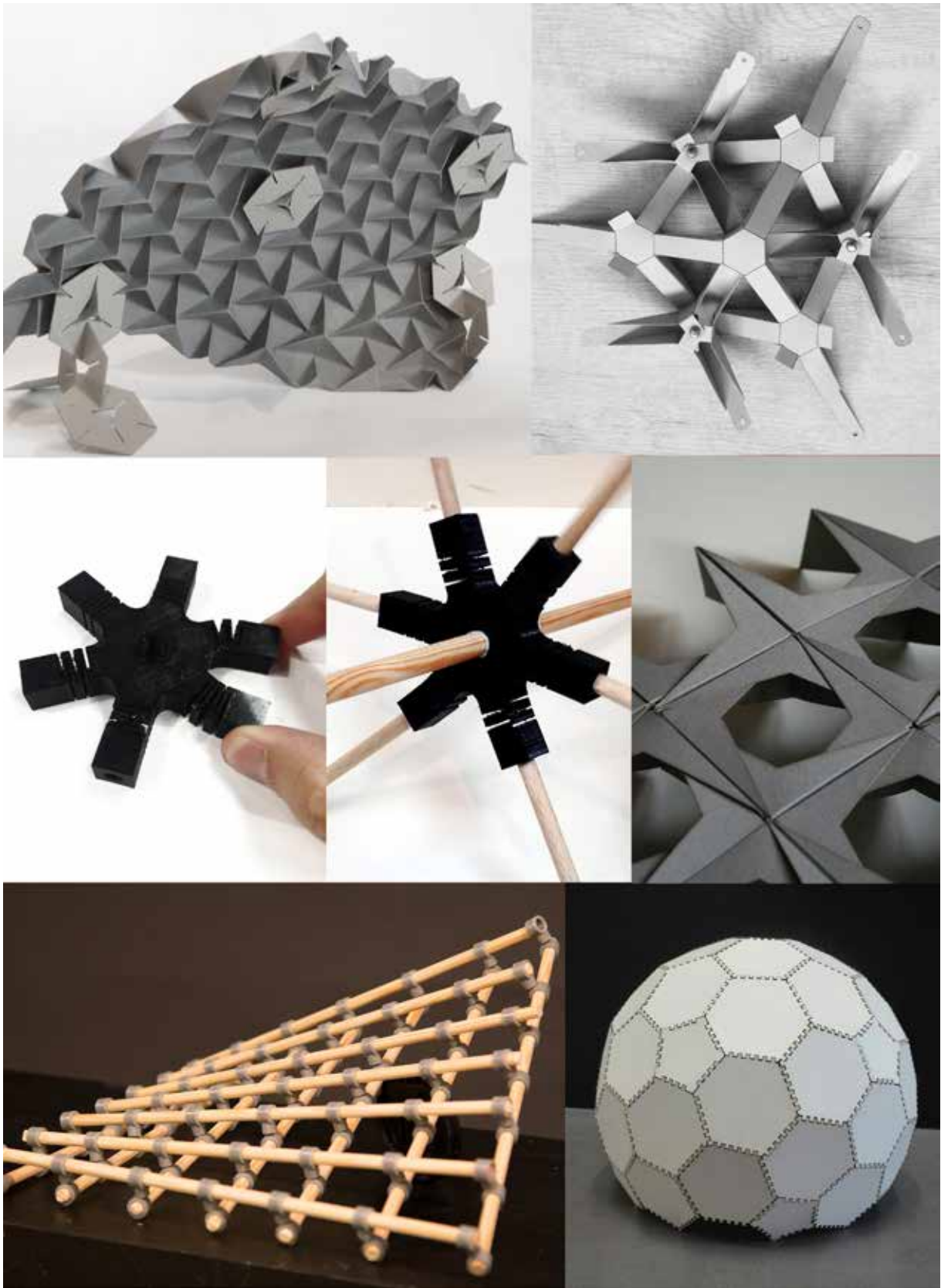


FIG. 2.21 'Form Finding Fabrication' prototypes. (images: A. Balderrama, A. Budde Thomaz Vieira, M. Makebrandt, J. Weil, L. Isabell Micus, C. Hartmann, C. Hagenhoff)



FIG. 2.22 'From making to drawing', fictitious architecture diagrams developed based on 'Digital Crafting' workshop results. (images: G. Biti and C. Lueddecke)

Digital Crafting as an Impulse to Student Realization Projects

Based on the experimental studies in the 'Digital Crafting' workshop 'Form Finding Fabrication' the students of both Master programs, the MID.MIAD 'Master of Integrated Architectural Design' and the MIAR 'Master für Innenarchitektur und Raumkunst' developed 1:1 realization projects. Throughout the semester the interior Architecture students developed a 'Generative Skin' and produced prototypes at 1:1 scale using a 3D printer, laser cutter, cutting plotter or CNC mill. The students of the MID.MIAD program developed a comprehensive proposal for an art installation at the Burning Man project (Nevada, USA) and applied their concepts for the annually announced Burning Man Honorary Art Grant. The projects were based on the following context:

Prototype Generative Skin (MIAR)

Inspired by the experiments of the group of artists and architects, Haus Rucker & Co, i.e. the 'Mind Expander' from 1967, as well as the current work of progressive fashion designers such as Anuk Wipprecht, Francis Bitonti and Iris van Herpen, the students had to develop a second, additional human 'skin' or fashion like 'envelope'. The concept and a first prototype had to be developed on the basis of various possibilities of generative modeling and computer-based (re-) production and fabrication methods. The fashion-like design also had to include dynamic, interactive elements and / or different, also technical, multimedial functions. The main aim of the task was to design a prototype of an additional, dynamic, possibly interactive body envelope using various digital modeling, prototyping and manufacturing techniques and methods.



FIG. 2.23 Desert eyes prototyping and CI development (with FB1) in project studio, Lemgo, 2017. (image: L. Albert)

Art installation at Burning Man (MIAD.MID)

In the project 'Liquid Space' the students developed a comprehensive concept and prototype of an interactive, kinetic, mobile or adaptive installation. This experimental project had to be based on the exploration of (open) digital tools, software (plugins) or new materials and techniques in order to design, develop and generate a functional prototype of such dynamic installation. The students of the master program MID.MIAD developed comprehensive concepts and partly large scale prototypes of their proposal. Several student works have been granted with free festival tickets. The student project 'desert eyes' by Pooya Kamranjam and Yonnie Kweon, both students in the MID specialization 'Computational Design', received a Honararia Art Grant of 10.000 \$. Their team has been the only selected team from Germany at the Burning Man event 2017 with the main theme 'Radical Ritual'. We provide a detailed report of this extraordinary student realization project in this book in the article 'Liquid Space'.

Conclusion

During the development of this workshop series and included studies, the dissolution of boundaries between the disciplines evolved to be a key part. Today industrially produced and used materials, especially when used in the field of building construction are, in a large part, applied far below their technical and physical capacities.

Digital, responsive and interactive systems and work flows, used in design, fabrication but also in material science represent a -still partly uncovered- but fundamental base for a real paradigm shift in architecture and design. Therefore a more interdisciplinary approach, a lively exchange of various fields and resources is required and to be intensified. During the industrial revolution in the 19th century, the exchange between different disciplines in regard to the choice of materials and technology was crucial in bringing about change and development in architecture and design.

“Grau, teurer Freund, ist alle Theorie und grün des Lebens goldner Baum.”

Johann Wolfgang von Goethe (1749 – 1832)

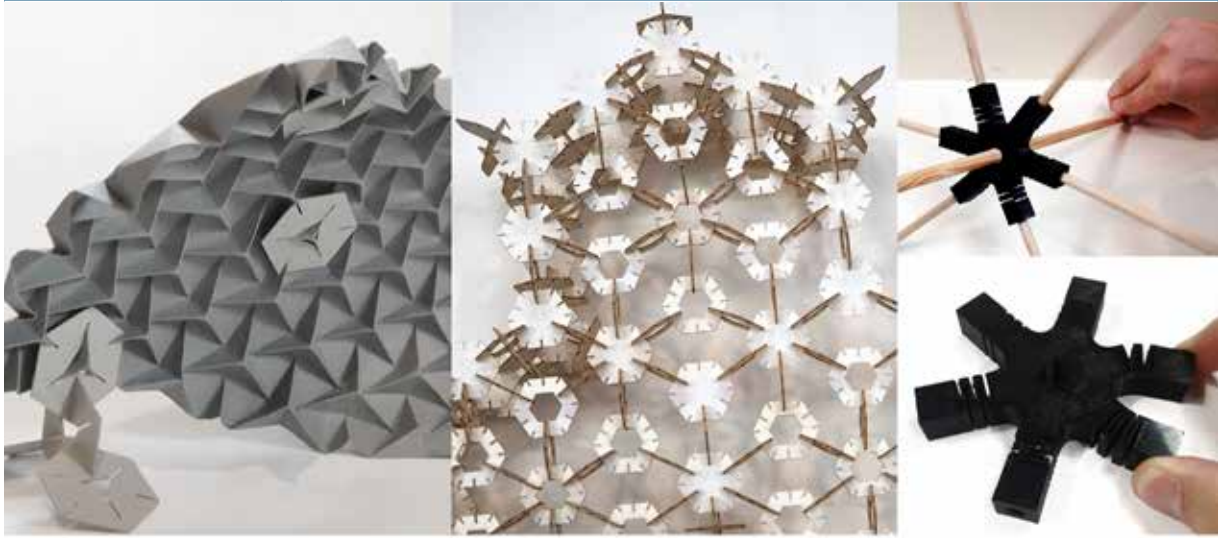
The workshop ‘Form Finding Fabrication’, which was widely based on the principles and strategies that has been argued in this article, in combination with the Symposium ‘Digital Methods’ has generated a strong dynamic within and between the workshop members and groups. Especially the opportunity to materialize ideas and virtual models with almost no waiting time and an immense precision in the same time even in the first prototype models has generated a good learning effect in various aspects: The mathematics and physics related insight in computer-based techniques for rapid prototyping and fabrication and the understanding of material, geometry and its strong relationship by the modification, reproduction and analysis of physical models.

Although the workshop does not present a base for an elaborate concept for a truly interactive and material- and process-informed production of architectural and design goods, they point out that the linkage of the referred processes represents a powerful instrument for individual and efficient creation of shape and space. Furthermore the studies mediate opportunities and challenges of a broader implementation of mass customization and open innovation processes in architecture and design.

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DIGITAL CRAFTING: FORM FINDING FABRICATION – DÜSSELDORF



Hochschule Ostwestfalen-Lippe
University of Applied Sciences

TU Delft

ALCOA
WHEELS

efn^M
european facade network mobile



DIGITAL CRAFTING: FORM FINDING FABRICATION – DÜSSELDORF

WHEN	19-23/09/2016
WHO	Students of MIAD (Master Integrated Architectural Design), MID (Master Integrated Design) and MIAR (Master für Innenarchitektur und Raumkunst)
FROM	Detmold School of Architecture and Interior Architecture, University of Applied Sciences Ostwestfalen-Lippe
DOCENTS	Prof. Hans Sachs, Prof. Dr. Uta Pottgiesser, Susann Kreplin B.A., Dipl.-Ing. David Lemberski
PROJECT CITY	Düsseldorf, Germany
WORKSHOP FUNCTION	Introduction workshop for first semester students at Glasstec fair 2016
GROUP SIZE	96 participants
INNOVATION STRATEGY	Open innovation workshop in the context of 'Digital Crafting and Methods' – Innovative digital tools: Rhino 3D Modeling, CNC Laser Cutter, 3D Printer, CNC Wire bender, CNC Cutting plotter

WORKSHOP CONCEPT

The goal of the educational workshop series 'digital crafting' is to explore and reflect the important links between form, function, material and fabrication. The interconnection of these main aspects of creation is particularly driven by the raising prominence of computational tools in the context of design and fabrication. Hereby the focus is especially on two points: the – even in real time – implementation of data in example user data which strongly relates to the concept of 'Open Innovation'. On the other hand it is about the crafting inspired approach of a comprehensive integration of material properties, its behavior and traditional processing techniques, into the design development process.

The here presented workshop and both the processes and resulting works are basically rooted in the interconnection of '3D modeling' and 'digital fabrication' techniques for model making. At the same time it is strongly related to the principles of the open maker culture, which "in general supports open-source hardware and. Typical interests enjoyed by the maker culture include engineering-oriented pursuits such as electronics, robotics, 3-D printing, and the use of Computer Numeric Control tools, as well as more traditional activities such as metalworking, woodworking, and, mainly, its predecessor, the traditional arts and crafts" (Chase, Richard B., 2006).

WORKSHOP RESULTS

In the "Form Finding Fabrication" workshop, students learned how to combine processes of the craft inspired experimentation, digital modeling and fabrication. The hereby developed folded paper structures and prototypes were then staged in a fictitious space in the second part of the workshop. In this process, the students have also mixed analogue and digital drawing techniques, i.e. integrating and modifying hand sketches in Photoshop and vice versa. The aim of this task was to use and combine the diverse working techniques (analog / digital) like hand drawing, digital image processing and 3D modeling into an artistic representation of architectural space.

2.3.2 Liquid Space

Student project for an art installation for the Burning Man Project 2017 within the core module digital tools & methods, Hochschule Ostwestfalen-Lippe, University of applied Sciences, Ricarda Jacobi

Introduction

*“We don’t stop playing because we grow old;
we grow old because we stop playing.”*

George Bernard Shaw

The project Liquid Space incorporates the idea of a student’s realization project based on the main aspects of design, dedication and professional project management. In addition the students do not only have to realize their ideas in a built project at 1:1 scale, but also do this on the other side of the globe, in a foreign country. Here the foreign culture plays an essential role being motivating and challenging at the same time. The student project has been a project work in the MID/MIAD (Master of Integrated Design / Master of Integrated Architectural Design) core module ‘C1 Digital Tools and Methods’. In this context generative and advanced modeling techniques with Rhino 5.0 in combination with the plugin Grasshopper have been used for an integrative project development: construction and organization wise. In the winter semester 2016/17 around 35 students developed comprehensive design proposals with which they applied to the Art Honoraria Grant that invites artists from all over the world to apply for financial support and assistance in the realization of a ‘Playa art installation’.

The educational concept of this challenging 1:1 realization project constitutes a very playful approach, focusing on spaces that allow to engage, to grow and change with it’s users own personal and professional development and needs. The student’s design proposals should even leave some elements of design open in order to encourage users to participate with their own input – whether this is creating the equilibrium of an adaptive and changeable object, or i.e. shaping flat-pack elements into a geodesic dome.

The module ‘Digital tools and methods’ is based on the principles of ‘Digital Crafting’, which is further explained in detail in an article with the same title in this book/ brochure. The goal in the semester project ‘Digital Crafting’ in the MIAD Core Module Tools & Methods I is to explore digital architectural ‘sketching’, modeling, planning and fabrication techniques, related software and CNC prototyping techniques such as laser-cutting and 3D printing. In this context the students gather not only experience at the intersection of these intertwined fields but also gain basic knowledge in material and process related design methods in project environment.

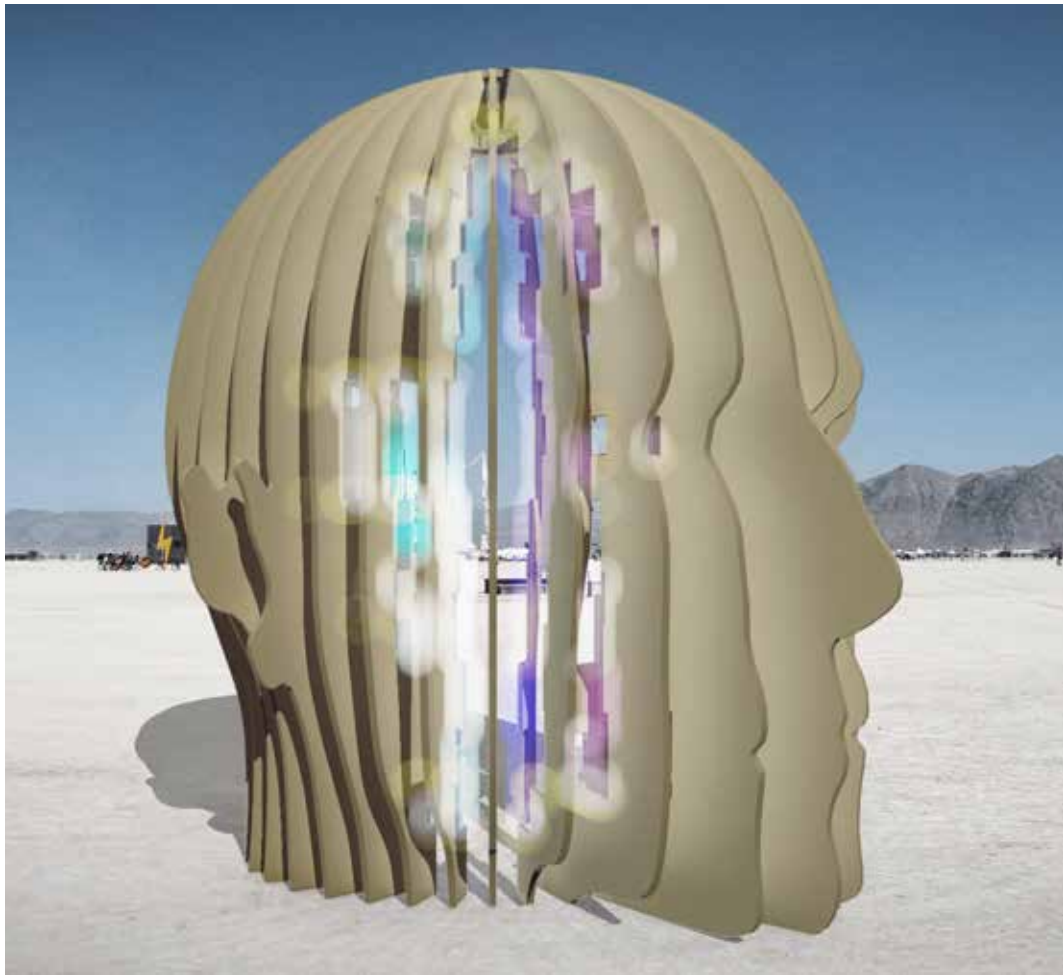


FIG. 2.24 Burning Man art Honoraria Proposal 'Perception'. (image: J. Kinder MIAD, Dec. 2016)

Task 'Liquid Space' – an art installation for Burning Man

The Burning Man Festival provides an enormous range of inspiration to create interactive installations, architecture, objects or vehicles. Unlike at a museum where works are usually just exhibited and ought not to be touched, 'Burning Man' forms a huge interactive playground. In the project 'Liquid Space' the students developed comprehensive concepts and prototypes of possibly interactive, kinetic, mobile or adaptive art installations. The experimental project should be based on the exploration of digital tools, various software in that area and related plugins in combination with innovative materials or techniques in order to design, develop and generate a functional prototype of such dynamic installation. The sensitive use of digital technologies at hand hereby becomes a means to an end, rather than a celebration of the latest tools.¹

Concept Development – individual work

The first part of the project included the research for material, techniques and software in order to formulate an idea for the installation. The use of digital production or prototyping techniques, CNC mill, laser cutter, 3D printer to explore technical potentials and boundaries was at the heart of this process. The concept had to be described in an official 'LOI – Letter of Intent', a concept proposal that should be sent as application to the Art Honorarium for Burning Man 2017 (<http://burningman.org/culture/burning-man-arts/grants/brc-honoraria/>)

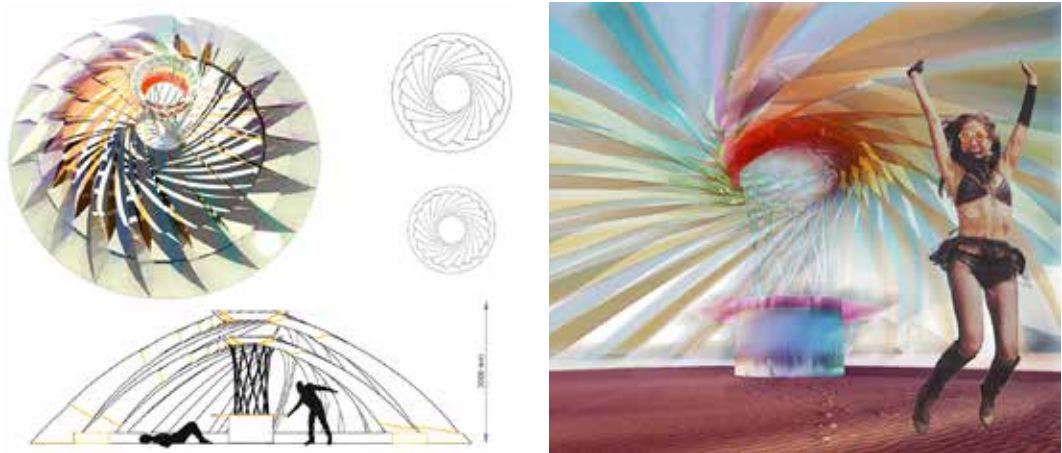


FIG. 2.25 Burning Man art Honorary Proposal 'Psychedelic Merry Go Round'. (images: G. Biti, MID, Dec. 2016)

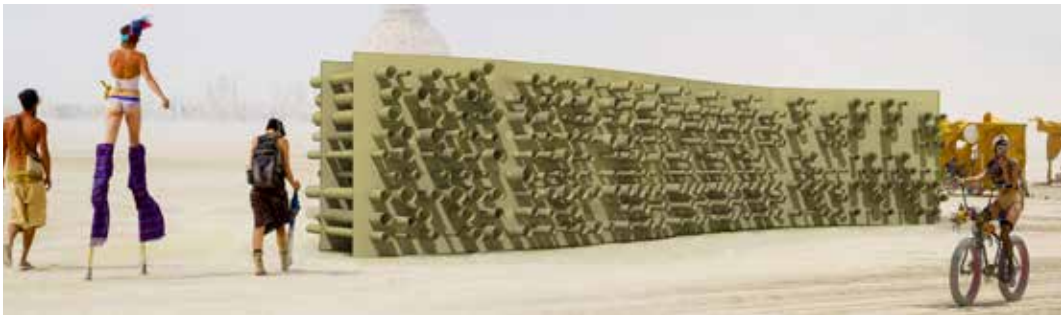


FIG. 2.26 Burning Man art Honorary Proposal 'NAGA'. (image: T. Mena, MID, Dec. 2016)

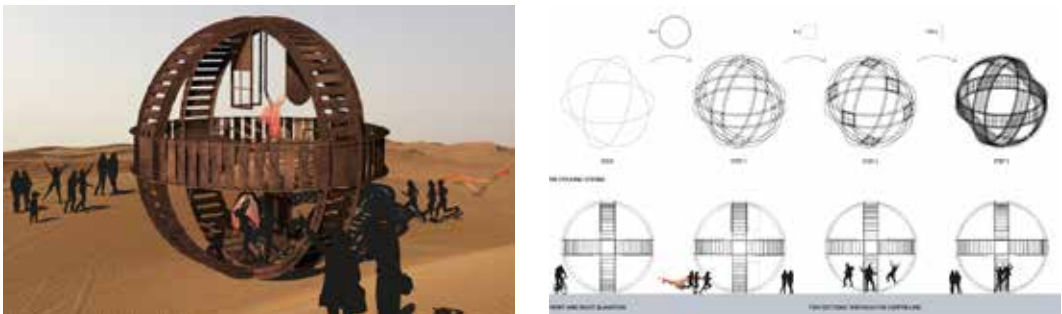


FIG. 2.27 Burning Man art Honorary Proposal 'Brightball'. (images: I. Schaeckel, MIAD, Dec. 2016)

Prototype Construction – teamwork

In a second step, a functioning prototype installation had to be planned, constructed, built and presented on the University Campus. The installations were evaluated and tested by a Jury with external guests. During the project the students had several seminars in basic and advanced 3D modeling, generative 3D modeling, optional additional software plugins, but also rendering and visualization techniques. Additionally the projects have been evaluated and supervised in regular revisions.

Why 'Burning Man'?

Burning Man² is an annual art event that takes place in 'Black Rock City', a temporary settlement in the desert of Nevada, USA during the last week of August. This 'experiment in community' as it is described by organizers gives any participant the opportunity to radical self expression. The rules within the community are basically reduced to safety issues and structures such as the regulation of spaces and movement. Therefore the event is not only remarkable in terms of the given opportunities to be creative in various ways but it also forms a society which is sociologically and psychologically very complex. The functionality of the collective is generally funded on the self-reliance of every individual inhabitant of the temporal city. As Burning Man, also described as "an annual experiment in temporary community"³, gives any participant the opportunity for radical self-expression, many art installations require interaction as crucial contribution to complete the pieces.⁴ The Festival thus presented a perfect playground for building and running the first prototype of such a student installation.

Temporality

'Black Rock City' is particularly identified by its art and architecture. An important factor that attracts people from all over the world each year is the planar surface of the desiccated lake bed that desires to be filled with life. The temporality of the event gives people the opportunity to take chances regarding installations, structures and materials because everything is going to disappear afterwards and there is almost no risk of permanent damage. Dr. Joerg Rekitke mentions five criteria in which the opportunities of temporary architecture are in evidence and can also be referred to 'Burning Man':

- Temporal architecture is able to be more daring – in concept and construction. It does not need to guarantee absolute success and can take a risk more easily than permanent architecture.
- The temporal limitation allows using materials that are improper for lasting architecture; they are adequate for the time being and can lead to a new perception of space and visual effects.
- Buildings can be constructed much cheaper than 'massive' ones.
- The building and the removal can and should be reciprocal. This means that the dismantlement is the same process as the montage and used materials don't need to be destroyed. Extensive foundations are usually not necessary; ephemeral architecture leaves no physical trace as its existence continues in the users' or spectators' minds.
- Extensive foundations are usually not necessary; ephemeral architecture leaves no physical trace as its existence continues in the users' or spectators' minds.



FIG. 2.28 Temple of Forgiveness. (image: D. Best, Burning Man 2007, MK)

Artificial People

The community of 'Burning Man' is based on ten principles which are radical inclusion, gifting, decommodification, radical self-reliance, radical self-expression, communal effort, civic responsibility, leaving no trace, participation and immediacy. These principles reflect the basic social idea behind the event. Therefore each citizen of 'Black Rock City' is ought to actively participate in the community. No spectators are wanted. This results in a society where everyone offers something without expecting anything back. Gifts include an immense offer of artwork from the tiniest selfmade stickers to monolithic structures like David Best's 'Temples'. Most participants also modify their appearance towards a fresh personality. Real identities are changed to 'Playa names' and new life backgrounds, professions or relations get invented.

Art Honoraria Grant awarded project 'Desert Eyes'

Several aspects played a role in the design and development process of the 'Desert Eyes' art installation. In general, the student projects should attract people with their visual appearance and refer to the theme 'Radical Ritual'. Due to special requirements such as long distance shipping, general world politics and local circumstances at the construction site, the structure needed to be light and elementary as well as affordable in transportation and material expenses.

"It is easier to ship recipes than cakes and biscuits."

John Maynard Keynes

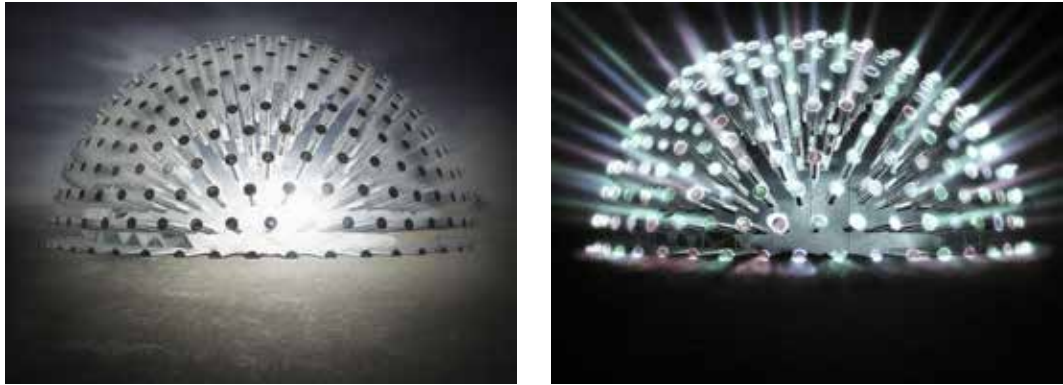


FIG. 2.29 Rendering of project 'desert eyes'. (images: P. Kamarajam and Y. Kweon, HS-OWL, 2017)

Following these principles the students were encouraged to develop their proposal based on the concept of local, digital fabrication which intensively reduced shipping and transportation costs and the complexity of logistics – and therefore the risk of failure. Therefore a large part of the constructive parts of the installation has been produced by a local CNC fabricator in Hayward, California.

The project consists of an eight metre diameter reflective, metallic dome with protruding pipes that stem from the center point, enabling viewers to view all the surrounding in separate frames. In this project, the natural context of Black Rock Desert is the conceptual focal point of the project with the installation maximising view in a 360 fashion when the user is standing in the middle of the dome. In order to achieve the qualitative aspect of contemplation in this project, there is no artificial light used inside the dome, allowing sunlight to come through 130 holes and giving viewers a unique and different experience of Black Rock Desert. Reflective shiny metal sheet is chosen as the only material used in the whole project to not only maximise the sunlight coming through pipes inside the dome, but also to reflect the natural surroundings from outside.”

Making it Happen – Project Realization in a Challenging Environment

The development of the art installation ‘Desert Eyes’ for the Burning Man Festival, can be divided into two main phases: the creative, conceptual phase, in which the idea of the project is developed; and the realization phase, in which a team composed of people with very different expertise meets and works together. This section gives an insight of the second phase. It mainly wraps around the assumption that one adopts and grows most when the risk of failure is very high and gives some impressions of this phase.

Across the disciplines

The implementation in a cross-disciplinary project with a team of students from various faculties with specific professional fields are different from other projects. The focus of this project, which is anchored in an academic environment lies on creating something new and thereby learning something new. In most cases the students have not yet developed the required experience or skills to develop a larger and complex project from sketch to realization. Hereby the biggest challenges lie in reliability, **collaboration and decision making**. It is essential to generate a certain level of trust on every team member’s ability to adapt, improve and **learn appropriate skills to find and solve problems independently**.



FIG. 2.30 Group discussion around the first prototype, 2017. (image: F. Hellmann)



FIG. 2.31 Prebuilding the construction of the dome "desert eyes", 2017. (image: J. Booth)

Furthermore everyone needs to find a way to maximize the potential as a group. This also means to be able to hand over responsibility. One single person can rarely master all skills needed in a project at this scale.

'Desert Eyes' has evolved from a student competition within a regular university course module to a 'real life' large scale art project. In the realization phase the project has been further developed by students from various faculties and disciplines. Therefore a major course module is required, that fits into the curricula of different faculties. Though the intrinsic motivation of being part of a real Burning Man art project, which is exceptionally high in this regard due to invitation to one of the world's most famous festivals, each student needs to be credited with suitable course modules. Depending on the field of study, the integration of a project-based course, outside of the compulsory courses, can be challenging or almost impossible. But at least in this case, the positive impacts of an interdisciplinary realization project surpassed the challenges: First, not being experienced and skilled sometimes opens new perspectives to new ideas and solutions. In addition it gives the opportunity to lead to a new mindset, not just professionally but also personally. Second, the best learning effect is mostly achieved by self-testing, self-proving and then finding true level of understanding. And third, working with people from other fields opens a wider appreciation and strongly develops the student's communication skills.

Detmold Campus Agency

Seeing the benefits of these kinds of projects, the Hochschule Ostwestfalen-Lippe has implemented the "Detmold Campus Agency", a network-based organization that makes such cross-disciplinary projects possible, providing practice-oriented support with funding, connections and knowledge. Next to the operational aspect, the DC Agency develops workshop formats and experiments with didactic concepts. But most importantly, it creates opportunities for students to develop their own ideas and skills without an available module manual and lets them test their project in an possibly real context.

The Burning Man project has been supported by 16 students from three different faculties. Besides coming from different disciplines, the team existed of students from seven different nations, which first of all changed the communication language to English and brought a powerful cultural diversity. The construction and project planning was handled by a team of five master architecture students. Another group of five students, from the media production, transformed the first architectural idea into a holistic business project with its own website, design concept, philosophy and social media strategy.

A third five-person team, with the study areas of electrical and computer engineering, developed the interactive lighting system for the 'Desert Eyes'. In addition there was one student handling the communication, marketing and strategy part to cooperate with potential sponsors with which the team consisted of four sub-teams. Each group pointed out one team leader with the tasks to overlook, organize and exchange most often with the other sub-teams. Other than their professional and organizational tasks the teams had to face relatively big challenges such as financials, timing and especially logistics.

Challenging context

“After an intense few months, Desert Eyes stood in the center of Burning Man’s Playa grounds resisting flash dust storms and even small amounts of rain whilst providing the Burning Man community with a space of refuge from the harsh elements. The project’s success is the result of the team’s perseverance and determination to overcome the many obstacles we were faced with.”

Yonnie Kweon, student project manager

To take up the starting hypothesis, there are a few initially required competences and some, which will be highly improved during the process. As a basic requirement, each team member should start off with a strong **curiosity** to learn and create something new, an intrinsic **motivation** to succeed, **courage** to do something new, even if perhaps risky, and to take over **responsibility** and a healthy **commitment** to the group to support each other. Coming out of the project, no matter whether it had been success or failure, the students have improved, adopted or realized the importance of **joint problem solving**, **diversity** and **communication**.

As the project has got more intense due to time pressure, cutting down meetings is often the first consequence. Yet, the most important part of teamwork is communicating. Keeping the team together is key. Having regular meetings and giving everyone the chance to present their recent accomplishments is important to keep everyone involved. And finally, it was absolutely essential to keep the project as transparent as possible for all team members, contributors and supporters. It is easy to spread out good news, but discussing the bad news makes sure nobody is left out and can be an opportunity to fight together.

“My best experience at Burning Man was the way that no matter what problem we encountered, there was always a solution. The Burning Man community is full of skilled and equipped individuals who are always ready to help out.”

Pooya Kamranjan, lead artist and project manager

Each team member had their own special experience at the dome with the visitors of Burning Man: A remarkable development of the Dome was its acoustics and climate: During the day it was surprisingly cool and at night it provided warmth, so many burners sat inside to take a rest or meditate. Often the space was used for sound experiments: for example a choir wandered through the room and filled it with sound.



FIG. 2.32 The Dome, 2017. (image: L. Albert)

Conclusion

*“Burning Man is no longer a counterculture revolution.
It’s now become a mirror of society.”⁵*

Mr. Hanson

Within the context of the presented, educational realization project, the focus of the comprehensive teaching method at first lies on the overall teaching project conditions and environment. The main goal of this project was to establish a project context that triggers positive emotions and motivation of the students to enable them to go beyond their existing limits – not only in professional but also personal aspects, of course within a reasonable framework of risk. Hereby the risk of failure is an essential element that can barely be reached with a pure simulation of an architectural or comparable development process. Each step and action forces immediate response that directly or indirectly relates to the development process and offers the possibility to fail or succeed.

Final resume by the student project team manager Yonnie Kweon on the extreme experience in Black Rock City: “The interaction and reception of the Burning Man community with Desert Eyes was overwhelming. Whether it was to seek refuge from the scorching desert sun or to get a few peaceful moments away from the excitement of Black Rock City, people connected to the space created by the dome, especially resonating with the Desert Eyes soundtrack playing in the background. The experiences made within the dome, whether personal or collaborative between strangers, were unique, heart-warming and inspirational. We made it!”

References

- 1 Manuel Kretzer, Christine Baumgartner, Hans Sachs: Architecture of Play,, Cologne/Zürich 2014
- 2 The story of 'Burning Man' started as a little ritual on the summer solstice in 1986 when Larry Harvey and a few friends met on Baker Beach in San Francisco and burned a 2,5m tall wooden man. This happened at one of Mary Graubarger' series of spontaneous art gatherings with some friends at Baker Beach in San Francisco. For no specific reason they continued doing that until 1990 when the burn of a larger 12m high statue attracted a crowd of 500 people and had to be stopped by the police for safety reasons. The same year, on Labor Day weekend, a similar event was held by John Law and the 'Cacophony Society' in a remote and largely unknown place called the Black Rock Desert in Nevada, 150km north-northeast of Reno. This location far away from civilization in a calm and empty environment proved to be the perfect place to continue. By 1995 4.000 people trekked to the desert and this marked the first time tickets were sold. In 1996 the first art-theme was proclaimed and the event grew to 8.000 participants. The population of 'Black Rock City' consistently kept growing as did 'The Man', until it reached its final height in 2002 of about 24m. Each year, more and more people attend the event, up to 70 000 in 2017.
- 3 Burning Man, 2012: Frequently asked questions, General Information. http://www.burningman.com/whatisburningman/about_burningman/faq_what_is.html, (accessed: 14.7.2013)
- 4 Doherty Brian: This is Burning Man, (New York: Little, Brown and Company, 2004), p. 274.
- 5 Mr. Hanson, Interview by The Diagonal, <http://thediagonal.com/tag/contemporary-art/>

LIQUID SPACE – DETMOLD

WHEN	01/10/2016-30/09/2017
WHO	Students of MIAD (Master Integrated Architectural Design), MID (Master Integrated Design) from the Detmold School of Architecture and Interior Architecture (FB1), student project group from the faculty of Media Production (FB2), student project group from the faculty of Electrical Engineering and Computer Science (FB5)
FROM	University of Applied Sciences Ostwestfalen-Lippe, Detmold School of Architecture and Interior Architecture, Master of Integrated Design / Master of Integrated Architectural Design
DOCENT	Prof. Dipl.-Ing. Hans Sachs, Prof. Dr. Dr. habil. Carsten Röcker, Prof. Dipl.-Des. Christoph Althaus, Ricarda Jacobi M.A., Jan Kahre-Heidemann M.A.
PROJECT CITY	Detmold, Germany / Black Rock City, Nevada, USA
BUILDING FUNCTION	Art installation for the Burning Man Project 2017
BUILDING HEIGHT	Temporary Architectural Installation
INNOVATION STRATEGY	Innovation in practical education, cross-disciplinary student realization project

PROJECT GOAL

The goal of the student project 'Liquid Space' within the context of the module 'Digital Tools and Methods' was to highlight the enabling powers of digitally driven, collaborative, participative architectural design and development strategies and show its full potential in a 1:1 realization project on the Burning Man festival in Nevada, USA.

The project has been initiated to simulate a abstracted, but holistic architectural project setup with a focus on digital development, planning and fabrication processes thus leaving space for uncertainty and surprise because this immediate experience is one of the basic characteristics of 'Burning Man'. Many artists at the event intensify it by actively integrating the participant into their art piece. Unlike at a conventional museum, where usually works are exhibited but ought not to be touched, 'Burning Man' forms a huge interactive playground without instruction rules.

Throughout the process of the project 'Liquid Space', two challenges stood in main focus in order to create a playful synergy that should finally lead to the 1:1 project realization abroad: The continuous dialogue between the team members, experts and project partners and the integration of digital design and fabrication tools and methods.



"Desert Eyes" on the Burning Man 2017 (Lars Albert)



FIG. 2.33 King Fahad National Library. (image: Gerber Architekten)

2.3.3 Textile Building Skin. New Functionality due to Smart Textiles

efnWorkshop Antwerpen, Paul Denz, FAÇADE LAB

(Smart) textile structures and façades have a long tradition in architecture due to their lightweight properties, geometrical flexibility and resource efficiency. With new developments by combination of different materials within textiles various requirements in the façade can be addressed more decentralized and individually to user needs and / or environmental impact.

Background

Textiles in general are already widespread used within the building envelope¹ in different kinds of integration levels (see FIG. 2.34). This is possible through the usage of specific textiles and constructional systems corresponding to the properties of the textile material in accordance to the requirements of the façade and building design.

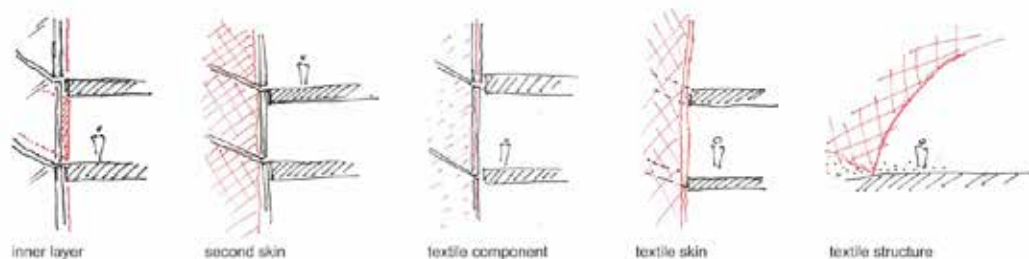


FIG. 2.34 Textiles within the building skin. (image: P. Denz)

Nevertheless textiles face several problems when applied in architecture and especially in the building envelope where they are exposed to interior and exterior influences and climate conditions. High requirements in durability and stability as well as the large-scale of building elements in comparison to current applications of smart textiles have so far prevented an integrative usage of such materials for building components or external surfaces. Also regulations such as fire protection, electric safety etc. are difficult to fulfil with current smart textiles as they are used for example in clothing industry.

Smart materials in combination with textile or membrane structures often are dealt with in the context of responsive / adaptive architecture.² Several design studies were developed where the textile surface is deformed through actuator systems sometimes also controlled by external sensors. Therefore the behavior of the user / human can be visualized within the architectural surface. Other responsive façade systems interact with the exterior like weather conditions.

But the development of smart textiles for real life applications so far is driven by disciplines like textile and clothing industry, medical technology, mechanical engineering, aerospace or automotive. Creating wearables for interaction with other smart devices, safety clothing for fire-fighters, space-suits or deformable plane-wings, health monitoring devices, measurement technology or multifunctional surfaces and composite materials.

Potential of Smart Textile Building Skins

Smart textiles in the building envelope could improve not only the all-over energy efficiency but also increase the user comfort of buildings by enabling more individual control possibilities. Energy efficiency through smart textile can be achieved because of two main reasons: textiles itself embody less energy and resources through fabrication and transportation than other cladding material. Through the added smart component the building skin can also operate more energy efficient. Directly integrated actuators like shape memory alloys need less energy, less material and less maintenance than external mechanical motors to deform the textile structure. Sensors could enable a more direct response for environmental impacts on the façade for example responding to sun and heat closing the façade. Using smart materials this could also be done automatically and self-sufficient. Integrated sensors could also be valuable for detecting breakage etc. in the façade surface therefore enabling a more efficient when needed maintenance. The user comfort could be improved through Smart Textile Skins for example by more individual and decentralized reaction to user needs through the structural integration of actuators operating different façade functions e.g. ventilation within the textile surface. Thus adjusting the façade more dynamically in correspondence to several users but also raising the psychological user comfort through individual control.

Workshop scheme

The efnMOBILE workshop on textile building addressed this potential and aimed to develop new concepts for textile building skins or textile façade components. Therefore teaching, research and practice from different fields was brought together at the workshop to trigger new concepts to be researched by architecture, façade design, engineering and textile design students.

The goal of the workshop was to investigate the potential usage of textile buildings skins according to certain façade requirements and the collaboration between different disciplines from building construction and textile design.

Therefore three main topics were preselected and handed out to two student teams per topic:

- Sun-shading
- Energy generating / harvesting
- Air quality / acoustics

To showcase the potential usage of textiles the Green Tower at the Schüco campus in Bielefeld, Germany, was used as a case study building to implement these façade solutions.



FIG. 2.35 Group photo at University of Antwerp.
(image: P. Denz)

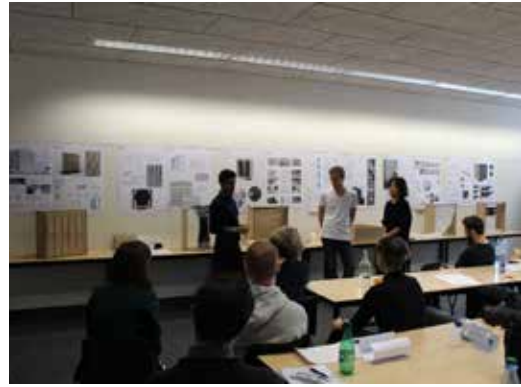


FIG. 2.36 Presentation of workshop results.
(image: P. Denz)

In total 24 students from the Master of Integrated Architecture focusing on façade construction at University of Applied Sciences Ostwestfalen-Lippe and from Textile and Surface Design at Kunsthochschule Berlin Weißensee participated in the workshop which was held at University of Antwerp. The students were supported by tutors and critics from Facade-Lab, Kunsthochschule Berlin, University of Antwerp and PJC Consulting.

Workshop results

The results of the workshop are still on a basic level of development due to the short time of three days. Nevertheless it already presents a diverse usage of materials within textile structures and geometries using textile techniques to fulfill the requirements of façade function considering local site conditions.

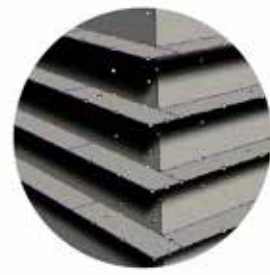
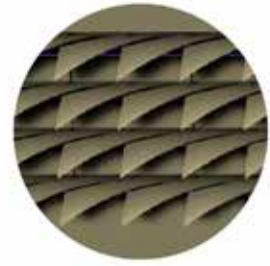
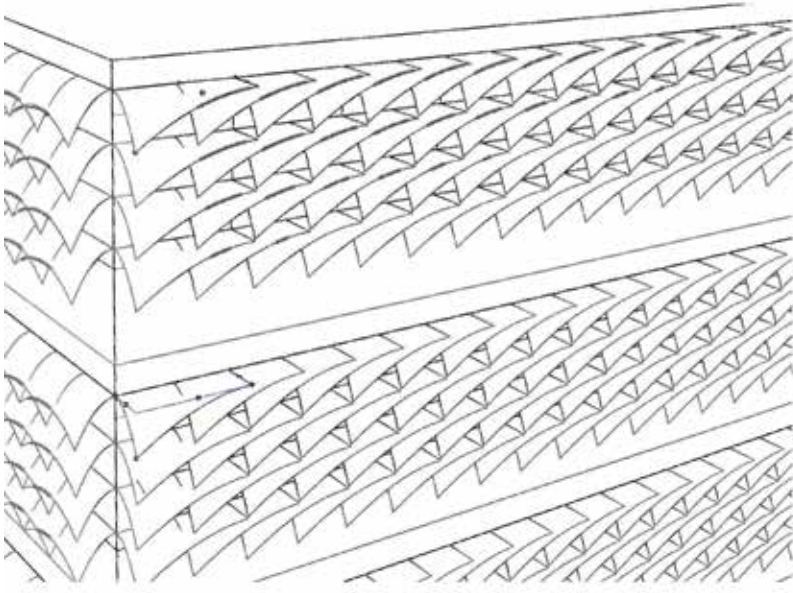
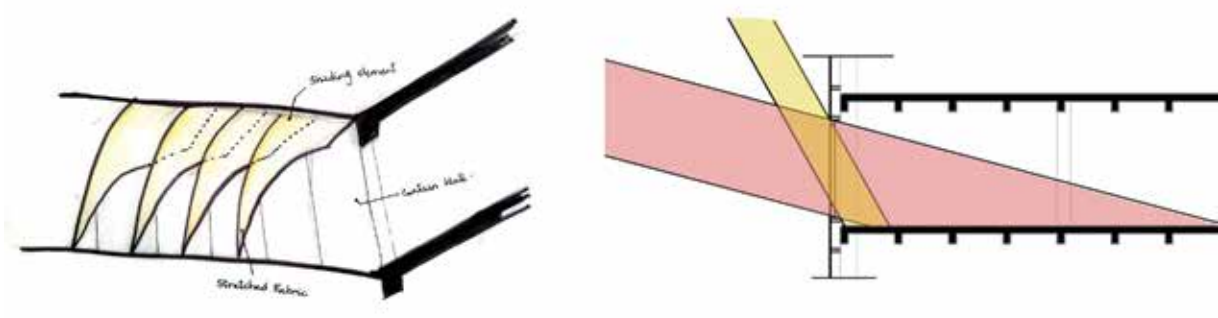
Moreover within this short but intense time the fruitful collaboration of these different fields could be demonstrated. The change of perspective and combination of knowledge triggers new developments especially shown in the upscaling of materials such as electric polymers or textile fabrication methods like the waffle weaving.

Based on the demonstrative outcome of the workshop in Antwerp future workshops are planned in collaboration with architects, engineers, fabricators and textile designers. These workshops shall deal again with specific topics in the intersection between textile structures and building skin focusing on modern fabrication techniques and constructional integration.

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- 1 Krüger, Sylvie (2009): Textile architecture: = Textile Architektur. Berlin: Jovis.
- 2 Dewider, Khaled; Mohamed, Nourhan; Ashour, Yassin (2013): Living Skins: A New Concept of Self Active Building Envelope Regulating Systems. Dubai: SB13 Conference.

TEXTILE BUILDING SKIN – ARTICULATED AWNINGS – ANTWERP



TEXTILE BUILDING SKIN – ARTICULATED AWNINGS – ANTWERP

WHEN	09-13/05/2017
WHO	Jameela Eranpurwala, Abigail Wheeler, Junshen Wu
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Sun-shading – Angle optimized sun sails.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

The Green Tower is an office building located in Bielefeld, Germany, owned and operated by the company Schüco. The angle of the sun's rays change drastically from season to season in Germany, which means the building needs sun-shading in summer, and glare protection in winter. Initial research determined the most extreme points of the sun during the winter and summer days on the north, east, south, and west facades of the building; the highest point being 60 degrees in July on the south facade and the lowest at 14 degrees in December on the east and west facades. During the winter months when the angle of the sun is lower, a more subtle glare protection is needed.

CONCEPT / SOLUTION

Because the sun rises at a much steeper angle during the summer, as well as stays higher in the sky longer, the sun protection can be solved simply by horizontal sunshades, all uniformly oriented perpendicular, or slightly angled down to the building's facade. These provide shade to keep the offices of the Green Tower cool, and stop glare on computer or television screens while allowing for nearly full visibility. During the winter when sunlight is at its most scarce, this would mean the blinds would be nearly always be shut, blocking light and visibility. To block the sun's direct rays while at low angles, but maximize visibility a new system was developed, focusing on the needs of the east and west facades.

FAÇADE INTEGRATION / DESIGN

On winter mornings, when the sun is rising from the south east at a low angle, instead of reducing all visibility and light on the east facade by shutting the blinds completely, just the exterior left corner of the sunshade can be lowered to provide the needed glare protection. The right side can remain open, to still allow light to come in. The sunshades overlap each other so that the maximum amount of southeastern direct light is blocked during the morning. A series of thin steel cables running parallel to the Green Tower's facade connect to the corners of the flexible sunshades to pull them into their positions. These positions change via an automated system specifically calibrated to block the direct sunlight on each facade.

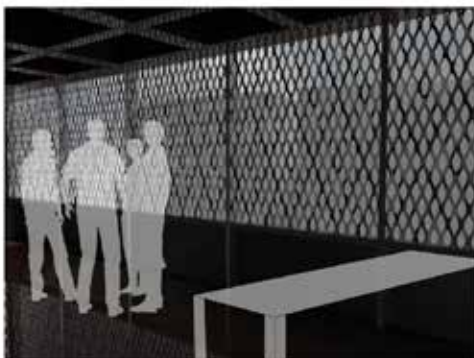
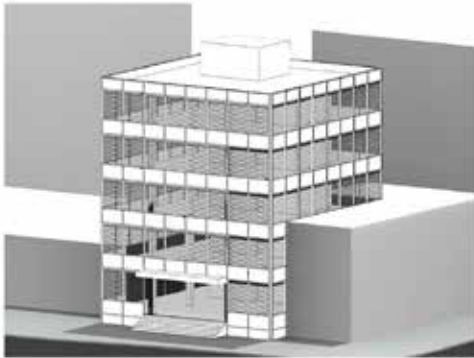
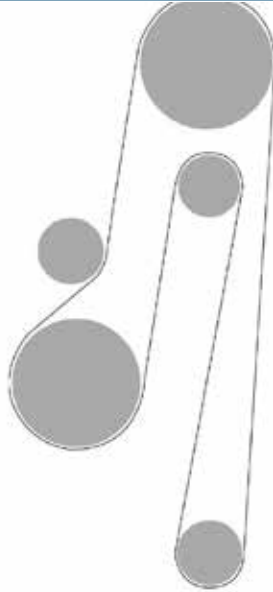
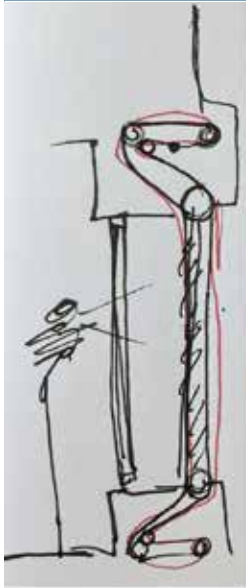
CONSTRUCTION PRINCIPLE / MATERIAL

Instead of stiff rectangular slats normally used in venetian blind systems, which work to block light and glare by adjusting the slats' angle to block light, a flexible outdoor material is utilized. This means that each corner of the rectangle can be adjusted independently from the others, allowing for more angles to block the sun while maximizing visibility. The material "Architectural Fabric by Shelter-Rite" was chosen because of its high durability in outdoor settings. Its knitted construction provides the stretch needed to be pulled into multiple positions.

CONCLUSION / OUTLOOK

This system of blocking direct sun with flexible slats could be used to create a micro mesh-like surface which would provide glare and sun protection simultaneously. Each module could be about 1 centimeter in width. This system could then potentially be applied indoors and take up minimum space. Additionally, the individual modules, whatever their size, could be programed to move independently from one another. This would optimize the system to allow the absolute maximum amount of light through while shielding the facade from any glare caused by low sun angles. A further question includes fixing the problem of the south facing facade. Ideally a solution could be found which allows some indirect light to still enter the office spaces while blocking the direct light and reducing glare.

TEXTILE BUILDING SKIN – CLOCKWORK – ANTWERP



material concept / inside view



material concept / outside view



weaving

TEXTILE BUILDING SKIN – CLOCKWORK – ANTWERP

WHEN	09-13/05/2017
WHO	Danny Mieles, Benjamin Gladki, Minyoung Han
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Sun-shading – Gradient screen.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

Our goal in this project was to provide a solution on how to provide sun-shading through the use of textiles. Over time, technologies have advanced and architecture in a way that has led us to our current use of large continuous openings on building facades. The larger openings allow more solar radiation to enter and with it the properties of the radiation i.e. warmth, light etc. This is something that must be controlled to cut down on excess or unwanted heat and light. Textiles are an old medium for solving this as we still use curtains, and shades in various spaces. We now have opportunities through new methods and technologies to develop new applications for sun shading through textiles.

The location for which we are apply and testing our concept is in Bielefeld, Germany. Located on the Schüco campus, the Green Tower is multistory office building dating back over 50 years. Given that Bielefeld has low radiation figures throughout the year and cold winters along with warm summers, shading for this particular building should allow for visibility while cutting down glare and allow for solar gain when wanted.

CONCEPT / SOLUTION

Our concept is to provide shading through a fiber mesh. This mesh will have a set gauge of its transparent areas to allow for visibility and solar gain. The gauges are set to various openings, the smaller gauges then provide more shading and less solar radiation through. Making this mesh change from one set of gauge size to another is what allows our solution to be more dynamic than some other existing solutions currently on the market.

FAÇADE INTEGRATION / DESIGN

The inspiration for the design of our concept came from mechanical advertising billboards that roll away printed ads from one to the next. Similarly our mesh would work on a system of rollers that work together to cycle through the different shading levels of the mesh. This would be manually done on our concept mockup but would be handled automatically in future iterations. The excess mesh would be house above and below and the entire system would live just within the window glazing.

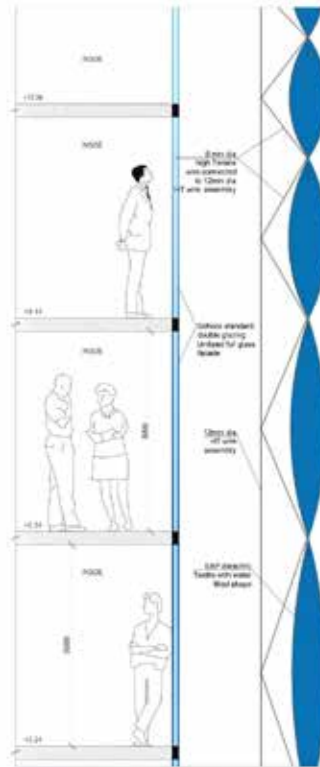
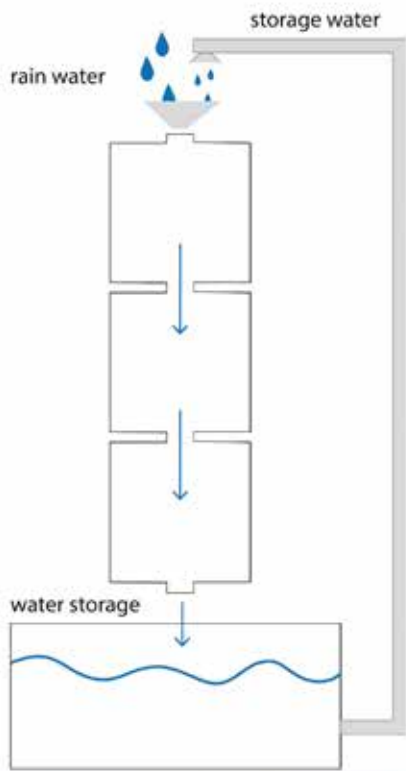
CONSTRUCTION PRINCIPLE / MATERIAL

The fabric used for the mesh would ideally be batyline fabric. It is an extremely durable and high quality material consisting of a polyester fiber covered by a coating of PVC, making it nearly impossible to tear. It is 100 percent synthetic and resistant to rot and mildew. The mockup consists of a mesh fabric and wood but a final production version of our concept would be lightweight metal rods all housed within a floor and ceiling unit.

CONCLUSION / OUTLOOK

Our concept has a lot of potential and could be applied to retrofit existing buildings with solar shading needs. The aesthetic impact from the facade aspect is minimal but can be designed to stand out as a design aspect. The next step of our solution would be to produce a custom batyline mesh with our specific needs and engineer a housing for the excess fabric stored above and below.

TEXTILE BUILDING SKIN – WATERGY – ANTWERP



TEXTILE BUILDING SKIN – WATERGY – ANTWERP

WHEN	09-13/05/2017
WHO	Lena Ganswindt, Ankit Patel, Mahsa Shafighnia, Malu Lücking
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Energy generating / harvesting – Liquid breathing; energy generation by textile movements.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

Generating energy by using innovative textiles is an efficient way to improve performance of façades and make them more sustainable. With 5 active floors, 1 basement and perfect square (14.5 X 14.5 meter) footprint the Schüco Green Tower is an ideal building to work with a textile facade. The facade area of one face is ca. 265 m² and total facade area is ca. 1058 m².

CONCEPT / SOLUTION

In the area of Schücos Green Tower are four renewable sources available that can be harvested and used for generating a sufficient amount of energy: sun, wind, noise and water. After the primary analysis of the building location, façade directions, related climatic data and analysis and primary research on available renewable energy source, we decide to use water for energy harvesting with the facade. The concept applies for the north facade and northern corner of the west façade.

FAÇADE INTEGRATION / DESIGN

The design is a combination of a simple square geometry, an organic mimicry that is following a physical principle. A square is an easy form to carry out for manufacturing process and the simple geometry helps a lot to reduce production cost with value engineering aspect. Organic mimicry means a breathing movement. By this movements the several square elements in our façade shall give an appearance of being alive. The breathing pattern will be maintained with a rain water collector and a distribution system which can be simply adopted from automated baggage sorting mechanism at airport, but here we just need a different slope and openings to distribute water, not automation. The physical principle refers to the pattern worm view which is narrow on top and broad at the bottom. This view helps to reduce the water weight of the upper square elements due to gravity factor.

CONSTRUCTION PRINCIPLE / MATERIAL

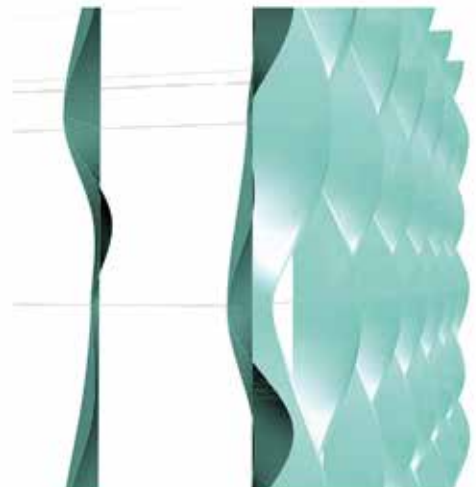
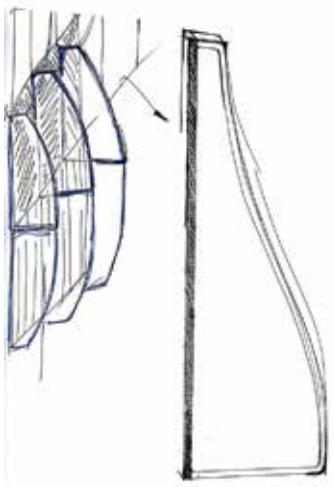
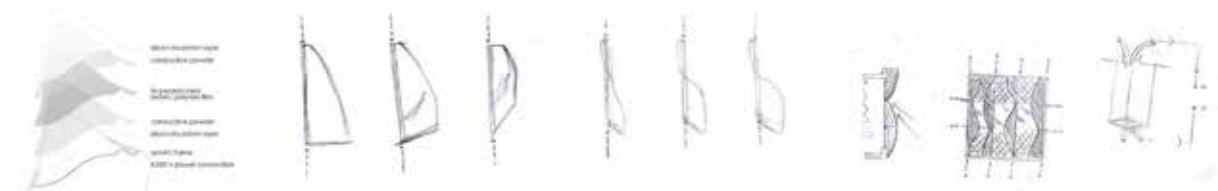
We decided to use Electroactive Polymer (EAP) for our construction. By reversing the process of EAP's reaction to electric charge we can produce approx. 2V (50 A) energy with achievement of 70–75 percentage of productivity. Dielectric EAPs are materials in which actuation is caused by electrostatic forces between two electrodes which squeeze the polymer.

We used rainwater to divert into square geometry of facade and strain the shape of square EAPs, which is applied on a second skin, made out of structural glass. Dielectric elastomer generators DEG could be fabricated using highly flexible elastic dielectric materials (Strain 300%) sandwiched between flexible electrodes that convert mechanical work to electrical energy using a variable capacitance mechanism. DEG energy density is superior to that of conventional variable capacitor generators partly because dielectric elastomer materials are essentially incompressible. Any change in one dimension produces volume conserving changes in other dimensions, amplifying the effect of deformation on the electrostatic energy.

CONCLUSION / OUTLOOK

Liquid breathing is a fresh facade concept and research topic regarding generation of energy in efficient yet environment friendly way. This Watergy (water + energy) skin envelope façade could be taken much further with more focus on various combination in shape geometry with form finding process. Watergy envelope allows a building to become greener as it catches the rain from terrace facade and using it for energy generation. Rain water, which is being released at the bottom could be again used for energy generation from water droplets or rain water storages. Liquid breathing combines energy generation from water droplets and rain water storages and therefore is a sustainable achievement in façade innovation.

TEXTILE BUILDING SKIN – CROSSWIND – ANTWERP



TEXTILE BUILDING SKIN – CROSSWIND – ANTWERP

WHEN	09-13/05/2017
WHO	Katja Riley, Rebecca Schedler, Tavishi Rana, Urvashi Tuli
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Energy generating / harvesting – Decentralized energy production by façade wind sails.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

The reference building requires refurbishment for the façade and enables different possibilities for research in upcoming new and innovative technologies in façade design. Combining the two fields of design -façade design and textile and surface design, the main idea for the refurbishment is evolved. An emphasis is laid on creating a sustainable concept, which is the need for today and tomorrow. The site is located in Bielefeld, Germany and is a part of the buildings in Schüco headquarters. The building stands at the entrance to the main complex and is an important part of the history of the company. The north and west facade of the building are facing the roads and other two face the buildings in the complex. The south side receives the sun whereas the west side receives the maximum amount of wind from all the directions. The north and west side of the building are the most important ones because visually it is a focal point that form the entrance to the company's headquarters.

CONCEPT / SOLUTION

Textile design opens new doors to light weight, transparent and innovative facades. It gives the designers an opportunity to take up new challenges and design more flexible designs. The main concept is developed with a focus on developing a façade that produces energy. The area of focus is itself a huge area for research in the future with its base being developed now in the present. The two main types of input energies that could be used to harness energy in the façade are solar and wind energy. The main idea came up with the possibility to use wind as a source to generate energy. The inspiration comes from sail boats which are the most common example of using wind as a source of energy. Movement is generated in the façade by the action of the wind forces which opens up the possibility to harness energy using kinetic energy and potential energy stored in the panels of the façade.

FAÇADE INTEGRATION / DESIGN

Each facade panels consist of a frame combined with a textile (elastomer). The panels are made of a frame which is fixed on one axis and the other sides are flexible. These panels are arranged on the facade and are fixed to an aluminum frame that holds the frames to the existing construction. The panels are arranged on the facade in an asymmetrical way and swing along the fixed axis which is connected to the main frame. The existing elevation for one floor of the building is divided into three parts. Considering the grid in mind the facade panels are designed and placed on the facade.

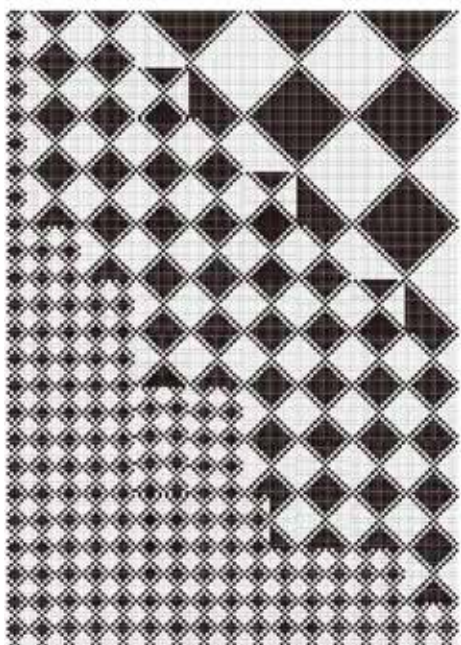
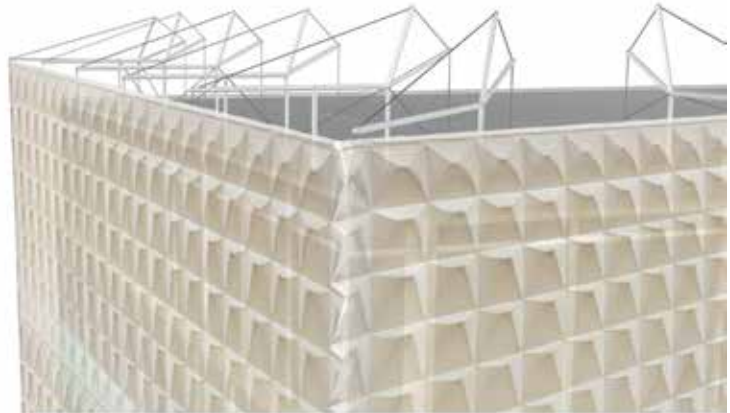
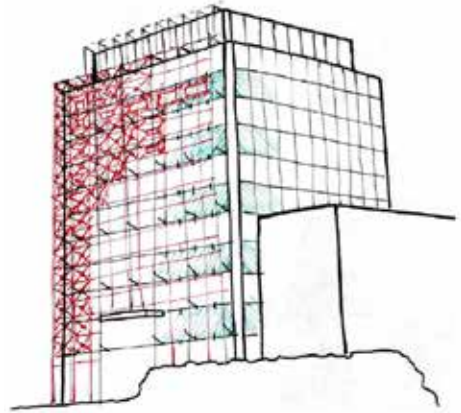
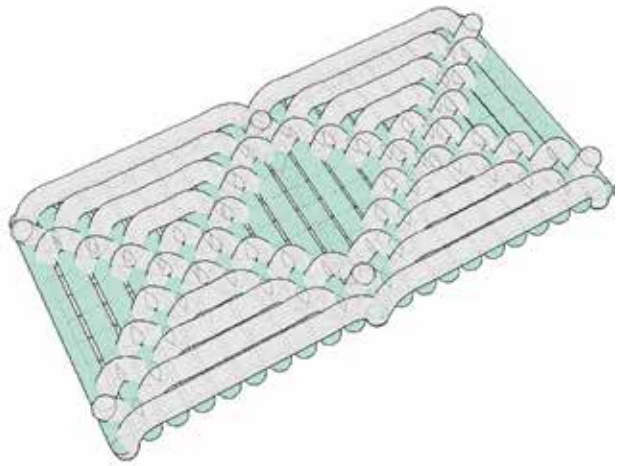
CONSTRUCTION PRINCIPLE / MATERIAL

The material is dielectric elastomers that are extremely extendable polymers. DEs are a subgroup of electro active polymers and are used in the fields of actuators, sensors as well as generators. It is a smart material system which is thin, and consist of electrode-coated foils that expand when a very high electrical voltage (kV) is applied through it. The charge can be harvested by mechanically and repeatedly deforming the material. Advantages of using this material are that it is extremely light. The expansion is about 300% and compression is precise and variably fast. Energy can be generated by oscillation, waves or vibrations. By stretching the polymers by wind power energy is harvested.

CONCLUSION / OUTLOOK

An effort has been made to create a facade that is responsive to wind and is able to process energy .The swinging of the panels can be used to create kinetic energy .The potential of generating energy by the elasticity of polymers is still in research phase.

TEXTILE BUILDING SKIN – DE ACOUSTIC WAFFLE – ANTWERP



TEXTILE BUILDING SKIN – DE ACOUSTIC WAFFLE – ANTWERP

WHEN	09-13/05/2017
WHO	Rute Chaves, Spencer Culhane, Dorothee Krings, Boram Park
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Acoustic Isolation – Noise buffering by three-dimensional waffle binding.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

The Schüco green tower is an open plan office building located at the Schüco KG corporate campus in Bielefeld Germany. The major thoroughfare, Herforder St. and the Bielefeld city tram border the northwest corner of the project site introducing significant noise pollution to the building occupants.

The installation method of the textile façade conceives the entire elevation as one massive loom. The façade is assembled using suspended scaffolding and manual weaving techniques.

CONCEPT / SOLUTION

The proposed solution improves the acoustic insulating qualities of the building's North-West elevations through the addition of an exterior woven textile façade covering. Textile construction techniques allow for simple surface construction with minimal production time and efficient material use. The system weave is composed of a unique UV stabilized closed cell foam tube with an ultra-hydrophobic coating allowing an object production technique to be used on an architectural scale.

FAÇADE INTEGRATION / DESIGN

The woven structure of the textile façade is supported via a series of vertical steel tension cables anchored to the concrete roof structure and concrete footers at the ground level. The weave is integrated directly onto the cables making them integral to the pattern. The geometry of the waffle weave pattern provides additional acoustic benefits beyond the properties of the material. The variation of pattern scale, weave density and tube thickness affects the noise reduction performance. The implementation of the textile façade with variations on these parameters results in noise reduction performance specific to the context. This allows an efficient use of material design variations that respond the existing building's requirement for daylighting.

CONSTRUCTION PRINCIPLE / MATERIAL

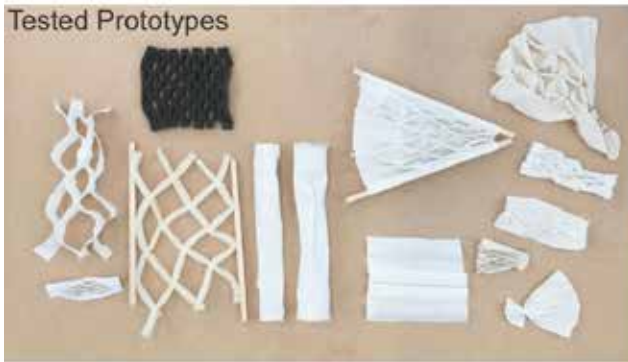
The installation method of the textile façade conceives the entire elevation as one massive loom. The façade is assembled using suspended scaffolding and manual weaving techniques. This holistic method makes the installation process akin to an art installation and expresses the traditional techniques of weaving on a building scale.

CONCLUSION / OUTLOOK

A further development of the system would incorporate a performance optimization evaluating the acoustic effects of varying material thickness, weave tightness, pattern scale, and geometry. A further proof of concept would investigate the constructability sequencing and structural detailing to accommodate wind and ice loads on the weave. Additional material studies would address the means and methods of weaving techniques on a building scale and inform the selection of the correct foam tube for constructability.

TEXTILE BUILDING SKIN – H2 SCHÜC-O – ANTWERP

Tested Prototypes

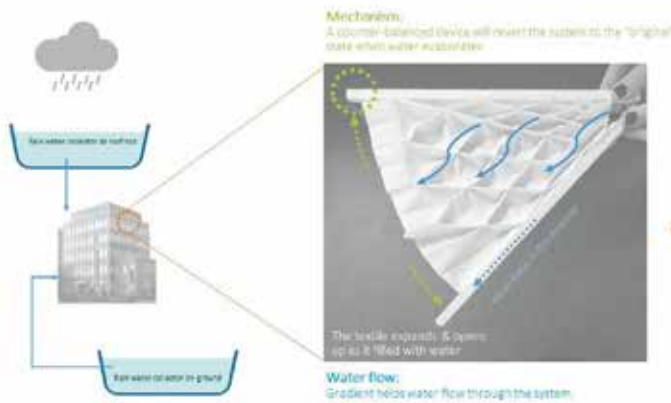


Detmold

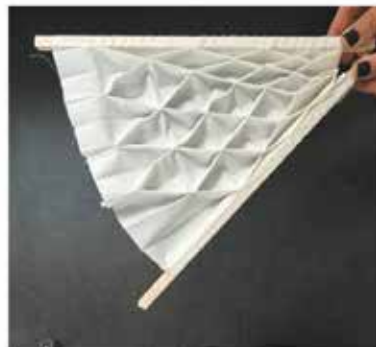
Inspiration
Regional climate characteristic

"Wetmold"

Bielefeld



Water evaporates through the textile & cool the building !



3. Opens up in FULL when the system filled with water and evaporates



TEXTILE BUILDING SKIN – H2 SCHÜC-O – ANTWERP

WHEN	09-13/05/2017
WHO	Charlotte Ackermann, Tali Berger, Anthony Chen, Jack Randol
FROM	OWL University of Applied Sciences, Integrated Architectural Design Kunsthochschule Berlin Weißensee, Textile and Surface Design
DOCENT	Dipl.-Ing. Paul-Rouven Denz, Agata Kycia Msc. Arch, Prof. Dr.-Ing. Uta Pottgiesser
PROJECT CITY	Bielefeld, Germany
BUILDING FUNCTION	Office building
BUILDING HEIGHT	Mid-rise (5-15 stories)
INNOVATION STRATEGY	Air Quality – Improving micro climate by controlled evaporation.

PROBLEM STATEMENT / CONTEXT / SITE ANALYSIS

How can a textile facade element be used to improve the climate and air quality around the building of Schüco?
Based on regional climatic characteristic of Detmold, high humidity.
“WETMOLD” is a play-on-words of Detmold from the British Army in the past.
Rain water is abundant in the region.

CONCEPT / SOLUTION

Rain water / water is the source of inspiration to generate the idea.
Water is also good cooling agent for heat evaporation thus regulates the temperature.
When water evaporates it takes away heat and to some extent improves the air quality.
Due to the cellular properties, textile is an ideal material for water absorption.

FAÇADE INTEGRATION / DESIGN

Provide a cooling agent to the “hottest” side of the building; the frontage that is subject to high temperature during the hot season.
The facade element will be textile material which absorbs and evaporates water as necessary.
The facade element is a modular system that takes up a unit of the window area and acts a “heat reducing curtain”.
The visual appearance of the textile facade element will be subjected to change which depends on its state or its function; the curtain is closed without absorbing water and opened up when it is filled with water and started the heat evaporation process.

CONSTRUCTION PRINCIPLE / MATERIAL

Rain water will be collected at the roof top and on ground level with catchment basin in rainy time.
The textile facade element will be gathered into a structural pattern which will increase the surface area to perform an effective water absorption and evaporation functions.
Rain water will be discharged to the textile facade element when it is needed to cool down the building.
The proposed material is PNIPAAm Coated Cotton which has the following performance properties:
a sponge-like structure at microscopic level can absorb 340 % of its own weight of water from misty air
the process of absorbing water and releasing it can be repeated many times
very cost efficient coating material as it is cheap and it needs very small amount
when temperature rises, the textile becomes hydrophobic and starts “releasing” water

CONCLUSION / OUTLOOK

A couple of prototypes have been proposed over the workshop period, and due to the tight time-frame only this option has been developed further for the simplicity approach.
Besides materiality of the textile facade element further investigation need to be carried out of how to control water evaporation process.
Another issue that needs to be further researched is how the rain water is collected in a controlled manner.



FIG. 2.37 The facade allows the user for different kinds of interaction from the inside and from the outside which is also based on different cultural and social experiences. (image: U. Pottgiesser)

2.4 User-Interaction with the Building Envelope

Uta Pottgiesser, University of Antwerp / HS OWL

The idea of integrating users into the design, production and operation process has been discussed for several reasons. In mass mass customisation, it can be a “promising strategy for companies ... to react to the growing individualisation of demand” (Franke and Piller, 2003). In architecture user interaction is mainly seen and analysed as user behaviour whose weight “on the energy balance of a building increases” (Hoes et. al., 2009). Next to those approaches there is the need to take into account the subjective dimension of user comfort and of user acceptance towards building design, building components and building operation strategies.

The building envelope is one of the most influencing building components in relation to user-interaction as it is not only affecting the energy-efficiency but also all aspects of the individual user comfort (thermal, visual, acoustic, olphactoric, haptic) more or less intensively. The user's role is crucial for the overall performance of the building envelope. Building monitorings show that calculated values are not achieved due to different reasons, an elemental one is the non-adequate user behaviour.

It seems to be reasonable that a complex system such as a building and its envelope are going to be explained to the user beforehand as any other consumer product. This can be improved by raising awareness with better information, training and education on the basis of mock-up testing and evidence based-design (EBD) in the design process and by post-occupancy evaluations (POE) during the operation phase. Sustainability is approached not only with an ecological and economical focus but more than that with a social focus, involving other disciplines such as environmental psychology, neuroscience and behavioral economics.

The user interaction was investigated in efnMOBILE 2.0 with two different foci in three workshops in Lucerne (2016), Delft and Detmold (2017). While the workshops in Lucerne and Detmold dealt with the diversity of users and designers, the workshop in Delft had its focus on the user comfort based on a comparative study of different buildings and building services systems. Both were investigating methods to implement individual and social factors into an early stage of the facade design process.

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- 1 Nikolaus Franke & Frank T. Piller (2003). Key research issues in user interaction with user toolkits in a mass customisation system. *International Journal of Technology Management (IJTM)*, Vol. 26, No. 5/6.
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- 2 P.Hoes J.L.M.Hensen M.G.L.C.Loomans B.de Vries & D.Bourgeois (2009). User behavior in whole building simulation. *Energy and Buildings*, Volume 41, Issue 3, March 2009, Pages 295-302.
To link to this article: <https://doi.org/10.1016/j.enbuild.2008.09.008>



FIG. 2.38 International master students during their visit of the facadelaab in Großbeeren near Berlin. (image: U. Pottgiesser)

2.4.1 Cultural Otherness and Architecture. Learning with and from Diversity

Uta Pottgiesser, University of Antwerp / HS OWL

Higher education institutions (HEI) are challenged to deal with the complexities and the potentials posed by a diverse student body (Rodriguez-Falcon, 2015). Similarly to other international programs, the presented façade programs and their related workshops aim to profit from this cultural and experiential diversity within their student bodies. Despite all technological innovations, architecture and design are inextricably linked to social and cultural conditions and traditions.

“L’architecture est une expression de la culture.”

Loi n° 77-2 du 3 janvier 1977 sur l’architecture, Art. 1er

The French Law on Architecture from 1977 was the first legal document that raised awareness of the public and cultural dimension of architecture. Since then, further activities in the Netherlands (1987), Finland (1999) and Sweden (2000), and other European countries, followed. In 2007, the Bundesstiftung Baukultur (2017) was founded in Germany with the “goal of anchoring the outward appearance and condition of the built environment as a topic of public interest.” These initiatives have emphasised the aim to improve the quality of architecture and the built environment as a political and educational task within the context of globalisation. This means the enabling of intercultural communication.

Intercultural communication and “cross-cultural learning do(es) not automatically occur whenever people meet, even for extended or intense periods of time (Otten, 2000). Instead, the tendency is to remain congregated together within cultural comfort zones.” Cultural interactions and diversity do not only take place between persons with different nationalities, but are relevant within any society or team. Thus, strengthening cultural diversity awareness through training is necessary. Two workshops in Lucerne (2016) and in Detmold (2017) aimed to test an experimental pedagogical tool for multicultural contexts that pursues its aims through housing and architecture. This is not only the area of specialisation of the students involved (architecture) but it also makes use of the student’s personal experiences in their native environments.

References

- 1 Elena Rodriguez-Falcon , Alma Hodzic & Anna Symington (2011) Learning from each other: engaging engineering students through their cultural capital, *Engineering Education*, 6:2, 29-38. To link to this article: <http://dx.doi.org/10.11120/ened.2011.06020029>.
- 2 Loi n° 77-2 du 3 janvier 1977 sur l’architecture (1977) To link to this article: https://www.legifrance.gouv.fr/lo_jo_pdf.do?id=JORFTEXT000000522423
- 3 Bundesstiftung Baukultur (2017) Link: <https://www.bundesstiftung-baukultur.de/en/foundation>
- 4 Otten, M. (2000) Impacts of cultural diversity at home. In: Crowther, P., Joris, M., Otten, M., Nilsson, B., Teekens, H., and Wächter, B. (eds.) *Internationalisation at home: a position paper*. Amsterdam: European Association for International Education, 15-20.

CULTURAL OTHERNESS AND ARCHITECTURE: LEARNING WITH AND FROM DIVERSITY / LUCERNE 2016

HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				
HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				
HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				
HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				
HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				
HOUSE	ANALYST	ANALYST	ANALYST	ANALYST
Guess house' country				
To which façade does it correspond				

CULTURAL OTHERNESS AND ARCHITECTURE: LEARNING WITH AND FROM DIVERSITY / LUCERNE 2016

WHEN	05 – 06 / 10 / 2016
WHO	9 Students Master International Facade Design and Construction (IFDC) / HS-OWL
WHERE	Hochschule Luzern, University of Applied Sciences and Arts, Lucerne, Switzerland
DOCENT	Prof. Dr. Sandra Marques Perreira / Prof. Dr. Uta Pottgiesser.
STUDENT COUNTRIES	Egypt, India, Iran, Germany, Syria, Croatia, Albania, Thailand, Korea, Indonesia, Venezuela
WORKSHOP TOPICS	Housing and Facade Design
WORKSHOP CONCEPT	Moderated team work and group discussions
WORKSHOP STRATEGY	Learning with and from diversity

METHODOLOGY

Globalization has contributed to international mobility with several purposes, from tourism and work to university education. The Master of 'International Facade Design and Construction (IFDC)' from Detmold School of Architecture and Interior Architecture has two important specificities: multiculturalism and interdisciplinarity. The present text summarizes an experience developed in 2016 within that Master that exactly aimed at exploring multiculturalism in pedagogical terms, in articulation with the thematic specificities of the course. The Workshop - Cultural otherness and architecture: learning with and from diversity - had two main objectives:

- 1) to deepen knowledge on cultural diversity;
- 2) to stimulate creativity and openness to incorporate different/unknown solutions in the design process, by exploring the built environment context and living conditions of multiple cultures - buildings facades, housing and domestic uses/ appropriations.

The two-day Workshop had 10 participants from 9 different nationalities: Germany, Croatia, Turkey, Egypt, Iran (2), India, Thailand and Korea; 3 women (Turkey, Iran, India) and 7 men. The workshop was composed by two exercises which are presented here with their results.

EXERCISE 1: HOUSE OF OTHERS

The first - 'House of Others' - as its name suggests explores housing and home's cultural diversity. The main purpose is that students have a first, but not that superficial, insight of their colleagues housing cultures (structures of houses, uses, materials, meanings) through the houses of each other. In a first moment, each student made a 'blind analysis' of 4 different houses. In this regard, they had to complete an empty layout (with furniture and rooms designation), guessing its functional structure and uses. Within this analysis, they should answer the following questions:

1. Guess the house' country.
2. To which façade does it correspond
3. How do you imagine this house is used/ (put the furniture).
4. Justification of these options.

Each student presented than his own 'blind analysis' to the entire group. After that, the owner of the house presented the real situation, explaining his housing and living conditions. Finally, each analyst made some observations about his own options and the most surprising aspects of the real situation.

Results

The figure on the left presents, in a summarised way, the results of the exercise. The criterion for distribution of the participants was the mix of nationalities. The first column represents the student's house subject of the 'blind analysis' and the other four columns refer to the 'blind' analysis of the different students. From it, one reflection should be underlined: the discovery of the 'identity' of a residential building is easier among single-family detached houses – multi-familiar buildings have adopted 'modern architecture' more generally than single-family houses which tend to be more attached to the 'local' aesthetic reinforcing their territorial specificities.

CULTURAL OTHERNESS AND ARCHITECTURE: LEARNING WITH AND FROM DIVERSITY / LUCERNE 2016

efnMOBILE. Efficient Envelope



COST TU 1403

Workshop: Cultural otherness and architecture: Learning with and from diversity

Exercise 2: Global Facades

Group 2

Yekira (Iraq)
Etimwehik (Iraq)



How would you define this facade (3 adjectives)?

- black and white colored style of facade
- plantation with window
- stepped / pitched roof
- small openings for cold climate
- earthquake resistant
- fire resistant

What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

- wood for beam and column skeleton structure
- facade for planting
- pitched roof to capture sun's light
- quick installation material (like pre-fabricated window profiles)
- more glazing - to fulfill customer's needs
- high-performance materials to support contrasting requirements

Description by the student responsible for the facade:

- Paul Rötter
- "Fachwerkhaus" (half timbered house)
- 19th century
- Paul Rötter
- 21st century
- Mohamed Zayed
- Egypt - Ayni (Hulu)
- lower part of town
- discovered in 1940s
- Mohamed Zayed
- Alexandria
- 1930s

efnMOBILE. Efficient Envelope



COST TU 1403

Workshop: Cultural otherness and architecture: Learning with and from diversity

Exercise 2: Global Facades

Group 2

Abekadi (Syria)
Bhaskarhwa (Thailand)



How would you define this facade (3 adjectives)?

- Islamic architecture
- planted with
- sustainable
- landscape integration with architecture
- a lot of openings (for natural light)
- combination of wood & steel are not well used
- balcony with plantation
- interaction between pedestrian & building
- square
- corner opening

What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

- using the pitched roof for window fabric
- using stone & clay
- water evaporating
- combine planting into facade
- corner window
- wood material
- free to provide shading
- big amount of glass of daylight in living area
- refined the verandah image
- steel doors & materials

Description by the student responsible for the facade:

- Saharun Bismahki
- house for middle family
- named "harajeh" (the)
- Saharun Bismahki
- residential buildings
- Ali Tugrul
- It's a traditional residential building
- approximately 100-100 years old
- Ali Tugrul
- It's a residential building



European COST Action TU1403
Adaptive Facades Network



European COST Action TU1403
Adaptive Facades Network



efnMOBILE. Efficient Envelope



COST TU 1403

Workshop: Cultural otherness and architecture: Learning with and from diversity

Exercise 2: Global Facades

Group 4

Mashkan (Iran)
Zayel (Egypt)



How would you define this facade (3 adjectives)?

- vernacular architecture
- ecological material
- simple
- old
- integrative
- social context
- international style
- compact (skyscrapers / high-rises)
- no respect to nature
- modern style
- eye lining
- no ornamentation
- bling
- quiet and calm
- organic
- respect to nature
- integrative
- careful
- beautiful
- related to typology
- modern, but not too
- sustainability
- integrated to nature

What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

- stone / waterproof
- extended roof (for shading)
- big openings
- inclusion openings
- punctured windows
- vertical extension of city
- population density
- evaporative cooling
- integrated to nature
- preserving traditional culture and craftsmanship
- water energy
- orientation

Description by the student responsible for the facade:

- Spring Rock (Dering) Sun
- in 20P weather
- Egypt - Alexandria
- Spring Rock (Dering) Sun
- lower palace
- getting burned in the same class
- Ayan Cakiray
- Barni houses
- local materials used
- stone
- city was made in village style
- Sun, animals
- Ayan Cakiray
- typical modern house

efnMOBILE. Efficient Envelope



COST TU 1403

Workshop: Cultural otherness and architecture: Learning with and from diversity

Exercise 2: Global Facades

Group 5

Sak (Korea)
Cakay (Chile)



How would you define this facade (3 adjectives)?

- old
- single
- religious
- rural
- functional
- high
- modern
- adaptive
- sublime
- connected to nature (symmetrical)
- traditional
- wood
- symmetrical
- local
- big trees (supernatural)
- glomy
- typical
- opened (more light, sunny)
- sustainable
- insulated

What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

- using local materials (bricks, stone)
- using simple economic design
- adapt colorful design
- space organization
- ensure the privacy
- use for preserving traditional culture
- practical, religious purpose
- use local stones
- connections to outer environment
- implementing wood for modern design
- connections to outer environment

Description by the student responsible for the facade:

- Nahira Wokub
- architect - James Baker
- for wall and formal concrete
- for a university
- year 1980s
- Nahira Wokub
- hot & dry climate
- year 2011 (approximately)
- farmhouse
- Azha Madjhan
- residential complex
- more than 500 years ago
- more than 10 families
- wind catcher
- night flash cooling
- low in elevation
- Azha Madjhan
- suburb of Seoul
- 2011 - 2014



European COST Action TU1403
Adaptive Facades Network



European COST Action TU1403
Adaptive Facades Network



CULTURAL OTHERNESS AND ARCHITECTURE: LEARNING WITH AND FROM DIVERSITY / LUCERNE 2016

WHEN	05-06/10/2016
WHO	Master Integrated Architectural Design (MIAD), (MID) – Facade Design and (MID) – Computational Design Students / HS-OWL
WHERE	Hochschule Luzern, University of Applied Sciences and Arts, Lucerne, Switzerland
DOCENT	Prof. Dr. Sandra Marques Perreira / Prof. Dr. Uta Pottgiesser.
PROJECT CITY/COUNTRY	Egypt, India, Iran, Germany, Syria, Croatia, Albania, Thailand, Korea, Indonesia, Venezuela, etc.
WORKSHOP TOPICS	Housing and Facade Design
WORKSHOP CONCEPT	Moderated team work and group discussions
WORKSHOP STRATEGY	Learning with and from diversity

EXERCISE 2: GLOCAL FACADES

For the second exercise, 'Glocal Facades', each student brought photographs of the facades of two different buildings from their own countries: a vernacular and a contemporary one. As in 'House of others', 'Glocal Facades' began with a "blind analysis" made by two students of 4 facades, which belonged to other two students. During this analysis, students should answer to the following questions:

1. Corresponding country;
2. How would you define this facade (5 adjectives)?
3. What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

After the presentation of the 'blind analysis', the students responsible by the Facades, presented the 'real situation'. The discussion on vernacular facades was, in general, more intense than the other: the dominant feeling among the students was that contemporary facades were largely characterized by some homogeneity that turned cultural diversity less perceptible. For the same reason, that perceived homogeneity made the geographical location of contemporary facades a more difficult task.

Results

The 4 posters on the left represent the results, each with 4 facades chosen by two students from different countries and commented by two other students from again different countries to clarify the different experiences and backgrounds.

SUMMARY

In both exercises, more interesting than the results by itself, group dynamics generated and the cultural learning process were the main achievements of this pedagogical experience, something expressed by the students in their post-evaluation of the WS: "better than normal lecture" or "discussion and communication helps to keep it in mind for a longer time and remember" were two of the several appreciations made by the students after the workshop.



GLOBAL FACADES / DETMOLD 2017



University of Applied Sciences and Arts
**HOCHSCHULE
LUZERN**
Technik & Architektur
Innovation & Inspiration

Hochschule Ostwestfalen-Lippe
University of Applied Sciences

Detmolder Schule für Architektur
und Innenarchitektur

MIAD // MID



GLOBAL FACADES / DETMOLD 2017

WHEN	04 / 10 / 2017
WHO	25 Students Master Integrated Architectural Design (MIAD) and Master of Integrated Design (MID) from Facade Design and (FD) – Computational Design (CD) / HS OWL
WHERE	Ostwestfalen-Lippe, University of Applied Science, Detmold, Germany
DOCENTS	Prof. Dr. Sandra Marques Perreira / Anica Dragutinovic, M.Arch.
STUDENTS COUNTRIES	Germany, Egypt, India, Indonesia, Venezuela, Syria, Albania, Kyrgyzstan and Cyprus.
WORKSHOP TOPICS	Facade Design
WORKSHOP CONCEPT	Moderated team work and group discussions
WORKSHOP STRATEGY	Learning with and from diversity

DESCRIPTION OF THE EXERCISE GLOBAL FACADES

The workshop in Detmold had 25 participants from 9 different nationalities: Germany, Egypt, India, Indonesia, Venezuela, Syria, Albania, Kyrgyzstan and Cyprus. There were 14 Architectural, 7 Facade and 4 Computational Design Students. There were 13 woman and 12 men.

Three criteria for the construction of the groups by hierarchical order:

1. nationality mix
2. course mix
3. different gender

For the exercise 'Glocal Facades' each student brought photographs of the facades of two different buildings from their own countries: a vernacular and a contemporary one. It began with a "blind analysis" made by two students of 4 facades, which belonged to other two students. During this analysis, students should answer to the following questions:

1. Corresponding country
2. How would you define this facade (5 adjectives)?
3. What type of solutions (materials, space organization, adaptivity, etc.) do you think could be used in a generally housing facade design?

After the presentation of the 'blind analysis', the students responsible for the facade, presented the 'real situation'.

LESSONS LEARNED

The students learned about different cultures through vernacular and contemporary architecture of the countries. The interactive workshop provided dynamic cultural learning process.

Furthermore, the students learned about specific elements of architecture – locally and culturally related. One example is Mashrabiya, an element of traditional Arabic architecture used in vernacular architecture since the Middle Age, but also in contemporary architecture.

Different aspects of facade design were included in the analysis of the facades, such as:

1. Relation between local climate conditions and facade design
2. Structure and construction – analysis of the structural elements that are visible elements of facades
3. Local materials applied, especially in the examples of vernacular architecture
4. Spatial aspects, such as openness/ closeness of the architecture, and how that influenced facade design
5. Other aspects, such as accessibility, safety etc.

Through this analysis, the students learned more about the relation between these aspects and design of the facades. Additionally, they learned how that is related to the function of the building.

The discussion on vernacular facades was, in general, more intense than the other: the dominant feeling among the students was that contemporary facades were largely characterized by some homogeneity that turned cultural diversity less perceptible.

HOUSE OF OTHERS / DETMOLD 2017

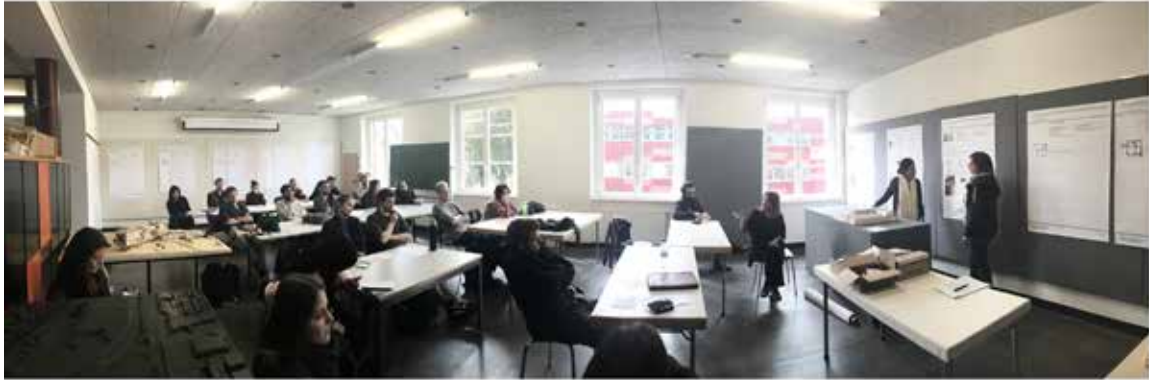


University of Applied Sciences and Arts
**HOCHSCHULE
LUZERN**
Technik & Architektur
Innovation & Entrepreneurship

Hochschule Ostwestfalen-Lippe
University of Applied Sciences

Detmolder Schule für Architektur
und Innenarchitektur

MIAD // MID



HOUSE OF OTHERS / DETMOLD 2017

WHEN	05 / 10 / 2017
WHO	25 Students Master Integrated Architectural Design (MIAD) and Master of Integrated Design (MID) from Facade Design and (FD) – Computational Design (CD) / HS OWL
WHERE	Ostwestfalen-Lippe, University of Applied Science, Detmold, Germany
DOCENT	Prof. Dr. Sandra Marques Perreira / Anica Dragutinovic, M.Arch.
STUDENTS COUNTRIES	Germany, Egypt, India, Indonesia, Venezuela, Syria, Albania, Kyrgyzstan and Cyprus
WORKSHOP TOPICS	Housing Design
WORKSHOP CONCEPT	Moderated team work and group discussions
WORKSHOP STRATEGY	Learning with and from diversity

DESCRIPTION OF THE EXERCISE HOUSE OF OTHER

The workshop in Detmold had 25 participants from 9 different nationalities: Germany, Egypt, India, Indonesia, Venezuela, Syria, Albania, Kyrgyzstan and Cyprus. There were 14 Architectural, 7 Facade and 4 Computational Design Students. There were 13 woman and 12 men.

Three criteria for the construction of the groups by hierarchical order:

1. nationality mix
2. course mix
3. different gender

The exercise 'House of Others', as its name suggests, explores housing and home's cultural diversity. The main purpose is that students have a first, but not that superficial, insight of their colleagues housing cultures (structures of houses, uses, materials, meanings) through the houses of each other. In a first moment, each student made a 'blind analysis' of 4 different houses. In this regard, they had to complete an empty layout (with furniture and rooms designation), guessing its functional structure and uses. Within this analysis, they should answer the following questions:

1. Guess the house' country,
2. To which facade does it correspond,
3. How do you imagine this house is used/ put the furniture,
4. Justification of these options.

Each student presented than his own 'blind analysis' to the entire group. After that, the owner of the house presented the real situation, explaining his housing and living conditions. Finally, each analyst made some observations about his own options and the most surprising aspects of the real situation.

LESSONS LEARNED

The students learned about different housing cultures through the examples of houses of the other students coming from different countries. The interactive workshop provided dynamic cultural learning process.

Spatial organization of the houses was a special focus of this exercise, where the students learned about different ways of using the space and organization of space.

Furnishing the empty layout of the house of other was an interactive way of learning about it. The students learned about different elements of space that are present in some cultures, while not in others. An example of that is a summer and a winter living room, "public" living room, space for shoes, reception for guests, etc.

Furthermore, the students learned about different distribution of the rooms and different spatial organization of the houses. Position of living room was different in different cultures, also orientation of rooms.

The flexibility of "room purpose" was also different in different cultures. In some cultures there is strong differentiation between the room purposes, while in other cultures different purposes could be merged within one room.

Additionally, the students learned about the relation between spatial organization and facade design, by finding a correspondent facade for the house that is being analysed.



FIG. 2.39 Faculty of Electrical Engineering, Mathematics and Computer Sciences, Delft University of Technology. (image: A. Prieto Hoces)

2.4.2 Interacting with the Façade. Lessons from Everyday Life in Office Buildings

efnWorkshop Delft, Alejandro Prieto Hoces, TU Delft

Commonly, architects and façade designers are present during design and construction stages of the façade development process, without mayor involvement during the operation phase. Hence, they usually miss the chance to evaluate how their designs perform in reality, preventing the use of valuable feedback for future projects and neglecting user interaction as design input.

The Assignment

The efnMOBILE workshop sought to position students in the operation phase of building envelopes, learning from the daily experience of users from real office buildings from TU Delft campus. Office buildings consider extra challenges compared to residential buildings, due to the higher technical complexity of façade systems and unclear user profiles, which results on a need for standardisation that not always matches users' comfort and control needs.

The workshop was structured around the assessment of real office buildings, focusing on three key aspects to promote a discussion about the role of the building façade during the operation phase, and the identification of existing possibilities for user interaction: comfort, automation, and adaptability over time.

Comfort / Occupants' behaviour: Perceived indoor comfort from users, and the identification of technical components from the building envelope able to adapt in order to accommodate to changing occupants' behavioural patterns.

Automation / Interface: How can we interact with the building envelope and the use of automation to allow for varying degrees of users' control over the operation of the façade.

Adaptability over time / Maintenance: Adaptability of the building envelope over time, with special attention on present and future requirements and necessary maintenance activities that support their operation under changing internal and external conditions. This aspect considers user interaction with facades, not only from the office occupant perspective, but also from the building's management team, adding another layer of user interaction during the operation phase of building envelopes.



FIG. 2.40 Inspiring lectures at the beginning of the workshop. (image: A. Prieto Hoces)



FIG. 2.41 Processing the data from the fieldwork. (image: A. Prieto Hoces)

In total, 9 students from the University of Applied Sciences Ostwestfalen-Lippe and Delft University of Technology participated in the workshop which was held at TU Delft from June 19th to 21st. The workshop was coordinated by Alejandro Prieto (TU Delft) with the assistance of Tommaso Venturini (TU Delft). Prof.dr. Philomena Bluysen, Dr. Natalia Romero, Dr. Stella Boess, and Juan Azcarate participated as guest speakers, giving inspiring lectures on the key selected aspects in which the assessment was based. The workshop was also supported by TU Delft's Facility Management & Real Estate, facilitating the participation of building managers and unrestricted access to the selected cases.

The Goal

The main goal of the workshop was to motivate a critical discussion among students and façade experts, about the role of façades during the operation phase of buildings, and the need for considering users' needs and behaviour as relevant inputs for the design and construction process; based on the evaluation of real office buildings.

The Outcome

The main deliverables were the assessment of 4 buildings within TU Delft campus, along with conceptual designs to improve the main identified problems of each case. The assessment took the form of a simplified post-occupancy evaluation of the buildings, based on surveys and interviews with users and managers, besides direct observation on-site. The results of the workshop were presented and discussed in front of a committee of façade experts from the European Façade Network (efn).

The evaluation of the case studies was thoroughly conducted, reaching an impressive level of depth considering the time constraints. The students were supported with inspiring lectures as brief introduction to the topics at hand, and with references of questionnaires and surveys as potential tools to use in the analysis. With this as a base, they designed and apply their own questionnaires and evaluation tools to characterize and identify the main problems in each building, from the perspective of the users. The discussion then centred around conceptual proposals to improve the identified problems. Hence, the resulting façade concepts (albeit not fully developed due to the aforementioned time constraints) were regarded as an exercise of synthesis, proposing potential ideas for the design of façade solutions based on the daily experience from users of real office buildings.

INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT



CURRENT CONDITION - BUILDING OVERVIEW

ASSESSMENT

ANALYSIS METHOD - SURVEY & RECORDS (OBSERVATION)

- How would you rate your general thermal comfort in your workspace?
- How often do you use the existing sun shading in your workspace?
- Do you prefer automatic (sensor regulated) sun shading system or manual?

".....it's very hot during the day and fortunately we've **Air-conditioning** system ;)"

"My workplace is **"BOILING"**, you'd come in and have a feel of it!"



".....**Too HOT** in Summer due to the restriction by Fire Departmentwhich **negatively** influenced the **natural airflow**." Interviewee: Business, Facade Secretary (20)

".....my workplace is just too **HOT** to work."

"It's very hot in the mid-day, my colleague bought a **FAN** last week."



Interviewees	Male	Female	Employee	Student	Satisfactory of the Thermal Environment	Presence of Air-conditioning	Use of Sunblind	Auto (A) / Manual Operation (M)	Orientation	Levels	Remarks
1		●	●		2	NO	All Day (Summer)	M	East	5/F	Still hot with fan
2		●	●		4	YES	All Day (Summer)	M	East	5/F	With Air-Con
3		●	●		4	YES	All Day (Summer)	M	East	5/F	Sunblind is not working
4		●	●		2	YES	All Day (Summer)	M	West	5/F	Sunblind is not working
5	●		●		2	YES	All Day (Summer)	M	West	5/F	Sunblind is not working
6	●		●		2	YES	All Day (Summer)	M	West	5/F	
7	●			●	3	NO	All Day (Summer)	A	West	5/F	
8		●	●		2	NO	All Day (Summer)	M	West	5/F	Sun glare disturbance
9		●	●		2	NO	All Day (Summer)	M	West	5/F	
10		●	●	●	1	NO	All Day (Summer)	A/M	West	5/F	
11		●	●		1	NO	All Day (Summer)	M	West	5/F	
12		●	●		1	NO	All Day (Summer)	M	West	2/F	The temp. is "boiling"
13		●	●		1	NO	All Day (Summer)	A	West	2/F	
14	●		●		5	NO	All Day (Summer)	A	West	5/F	With fan
15	●		●	●	2	NO	All Day (Summer)	A	East	5/F	Too "crowd" to go to the other side
16		●	●		2	NO	All Day (Summer)	M	East	1/F	
17		●	●		2	NO	All Day (Summer)	M	East	1/F	
18	●		●		2	NO	All Day (Summer)	M	East	1/F	
19	●		●		2	NO	All Day (Summer)	M	East	1/F	
20	●		●		2	NO	All Day (Summer)	A	East	1/F	



SUN PATH DIAGRAMS SunCalc



ADAPTIVE SHADING MODULE

TYPE A

variation A-1 (without blinds)



variation A-2 (with blinds)



TYPE B

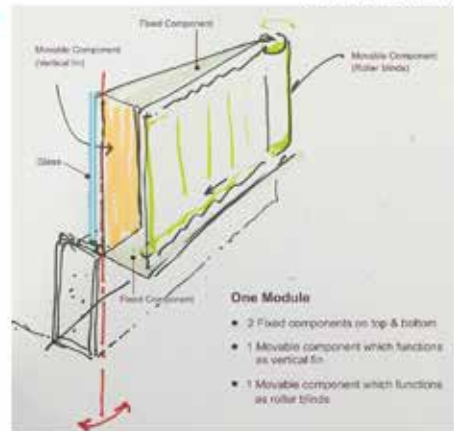
variation B-1 (without blinds)



variation B-2 (with blinds)



PROPOSAL



INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT

WHEN	19-21/06/2017
WHO	Anthony Chen, Kallia Theodoraki
FROM	Hochschule Ostwestfalen-Lippe University of Applied Science, Architecture and Interior / Master of Facade Design and Construction Delft University of Technology, Faculty of Architecture and the Built Environment / Master in Architecture, Urbanism and Building Sciences (Building Technology track).
DOCENT	Alejandro Prieto
PROJECT CITY	Delft, The Netherlands
BUILDING FUNCTION	Office
BUILDING HEIGHT	Middle-rise building (7 stories)
INNOVATION STRATEGY	Modular façade component with movable shading device

FACULTY OF CIVIL ENGINEERING AND GEOSCIENCES, TU DELFT

The building of the Faculty of Civil Engineering and Geosciences is a post-war concrete middle-rise building (7 floors). The façade systems consists of single glazing window units with metal frame, which generated a thermal bridge between the interior and exterior environment. The west façade additionally considers automatic sun blinds. However, inspection on-site shows that some of them are not working properly.

The main comfort problem was found to be overheating, identified after a first round of interviews with the facility manager and some occupants. Based on this initial idea, a survey was carried out for a larger sample, focusing on three main aspects: general thermal comfort, operation of the existing shading system, and preference of automated or mutual operation of façade components.

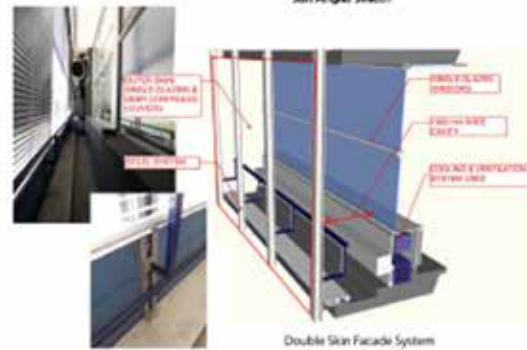
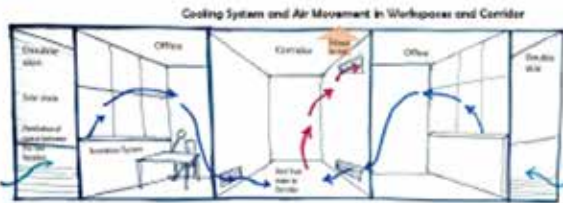
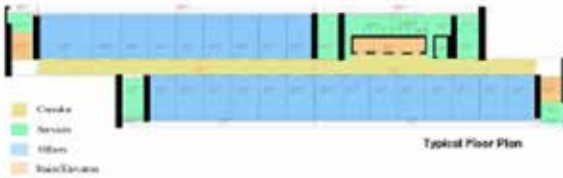
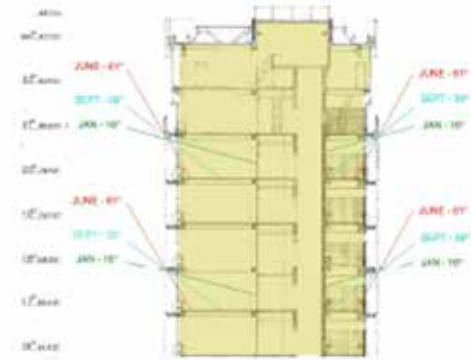
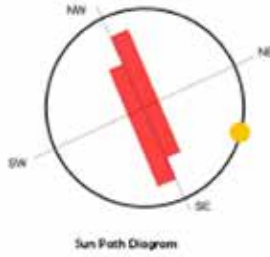
The survey considered a diverse sample in terms of gender (male/female) and occupation of the user (employee/student). The results showed that the people are unsatisfied by their thermal environment and they all declared to use shading all day during summer season. Nonetheless, the majority preferred to manually operate the shading system, given the option. This feeling was made worse by the fact that each shading module comprises more than one office, reducing the perceived user's control. The façade concept deals with the results, proposing a base module with fixed and movable components for sun shading.

The fixed components act as overhang, being oriented to the sun path and blocking solar radiation at high angles, while two movable mechanisms act as complement: a vertical fin and an horizontal roller blind, manually operated. When open, the vertical fin allows for ventilation, serving as fresh air intake to reduce indoor temperatures.

INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT



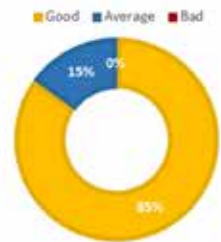
The EWI building was built in the 1960s. It is 90m high and has 21 floors. South east and south facades are getting most sunlight during the day causing overheating in summer. Less insulation in the facade causes thermal bridge and water leakage inside the building.



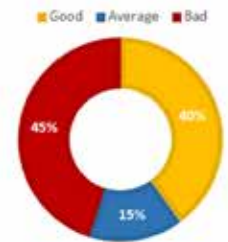
ASSESSMENT

BadSmell
BadVentilation
ColdInWinter
TooHot
BigWindows
WaterLeakage
GoodDaylight
NiceView
SolarShadingControl
OperableWindows

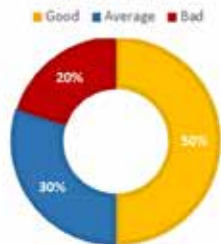
OVERALL COMFORT



THERMAL COMFORT



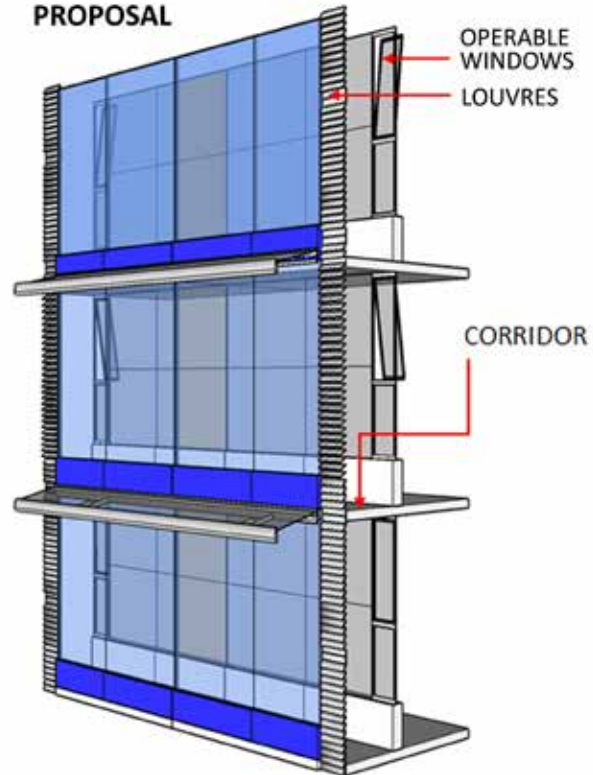
VENTILATION



LIGHT LEVEL



PROPOSAL



INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT

WHEN	19-21/06/2017
WHO	Jameela Eranpurwala, Radwa Abouelseoud
FROM	Hochschule Ostwestfalen-Lippe University of Applied Science, Architecture and Interior / Master of Facade Design and Construction
DOCENT	Alejandro Prieto
PROJECT CITY	Delft, The Netherlands
BUILDING FUNCTION	Office
BUILDING HEIGHT	High-rise building (21 stories)
INNOVATION STRATEGY	Alternating façade with air cavity and direct air intake

FACULTY OF ELECTRICAL ENGINEERING, MATHEMATICS AND COMPUTER SCIENCES, TU DELFT

The faculty of electrical engineering, mathematics and computer sciences is housed in a 60s high-rise building (21 floors), oriented in a north-west/south-east axis. This high-rise is highly recognizable in the area, becoming one of the landmarks of TU Delft. The façade system is a double-skin façade on east and west orientations, with integrated heating, cooling and ventilation units in the sill of the inner layer. Inner windows are non-operable, with single glass panes and steel profiles, causing thermal bridges between inside and outside. The outer layer of the double-skin is fully glazed, and also consists of single glass, with louvres for air intake into the cavity of one meter wide. An automatic venetian shading system is incorporated in the cavity for solar protection. As mentioned, ventilation is achieved exclusively through the façade cavity. Hence, Air in the cavity is handled by the ventilation units at the sill, and injected into the room. At the same time, exhaust air is taken from the room through vents located at the bottom of the partition walls to be finally rejected throughout a shaft in the central corridor, leading to the roof.

The assessment of the building was conducted through a short survey, especially designed for this task. The survey was printed and handed out to a group of twenty persons. Two floors at the top and two at the middle were selected as the universe for the sample. Also, ten persons from east-facing offices and ten persons from west-facing offices were chosen to take part in the survey. The results showed that people are satisfied in terms of general overall comfort (85%) and in terms of lighting levels (70%), benefiting from access to daylight and outside views. However, 45% of the sample declared to have problems regarding their thermal comfort, identifying overheating issues as the main source of concern, followed by ventilation issues related to the presence of bad smell and lack of proper air ventilation at command.

The new façade concept deals with the identified issues, proposing the application of alternating modules, considering an improved version of the existing double-skin façade (with better insulation and glazing), and modules that allow a direct relationship with the external environment through operable windows and external open louvres. Additionally, an overhang is added, to assist the venetian blinds in solar control. The alternating façade seeks to benefit from the advantages of the current system, updating its performance, while also given more control to the occupants for manually operated ventilation, injecting fresh air directly from the exterior to lower inner temperatures and/or improve their indoor air quality on demand.

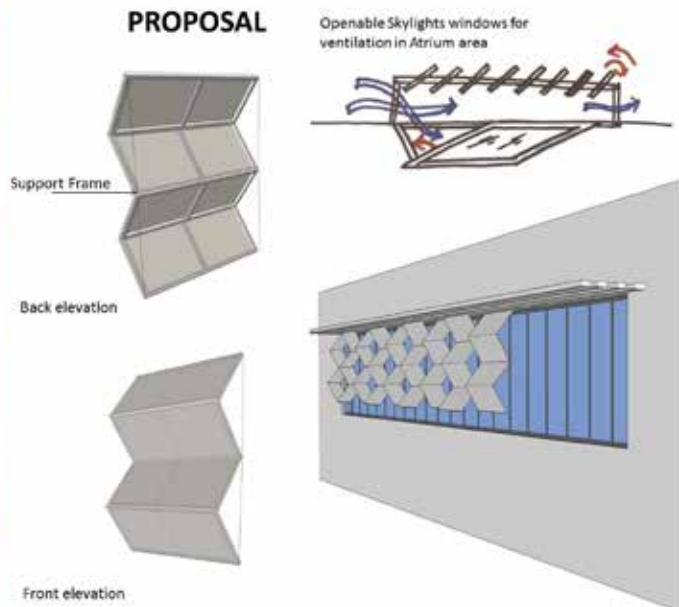
INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT



ASSESSMENT

INTERPRETING DATA

	TECHNICIAN	STUDENT	PROFESSOR	VISITOR
Icon: Person	18-35	18-35	46-50	18-35
Icon: Office	Shared	Shared	Private office	Visitor
Icon: Compass	West	West	West	-
Icon: Person sitting	Sitting/walking	Standing	Sitting	Walking
Icon: Thermometer	Warm	Hot	Warm	Warm
Icon: Speaker	Very less noise	Noise from machines	Very less noise	-
Icon: Sun	Natural lighting	Natural lighting	Natural lighting	-
Icon: Window	Blinds	Blinds	Blinds external/internal	-
Icon: Triangle	Mostly using	Always	Not using	-



INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT

WHEN	19-21/06/2017
WHO	Tavishi Rana, Urvashi Tuli
FROM	Hochschule Ostwestfalen-Lippe University of Applied Science, Architecture and Interior / Master of Facade Design and Construction
DOCENT	Alejandro Prieto
PROJECT CITY	Delft, The Netherlands
BUILDING FUNCTION	Office
BUILDING HEIGHT	Low-rise building (5 stories)
INNOVATION STRATEGY	Foldable textile shading system

FACULTY OF INDUSTRIAL DESIGN, TU DELFT

The case study is a mixed use building consisting of an “U” shaped five storey building, surrounding a central open space three floor high. The central space functions as an atrium with skylights to allow for daylight, while the perimeter houses workshops and studio rooms for students in lower levels, and private offices for employees at the upper two floors. The façade system consists of strip windows along the perimeter of the higher building, with internal glare control blinds and opaque external textile blinds for solar protection.

The assessment of the indoor conditions was based on a series of interviews with several user types, namely technicians, students, professors and visitors, establishing overall preferences for each type. Two main areas were found to be problematic: the central atrium and the west facing building. People in the atrium experienced noise discomfort besides overheating during summer. On the other hand, west oriented offices also suffered overheating, with the added problem of lack of ventilation, particularly in studio rooms and workshop. The opaque textile blinds were source of special concerns regarding the impossibility to have views to the exterior, while also making ventilation more difficult in the lower floors.

The proposed façade concepts focuses on the west façade, being judged as the most problematic. The concept seeks to redesign the current shading system, using the same materials, but changing the geometry of the solution. Hence, textile is applied in a foldable sub-structure, which hangs from an overhang installed over the existing windows. The idea being that even when the sun shading is completely in place, blocking low-angle solar radiation, it could allow for a visual connection with the outside world, while also allowing for indirect daylight and air currents. Additionally, openable skylights were proposed to improve ventilation in the atrium, as part of an overall strategy for the whole building.

INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT



COMFORT

- Good to too cold
- Good
- Good to too much

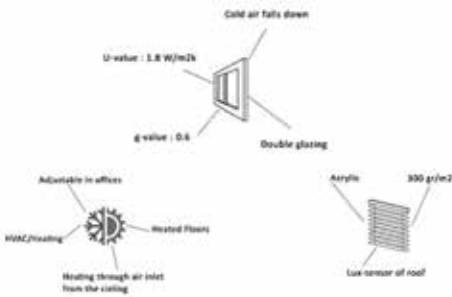
AUTOMATION

- Automated + adjustable (but not work under extreme weather conditions)
- adjustable, but not exact temperature
- manual

MAINTENANCE

- Cleaning order :
 - 1- Concrete
 - 2- Shading
 - 3- Window
- Frequency of cleaning the Sun Shading too high

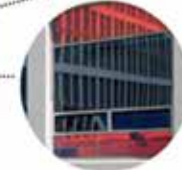
■ Unsatisfied
■ Satisfied



Sun-Shading Device

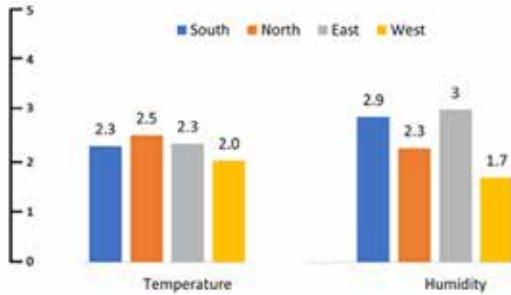


- Stick System - Lamella

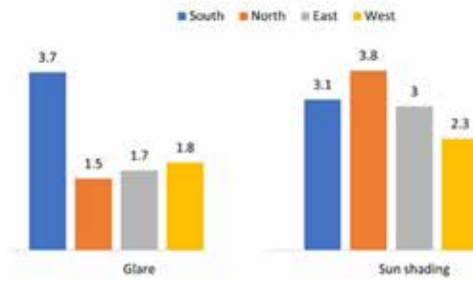


Prefabricated Elements

ASSESSMENT

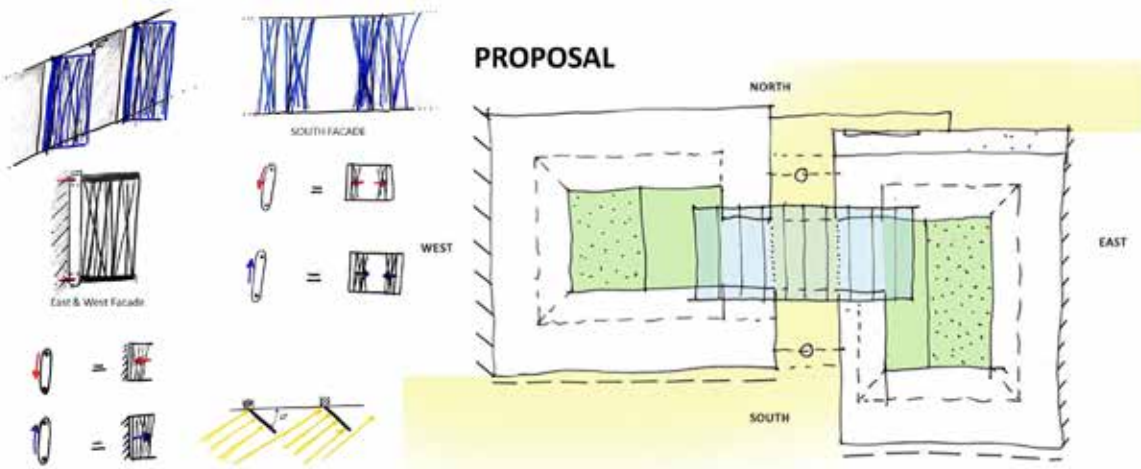


Too cold - 1 2 3 4 5 - Too warm
Too low - 1 2 3 4 5 - Too high



No glare - 1 2 3 4 5 - Too much glare
Not efficient - 1 2 3 4 5 - Highly efficient

PROPOSAL



INTERACTING WITH THE FACADE – LESSONS FROM EVERYDAY LIFE IN OFFICE BUILDINGS – DELFT

WHEN	19-21/06/2017
WHO	Ankit Patel, Mahsa Shafighnia, Tubâ Elâ Çinar
FROM	Hochschule Ostwestfalen-Lippe University of Applied Science, Architecture and Interior / Master of Facade Design and Construction
DOCENT	Alejandro Prieto
PROJECT CITY	Delft, The Netherlands
BUILDING FUNCTION	Office
BUILDING HEIGHT	Low-rise building (3 stories)
INNOVATION STRATEGY	

FACULTY OF APPLIED SCIENCES, TU DELFT

The Faculty of Applied Sciences is housed in a recently built building, consisting of two three stories volumes, connected by a central atrium, with centralized vertical circulations. Each volume has a central courtyard to give daylight access to the inner office rooms. The façade system consists of prefabricated unitized modules, with a textile awning as automated external solar protection system. Windows are double glazed, with a global transmittance of 1,8 W/m²K and a g-value of 0,6. Additionally, the building has a centralized air-conditioning system, which can be adjusted to a certain degree in each office, by changing the settings of the fan-coil for air delivery.

The assessment of the building was conducted through surveys using likert scales in an attempt to quantify perception of several comfort issues. The sample was twenty users considering professors, technicians, service managers and students. It was also balanced regarding gender (13 males and 7 females) and location within the building, defining zones based on orientation (north, east, south and west). The people were asked to rate their perception on temperature, humidity, glare and the operation of the sun shading, based on a 5 point scale. The results by zone showed that there is no relevant difference in terms of temperature, being rated between cold and neutral, possibly by the effect of the AC. The same similarity goes for humidity levels, judged somewhat low (although particularly at west zones). However, there is marked difference in perceived glare issues by people located in south facing offices, while west occupants rated sun shading systems as less efficient compared to other orientations. It was added that the shading system gets overridden under extreme weather conditions, which tends to happen often regarding gusts of wind.

The façade concept deals with the findings proposing a new shading system differentiated for south and west application. In west and east façades it is oriented towards the sun path, as vertical fins, while on the south façade it is a sliding element parallel to the building. The solution considers more wind resistance than the current awning, allowing for operation when it is needed regardless other weather parameters. Additionally, it is explored in the proposal to consider operable elements within the component that may give the possibility to control the opacity of the shading unit, allowing indirect daylight while preventing glare issues in the adjacent rooms.



Allianz Arena München (image: U. Knaack)

3 Future Facades Research and Innovation



FIG. 3.1 Vacuum façade experiment (image: T. Klein)

3 Future Facades Research and Innovation

Ulrich Knaack, TU Delft

Coming from an academic background, we always approach future research via technical development, improvement of performances and innovation. But reading the word innovation correctly, it means a new technology being available in the market and being bought! Understanding this, we approach industry and try to convince them, that certain developments, we made, would help them, would fit to their product portfolio or improve things. And in the same way industry comes to us – asking us either to develop something, they need or ask us to technically proof a product, they developed and name in an innovation.

There is nothing wrong with this – both sides benefit from this cooperation: Industry gets development proven and gain access to highly educated researchers with specialised knowledge. In turn, the research community gets feedback about technology from industry and, of course, funding, which cannot be neglected in our current academic environment!

We structure such activities as industry-driven research and academically-driven research – the two directions from which this work is initiated. We call this a push and pull situation: the academic environment pushes long-term, strategically investigated and targeted developments into the picture, positioning the themes within public (national / European / international) grand calls and then delivering research proposals to fulfill the requests of such calls. This activity needs a long term strategy and, of course, is not always a success in every aspect – its failure may be caused by political influences, coincidental impulses, and competition in the research and science market. However, in the long term, development is delivered! The pull factor comes from industry. Here, the timeline is a lot more compact: new regulations, competitors with better solutions, or defence and cost-reduction / efficiency activities drive the demand for certain new technical solutions. These need to be developed, tested, and evaluated – all typical research activities.

An additional impulse can be seen in the ideas that come directly from designers (architects and engineers), which run alongside other channels - coincidental ideas that developed from project-based activities. The nice part of this is that ideas come that are unexpected and uncontrolled! These projects produce ideas that are sometimes weird or impossible, and sometimes are just a rebrand of existing things, but most of the time these projects contain serious aspects that have not yet been seen in structured, developed research. If taken seriously, followed, and developed, these coincidental impulses do speed up the general developments and, if they are successfully used in a project, may boost entire areas of development. Dr. Tillmann Klein mapped this in his PhD theses “Integrate Façade Constructions – towards a new product architecture for curtain walls”, in which he discussed the involvement of the different stakeholders in the design and development process of a façade construction. By mapping this, it becomes clear who is influencing the process and where innovations can take place: systems are mainly developed by system suppliers.

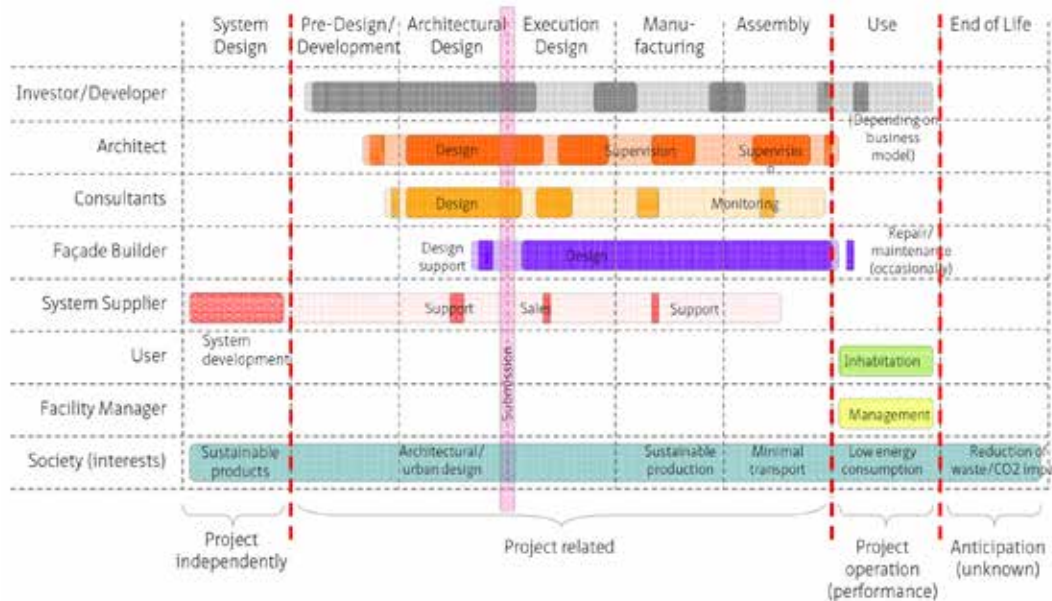


FIG. 3.2 Involvement of the stakeholders in the different phases of a facade design and construction process. (image: T. Klein)

The consequence of this is that these systems target larger areas of applications, and therefore will not match perfectly to an individualised request. However, by being used more frequently, they become financially more feasible. Conversely, a solution designed specifically for one project - one that is designed, engineered, and manufactured for a unique situation - allows for maximal individualisation. In these situation, perfect performances lead the development rather than cost .

This process is mainly controlled by the designers and engineers, who relay solutions to the manufacturing and assembly. Obviously there is a wide range of variations in the use of parts or components of existing systems, and with influence implemented by the players involved.

In his further investigations, Klein maps the developments of various technologies and products and proofs, where the development took place and how it was influenced. Klein uses this to investigate the relations and forces in the process, and by doing so helps to understand the prudence of the players and products that are yet to be developed. (Klein, Tillmann: Integrale Façade Constructions; PhD at TU Delft 2013).

An example of this system is the development of double façades into component façades, and shows why they did not become a broad product success. The story starts with an architect called Mick Davies and his idea to develop a so-called “Polyvalente Wall” for the Lloyds of London building. The concept was to have all façade functions in one layer and, in addition, integrate energy collection and ventilation. This was obviously impossible at that time, but Winfrid Heusler, a engineer at Garther, a German façade construction company, developed a technical solution by separating the functions and thus addressing the problem in a floor-height solution.

This project is followed by several solutions for the integration of service functions into the building envelope, starting with double-façades, façades with an additional outer glass layer to provide preheated air from the cavity for natural ventilation. Various layouts and several prominent projects prove that there is a general technical potential, which can be well integrated in the design process and energy concept, and can be beneficial for the building.

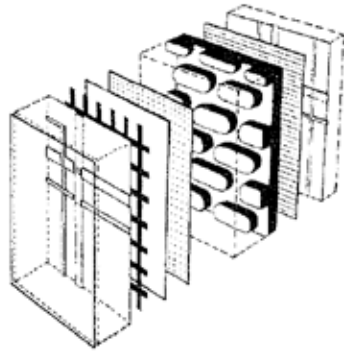


FIG. 3.3 Polyvalent wall. (image: M. Davis)



FIG. 3.4 Lloyds of London, technical solution of the facade (image: U. Knaack)



FIG. 3.5 Stadttor Düsseldorf with one of the early double facades (image: U. Knaack)

In a further step, engineers and designers of the Posttower Bonn also integrated the service components of the building into the façade, thereby creating the next generation of façades: component façades. The idea behind is, alongside the normal functions of façades and natural ventilation strategies, to integrate the building services in the façades and thus limit the floor space required for these components and ducts within the building. Again, this strategy was first put in place in an individualised, in-situ solution.



FIG. 3.6 Posttower Bonn – inner path of the double façade with service components (image: U. Knaack)



FIG. 3.7 Capricon Building Düsseldorf – one of the few build component facades (red areas). (image: U. Knaack)

When an individual solution is created, this narrows the potential for a broader use so, in parallel, designers/ engineers and companies started to develop solutions to meet a required specific technical performance to launch as a product in the market. One of the few built solutions is the Caprico project in Düsseldorf, in which the decentralised components are integrated in the double façade as an add-on unit. This allowed for parallel developments of the façade and the service component. However, it also required cooperation in design, engineering, construction, and warranty. In a further step, this principle was brought to a broader market – but was not accepted. Reasons for this may have been the need to implement such a solution very early in the design process, which required design team competence, or the financial consequences of a limited market for possible construction companies.

An initial conclusion from the analysis of this process, and its limited success, is that the limitations of such a complex product are twofold: 1) its required early integration into the design and decision process and; 2) the limited market. The second aspect was answered by solutions that tried to develop open systems, which would allow – similar to stick façades systems – the use of a general system, and integrating components as wanted or needed for the certain function. These open integrated component façades would allow for later adjustment and keep open access to a market for providers for various components. The difficulty here appeared to be that the driver for the product could not be easily identified: the façade system provider would need competence in the service market, and the service component provider would need to engage with a façade market. Ultimately, the total benefit would not be to the one taking the action, but to the market – so there was limited motivation to get active. Therefore, the more complex a product becomes, this complexity, a limited market power, and an unclear benefit can be concluded as the limitations for the development of such products.

Directing their attention towards the stakeholder in the process that would ultimately benefit from such technical solutions, the team in the Façade Research Group at TU Delft developed a concept for façade leasing. Here, technical solutions are provided in an open system and can be chosen by the client. An consortium of manufacturers, component providers, and financiers will supply an integrated concept and offer it for the expected contract time. Through this, the benefit of the improved functionality is given to the client / user and in tandem an improved solution will benefit the consortium during the lifetime of the façade. Therefore, the interest in a complex and integrated product, open to be designed for individual solutions, does generate the benefits of the solution, by taking decisions, and paying for the product. However, it must also be mentioned that this only is possible in a fiscal situation in which the client / user is able to act during the lifetime of the product, which is a limitation of the accessible market.

It can be concluded that the development forces for future façade systems can be driven by industry (pull) and academic environment (push), AND by designers / engineers, who are driven by project related impulses. However, all activities do result in one-off solutions with a maximum potential for the individualisations, or in system solutions, which will only offer a limited individualisation. In addition, it must be considered that market impulses are not only related to technical / functional issues, but follow traditional behavioral patterns, being motivated by financial parameters. The key question that we identify: Who pays and who has the benefit?

How do we continue? This chapter was intended to give a viewpoint towards future façade innovations and development, but, as described, this viewpoint is not only related to what we want to develop, but also to who needs it, and how it can be used and integrated into the development process. Having understood this, we now can give an outline of current and future research areas that are important for the façade or, even more broadly, for the building envelope:



FIG. 3.8 Mockup of the Leasing Façade Concept at TU Delft with 4 different technical solutions to be tested. (image: U. Knaack)



FIG. 3.9 Glass Brick Wall of the PC Hooftstraat shop in Amsterdam, developed by the TU Delft Glass Team around Prof. Rob Nijse. (image: U. Knaack)

Materials: as we can see, new technologies for the production of new materials do appear, and consequently result in the construction of a new façade environment. This can be seen in sample materials such as thin glass or solid glass are expressing this impressive.

Geometry: constantly developing software tools now allow us to design and engineer freeform geometries. In a second step, this is now pushed to production – with the consequence that nearly tolerance-free construction of expressive geometries are technically and financially feasible – and waiting to be more commonly used.

Technology: here, we see a constant improvement in the technical aspects of façade systems: thermal improvements, structural integrity, and functionality are the driving aspects. However, next to this, additional themes appear in this area such as the question of the acoustic performance, not only for the building itself, but for the environment. In addition, the application of the additive manufacturing technology – a production technology that allows one-off products to be made in an industrialised production. Here, a clear link to the field materials must be identified, although the integration of the technology is more so the focus of façade related developments and fundamental material research.

Energy: the focus of our activities is on the potential limits of technical improvements – at a certain point the physical limits are simply reached. So, either new façade typologies will be developed that allow the general limits of the construction to be overcome, or we concentrate on the area of global energy consumption through construction, integrating the energy needed for production with the functionality and the lifetime of the façades.

Functionality: functionality is an interesting and newly-developing field, and we also see its development other areas. Accepting a general digitalisation of our environments, and getting used to the potentials of functionality improvement by using digital interfaces and interaction, might lead to an improvement of the performance of façades simply by utilising better controls. Next to this, a deeper knowledge and understanding of human interaction with the building envelope delivers a potential for improvement: how might we be willing to act in a more energy efficient way, and how might we be motivated to do so rather than forced?

Market: here, we see that, following a consolidation period after the financial crises and the current redevelopment of the market, larger players are orienting themselves toward a global market. However, as described in this chapter, the interaction of the persons involved is key in the development: A good team will realise a nice project, but needs a functional / performance benefit to boost the result. Simpler commutation and travel allow for a broader technology exchange, but personal interaction is - luckily - still needed.



FIG. 3.10 International Conferences connect and integrate students and young scholars with the professional world.
(image: U. Pottgiesser)

3.1 Conference Series on Facades

Uta Pottgiesser, University of Antwerp / HS OWL, Ulrich Knaack, TU Delft

Conferences and symposia are the traditional way of presenting new content and findings to the professional practice and to the wider public. They allow for a better overview within the variety of academic publications and mirror the relevant investigations, topic and trends. But they are also important networking events to personally connect the different stakeholders, in particular science, industry and polica makers.

This explains why the European Facade Network (efn) when founded In 2009 with 5 European institutions being active in education and research, put a high emphasis on this aspect. To allow for a more concentrated and synergetic way the main European events were connected and organised in a rotating principle to prevent the explosion of events and to make sure that relevant stakeholdes will be present. This resulted in a series of two efn-conferences per year taking place in Delft/Bath and Detmold/Lucerne. In 2016 more than 10 European institutions are connected within the efn-network with an increased number of activities joint and rotating conferences, a journal and different publications. This resuted in three conferences per year from 2017 onward.

As a next step the network is reaching out to other continents in North and South America and in Asia. In 2016 the first North American Facade Congress took place, organised by the Facade Tectonics Institute (FTI). 2017 was the year, when European and global facade activities merged for the first time during the ICBEST2017 Conference in Istanbul – to be repeated at the next ICBEST in 2020.



FIG. 3.11 Participants of the ICBEST Conference 2017 in front of the Faculty of Architecture of Istanbul Technical University. (image: ICBEST 2017 - ITÜ)

Lucerne University of
Applied Sciences and Arts

**HOCHSCHULE
LUZERN**

Engineering and Architecture
FH Zentralschweiz

Hochschule Ostwestfalen-Lippe
University of Applied Sciences



Façade2016 – Conference on Building Envelopes

“What’s next?”

Friday, 7 October 2016
KKL Lucerne



FAÇADE2016 – CONFERENCE ON BUILDING ENVELOPES

STARTING YEAR	07.11.2016
LOCATIONS	Lucerne, Switzerland
FOCUS	“What’s next?”
SESSIONS	International engineers and architects presented the latest trends and developments and forward-looking technologies in the area of the building envelope.
LOCATION 2016	Lucerne, Switzerland
ORGANISORS 2016	Competence Center Façade and Metal Engineering
INSTITUTION 2016	Lucerne School of Engineering and Architecture, Institute of Civil Engineering

CONCEPT CONFERENCE

“What’s next?” At this international conference – which took place in Switzerland for the fourth time – renowned international engineers and architects presented latest trends and developments and forward-looking technologies in the area of the building envelope. The conference – whose theme was “What’s next?” – forms part of the European Façade Network (EFN) and takes place after the meeting of the European research network COST TU1403 “Adaptive Facades Network”.

FOCUS 2016

“What’s next?” Which developments can we expect in the coming years in the area of façade construction? How will energy-efficient building envelopes work in future and will they become adaptive, high-tech engineering components? Will the use of digital planning and manufacturing methods have an effect on realizing our building envelopes? These are just some of the interesting questions that have been discussed at the international conference Façade2016.

The conference was held by the Competence Center Façade and Metal Engineering of the Lucerne School of Engineering and Architecture and the Ostwestfalen-Lippe University of Applied Sciences (Detmold, Germany), in collaboration with the Swiss Center for Windows and Curtain Walls (SZFF).

Presentations:

- Anton Falkeis, falkeis architects, Austria
Active Buildings
- Wilfried Laufs, Laufs Engineering Design, USA
Recent structural façade innovations – US case studies
- William Matthews, William Matthews Associates, UK
Designing the Shard: from sketch design to lessons learnt
- Steffen Feirabend, Werner Sobek Stuttgart AG, Germany
Iconic, transparent, sustainable – Trends and challenges for contemporary façade engineering
- Per Heiselberg, Aalborg University, Denmark
Interaction between users and façades
- Kenneth Ross, Richter Dahl Rocha & Associés architectes, Switzerland
Richter Dahl Rocha & Associés architectes: Recent and Upcoming work
- Martin Manegold, Imagine Computation, Germany
Automation of 3D Planning and Data Generation for Manufacturing
- Susanne Gosztonyi, LUND University, Sweden
Biomimetic ideas for thermally adaptive façades
- Jan Lipton, Switzerland
Optimized Closed-Cavity Hybrid Window for Glass Façades

THE FUTURE ENVELOPE

NEXT BUSINESS

#11

CONFERENCE ON BUILDING ENVELOPES

FACULTY OF ARCHITECTURE TU DELFT (NL) | THURSDAY 22. JUNE 2017

NEXT Business is organised by the Façade Research Group, TU Delft in cooperation with the European Façade Network (EFN)

'Next Business' aims at answering the following questions:

What are the **trends** that determine the future of the building envelope? Which business concepts can be found to react to these trends and what can we learn from other industries? What are the **legal and financial implications** for a different approach? How will new business concepts **shape our façade products and services**?

During the 11th edition of the annual conference, twelve international speakers from research, industry, management and design will share their experience and visions of the future building envelope.

PROGRAMME

8:30 **Registration**

9:00 **Opening**

Andy van den Dobbelaar, Head of Department AB+T, TU Delft, NL
Bert Lieverse, VMRG, NL | Moderation Ulrich Knaack | Tillmann Klein

9:30 – 11:00 **Session 1 – Business Models**

Olaf Blaauw, Delta Development, NL | Marc Wesselink, Startbootcamp, NL
Juan Azcarate-Aguerre, TU Delft, NL

11:30 – 13:00 **Session 2 – The Product Perspective**

Carlos Mella-Cottenie, Hunter Douglas, CL | Frank Ilg - PERI Group, DE
Thomas Fehlhaber, Unipor, DE

14:00 – 15:30 **Session 3 – Building Industry Insights**

Marc Zobec, Permasteelisa, IT | Simon Sun Nung Chan, HKFA Hongkong
Façade Association, HK | Joep Rats, Bouwend Nederland, NL

16:00 – 17:30 **Session 4 – The Architectural Challenge**

Hans Hammink, Architekten Cie, NL | Fredrik Nilsson, White Arkitekter,
TU Chalmers, SE | Lone Wiggers, C.F. Møller Architects, DK

17:30 - **Discussion**

<http://futureenvelopeconference.eu>



THE FUTURE ENVELOPE – CONFERENCE ON BUILDING ENVELOPES

STARTING YEAR	May 2007
LOCATIONS	Delft, The Netherlands and Bath, England in yearly turns
FOCUS	Next business opportunities for building envelope related industry and
SESSIONS	Session 1 New results from research Session 2 Examples from the industry Session 3 Legal and financial implications Session 4 The architectural challenge
LOCATION 2017	Delft, The Netherlands
ORGANISORS 2017	Ulrich Knaack, Tillmann Klein, Thaleia Konstantinou
INSTITUTION 2017	Delft University of Technology

CONCEPT CONFERENCE

Building envelopes today are one of the most complex building components and a truly multidisciplinary discipline. Their impact on the energy use of buildings and the user comfort is obvious. The conference targets radical future developments in this field, but always keeps an eye on what the impact on the building industry will be.

Future Envelope is the central façade related conference, which we organize at TU Delft. The conference takes place every second year, organised by the Façade Research Group and addresses the future development of this exciting field by applying an integral approach. The speakers come from different fields such as architecture, climate design, structural engineering, product development, research and industry.

The Future Envelope is embedded in numerous activities that are organised around the event. Researcher and students from our partner universities use it for meetings and discussions. With its accompanying workshops it is a fixed part of the curricula of the Façade Master Programs in Lucerne (CH), Detmold (D), Bath (UK) and San Sebastian (ES). The goal is not merely to gather and learn what is technologically and scientifically cutting edge, but to create a relationship between those who currently define the business and those who aim to do it in the future.

Next to this there are parallel activities with other cooperating partners / projects, in which the Façade research group participates in workshops / conferences, related to the theme building envelope, such as the architects conference at Glastec, Dusseldorf, Fassade in Detmold / Luzern or PowerSkin, BAU Munchen.

FOCUS 2017

Over recent years, we have observed new trends and legal requirements such as lifecycle concepts and the need for buildings that use nearly zero energy. User and comfort level are moving into the focus. This asks for new and integrated building and façade concepts.

'Next Business' aims at answering the following questions: What are the trends that determine the future of the building envelope? Which business concepts can be found to react to these trends and what can we learn from other industries? What are the legal and financial implications for a different approach? How will new business concepts shape our façade products and services?

INTERNATIONAL CONFERENCE ON BUILDING ENVELOPE SYSTEMS AND TECHNOLOGIES – ICBEST



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INTERNATIONAL CONFERENCE ON BUILDING ENVELOPE SYSTEMS AND TECHNOLOGIES – ICBEST

STARTING YEAR	1994
LOCATIONS	Singapore, Bath – UK, Ottawa – Canada, Sydney – Australia, Bath – UK, Vancouver – Canada, Aachen – Germany, Istanbul – Turkey
FOCUS	Aspects of building envelope design and engineering
SESSIONS	Performance & Sustainability, Envelope Technologies, Structural Systems, Materials & Components, Failures & Refurbishment, Case Studies,
LOCATION 2017	Istanbul, Turkey
ORGANISORS 2017	Aslihan Tavit, Oguz C. Celik
INSTITUTION 2017	Istanbul Technical University

CONCEPT OF THE CONFERENCE

International Conference on Building Envelope Systems and Technologies – ICBEST is the premier conference for attendees to benefit from the cutting-edge information on building envelope systems and technologies. ICBEST is a worldwide forum for building envelope architecture and engineering. It provides information exchange, networking, and discussions of recent developments and their application, thus bridging the gap between architects, designers, engineers, manufacturers, and researchers.

The first ICBEST Conference was held in 1994 in Singapore, continuing in Bath (UK), Ottawa (Canada), Sydney (Australia), again in Bath (UK), Vancouver (Canada), and finally in Aachen (Germany), with generally three year intervals between.

FOCUS 2017 – INTERDISCIPLINARY PERSPECTIVES FOR FUTURE BUILDING ENVELOPES

ICBEST Istanbul has been the eighth conference series that focuses on various aspects of building envelope design and engineering in which the approach is interdisciplinary. Therefore, the main theme of the conference was “Interdisciplinary Perspectives for Future Building Envelopes”.

With this, it is believed that the conference has bridged the gap between architects, engineers, researchers, manufacturers, and practitioner professionals. Around 70 papers + talks from many countries were brought together under the themes of Performance and Sustainability, Structural Systems, Materials and Components, Life Cycle, Envelope Technologies, Failures and Refurbishment, and Case Studies which are organized as plenary and parallel sessions to possibly address the needs in specific fields. Furthermore, a Special Session on Adaptive Building Envelopes was presented during the conference. Well-known keynote speakers (Uta Pottgiesser, Ulrich Knaack, Tim Macfarlane, and Toru Takeuchi) have enriched the conference and delivered speeches on state-of-the art topics with their high level of experience.

Four keynote speakers, session organizers, authors, student competition participants, and last but not least ICBEST sponsors (ITU, Metal Yapi, Saint-Gobain, Sika, Efectis Era, Dow Corning, Galpan) and many partner institutions have contributed to the event significantly. With the feedback received in the aftermath of the conference, it is believed that the conference has been one of the key conferences in this area. With great efforts of the editorial board of JFDE (Journal of Facade Design and Engineering), a special issue has been formed from the selected papers submitted to the conference secretariat. This special issue has been finalized before the conference and has become available online and hardcopy as well.

Local Organizing Committee (Lo-Co), Advisory Board, ICBEST Community, Scientific Committee, and Event Organization Company 1957 have closely collaborated during the preparation of this conference. Lo-Co core members Dr.Fatih Yazicioglu as the Scientific Secretary, Dr.Ecem Edis and Dr.Buket Metin as the associate editors for preparation of the conference proceedings are worth mentioning.

It is thought that ICBEST Istanbul 2017 has ignited new directions in future's building envelope design, research, and technologies and will eventually develop a stronger bond among the participants. During the closing session, it is decided that the next conference will be held in the American Continent in 2020.

Aslihan Tavit & Oguz C. Celik

ne — xt *facades*

COST ACTION TU1403
ADAPTIVE FACADES NETWORK
MID-TERM CONFERENCE

TUM

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EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

NEXT FACADES – INTERNATIONAL CONFERENCE BUILDING ENVELOPE DESIGN AND TECHNOLOGY

STARTING YEAR	November 2017
LOCATIONS	Munich
FOCUS	Adaptive Building Envelopes
SESSIONS	Session 1 – New Functionalities Session 2 – Digital Environments Session 3 – Climate Response Session 4 – The Architectural Challenge
LOCATION 2017	Munich, Germany
ORGANISORS 2017	Matej Banozic , Phillip Molter, Moritz Mungenast, Oliver Englhardt, Tillmann Klein
INSTITUTION 2017	Technical University Munich

CONCEPT CONFERENCE

The conference addresses creative and innovative professionals and researchers at the forefront of facade design. We discuss tasks and issues in research, design and manufacturing of high-performance building envelopes. Participants will gain new perspectives on, and an enhanced insight into developments and research in design and engineering for tomorrow's advanced building skins..

FOCUS 2017

The next facades conference is setting the focus on adaptive facades:

In the same way as natural organism adapt to their environment, adaptive facades can adapt to changing dynamic climatic conditions. Designers and engineers are developing concepts and technologies to increase interior comfort and reduce the energy consumption of buildings. It needs an integrated effort to create a new type of architecture by bridging the disciplines of architectural design, building physics, climate design, and structural design.

Science meets practice

The COST Action TU1403 is a scientific network with the aim to harmonise, share and disseminate technological knowledge on adaptive facades on an European level. During the midterm conference first results will be presented to stakeholders from industry and design and the public. The goal is to share knowledge and discuss novel facade concepts, effective evaluation tools and design methods for adaptive facades.

The program 2017 is organised in 4 sessions, each comprising four short lectures followed by a discussion. Researchers of the COST Action will exchange their ideas with representatives from practice.

Session 1 – New Functionalities

Increase in adaptivity of facades leads to new facade functionalities such as shape changing or adapting material properties, function enlargement by integrating HVAC systems or photovoltaics. Session 1 aims at analysing the state of the art of adaptive facades and cast a view ahead of future possibilities.

Session 2 – Digital Environments

This second session targets new digital developments and tools for the design, testing and monitoring of facades. It explores new concepts control, self-organisation, IT and the internet of things.

Session 3 – Climate Response

An optimized interior comfort and savings in operational energy is one of the main drivers for adaptivity in building envelopes. The session looks at new means of achieving and evaluating the desired performance. One important aspect is how that is done technically: By using high-tech versus low-tech solutions.

Session 4 – The Architectural Challenge

The implementation of new adaptive materials, components and facades always falls in the context of architectural design. But how are design and technology geared towards holistic new built applications? What is the role of the different stakeholders and how can the process of creating new innovative adaptive facades be organised?

facade2017

Nov. 24th // RESILIENCE

Since 2000 (in the beginning 21st Century) climate change and globalisation have influenced the actual world and all societies tremendously and they have also affected the way we are building. Safety and security requirements are increasing and are consequently influencing the design of the building envelope. 'Resilience' describes the function and ability of buildings and their facades to recover from or adjust easily to change; this can either be in a direct way to specific stresses forced by water, wind, fire, explosion or earthquake but also in an indirect way seen as a general ability of adaptivity to different changes. These issues will be addressed at the conference facade2017 from different academic and professional perspectives.

8.30 Registration

9.00 Welcoming

Prof. Ulrike Kerber (VP Communication)
Prof. Carsten Wiewiorra (Dean DS)

Prof. Dr. Uta Pottgiesser, University of Antwerp (Moderation)

Global Challenges

9.15 Challenging Structures and Facades

Daniel Meyer, Lüchinger + Meyer Bauingenieure AG;
Zürich, Switzerland

10.00 Prospective Challenges in Holistic Façade Design

Daniel Arzmann, Schüco International / HS OWL;
Bielefeld / Detmold, Germany

10.30 Contextual Resilience - Case Study of Burj Alshaya Centre

Taeyoung Kim, Korea National University of Arts;
Seoul, South Korea

11.00 Coffee break

Existing Buildings / RMB-Session

11.30 Dirk Roosenburg and Fritz Peutz, seismic resistant Building in the 1930's in Heerlen NL

Michel Melenhorst, HS OWL;
Detmold, Germany

12.15 Holistic Seismic Behavior and Design of Buildings

Oguz C. Celik, Istanbul Technical University;
Istanbul, Turkey

12.45 Climate Responsive Facades and Sustainable Building Materials

Minni Sastry, TERI The Energy Research Institute;
Bangalore, India

13.15 Lunch break

Future Architectural Concepts

14.15 Light facades - a Process towards the Limit

Xavier Ferrés, Ferrés Arquitectos y Consultores;
Barcelona, Spain

15.00 //

Robert-Jan van Santen, VS-A Group;
Lille, France

15.30 //

Charlotte Kjellander, Trespa International B.V.;
Weert, Netherlands (requested)

16.00 Final Discussion

17.00 End

Registration: <http://www.hs-owl.de/fb1/techbereich/facade2017> until Nov. 11th, 2017
Changes or cancellation are subject to alterations by the organisers.

Fees: 150 € Professional Ticket
100 € Members of German Chamber of Architecture / eIV/ RMB Consortium
80 € Members of HSDWL
25 € Students / Graduates of HSONL

Venue: Casino/Campus Emile//Emilstr. 45//Detmold//Germany

Directions: <http://www.hs-owl.de/fb1/en/service/anfahrt-kontakt.html>

Homepage: <http://www.hs-owl.de/fb1/forschung/construction-ibv/veranstaltungen/facade2017.html>

Contact: susann.kreplin@hs-owl.de



Photo: Puri Bhandari

FACADE2017

STARTING YEAR	2005
LOCATIONS	Detmold / Lucerne
FOCUS	Facade Design, Construction and Technologies
SESSIONS	Session 1 Global Challenges Session 2 Existing Buildings / RMB – Session (Re-Use of Modernist Buildings) Session 3 Future Architectural Concepts
LOCATION 2017	Detmold
ORGANISORS 2017	Uta Pottgiesser, Michel Mehlenhorst, Christine Naumann
INSTITUTION 2017	Ostwestfalen-Lippe University of Applied Sciences

CONCEPT CONFERENCE

The conference is an annual meeting place for experts in the field of building envelopes. It shows research, innovation and state-of-the-art developments in current facade technology. Past conferences focused on topics like 'Computational Optimisation' (2015), 'Design vs. Development' (2013), 'Supergreen' (2011) or 'Rehabilitation and Renewal' (2009). The conference series started 2005 in Detmold, since 2010 the location is changing annually between Detmold and Lucerne.

FOCUS 2017

Since the beginning of the 21st century climate change and globalization have influenced the actual world and all societies tremendously and have also affected the way we are building. Safety and security requirements are increasing and consequently influencing the design of the building envelope. Resilience describes the function and ability of buildings and their facades to recover from or to adjust easily to change; this can either be in a direct way to specific stresses forced by water, wind, fire, explosions or earthquakes but also in an indirect way seen as a general ability of adaptivity to different changes. International speakers will discuss the relevance of resilient concepts and constructions and their impact on design, fabrication and life cycle of facades.

Session 1 Global Challenges

Daniel Meyer talked about the topic of 'Challenging Structures and Facades'. He emphasized the close collaboration of designers, engineers and researchers to keep up with the challenges of structures and facade. He reported about two buildings: the museum 'La Maison des Fondateurs' in Le Brassus, Switzerland and the Arch-Tech-Lab building at ETH Zürich. Daniel Arzmann's speech 'Prospective Challenges in Holistic Façade Design' concentrated on the need to react to the direct impacts of the climate change and globalisation by using a holistic facade design approach. Good design efforts are visible in industry and science that deal with windows and facades resilient to torrential rain, hurricanes, corrosion and seismic activities. Taeyoung Kim presented the Burj Alshaya Center in Kuwait City. She examined the design process and tools that developed the envelope into facade, fins, canopy and roof in accordance with differing functions, orientations and configurations. She proposed the diagonal geometry of the envelope to be a framework enabling both consistency and differentiation, thus achieving contextual resilience.

Session 2 Existing Buildings / RMB – Session (Re-Use of Modernist Buildings)

Michel Mehlenhorst presented seismic resistant building from the 1930's in Heerlen (Netherlands) and showed the influence of architectural style on decisions in resilient façade construction of Dirk Roosenburgs' 'Oranje Nassau' headquarter and Fritz Peutz's 'Moneigneur Laurentius Shrijnenhuis'.

In Oguz C. Celik talk basic seismic design principles and their application on seismic/Earthquake resistant design and retrofit of building like structures were briefly given. Special emphasis was placed on possible causes of structural and non-structural damages (or failures) during earthquakes.

Minni Sastry showed various strategies and external shading devices for commercial and residential buildings to achieve indoor occupant comfort. She provided case studies to show an integrated, holistic approach of responsive facades built in dense areas to achieve both visual and thermal comfort inside buildings, while maintaining comfortable outdoor neighborhood.

Session 3 Architectural Concepts

Xavier Ferrer emphasised that projects with the highest technical and formal demands have only been possible due to permanent evolution of both the concept of enveloping systems, which have been subdivided into more determined, more defined layers every day; and the systems of light construction and the specific products used in its industrialisation.

Robert van Santen presented a new approach for facades as a changing and sustainable concept of architecture.

Spencer Alfred Culhane will speak about the integration of facades into the acoustic design of music performance spaces.



FIG. 3.12 The Cube Stage, Winnipeg. (image: U. Knaack)

3.2 On ICBEST. Istanbul Student Design Competition

Ecem EDIS, Caner GOCER, ITÜ, Istanbul

‘Ten Facades for the Future’, a design competition open worldwide to the undergraduate and masters students of all building-related fields, was organised as a part of ICBEST Istanbul 2017 that took place at Istanbul Technical University. The competition was completed with the award ceremony session which took place on May 16th, 2017 as a part of the conference, and five proposals qualified to be awarded were presented briefly by the entrants.

The objective in organising this competition was promoting the search for new and creative ideas on facade systems and technologies, and benefiting from the creativity of students in searching for innovative solutions. In this search, the entrants were expected to further concretise their conceptual idea by considering the listed performance headings of structural safety, fire safety, technical functionality and durability, indoor environment related performances, environmental sustainability, constructability /maintainability, and usability / user related functionality. Facade system proposals are expected to provide either a **general improvement** in all of these headings or a **significant improvement** in limited number of headings selected among them, but without ignoring to fulfil fundamental requirements associated with the remaining ones.

Two building types; **residential** and **office** buildings that could be either **middle-rise** or **high-rise** were determined for the facade system of the future, considering their prevalence. To have a sound base for considering the climatic issues in the design proposals, entrants were expected to specify either a **climate type** according to Köppen-Geiger classification scheme or a **certain city** and provide long-term climate information in the design report submitted. In the search for innovation in topics such as, but not limited with, energy efficiency, environmental sustainability, adaptability, production efficiency, wind and seismic resistance, adopting widely known strategies such as prefabrication or adopting more recent ones such as biomimicry were both welcomed.

In relation with the aforementioned alternatives for the facade system proposals, most of the entrants were observed to prefer studying on office buildings, sometimes because of seeing a design challenge in solving the performance conflicts associated with the current solutions used (see e.g. Hybrid Double Skin Façade in Cairo, Egypt). It is worth noting that suiting to both functions together with some others was also set as a design challenge in some proposals (see e.g. The Flexible Façade). In terms of the location of the buildings, all entrants, except one, preferred to study at specific cities rather than selecting a climate type, and the selected cities were at various locations on the world, i.e. Melbourne – Australia, Cairo – Egypt, Ahmedabad – India, Turin – Italy, Den Haag – Netherlands, Istanbul – Turkey, Samsun – Turkey. Entrants’ preference of considering a specific city seemed to direct them not only in studying climatic issues, but also, for instance, in generating the form (see Sails in the Ocean), in material assessment by considering the local regulations (see Brickxel Skin), or in setting project specific goals (see Environment-Adapted Façade).



FIG. 3.13 Award ceremony for the Student Design Competition at ICBEST Istanbul conference. (image: ICBEST 2017 - ITÜ)



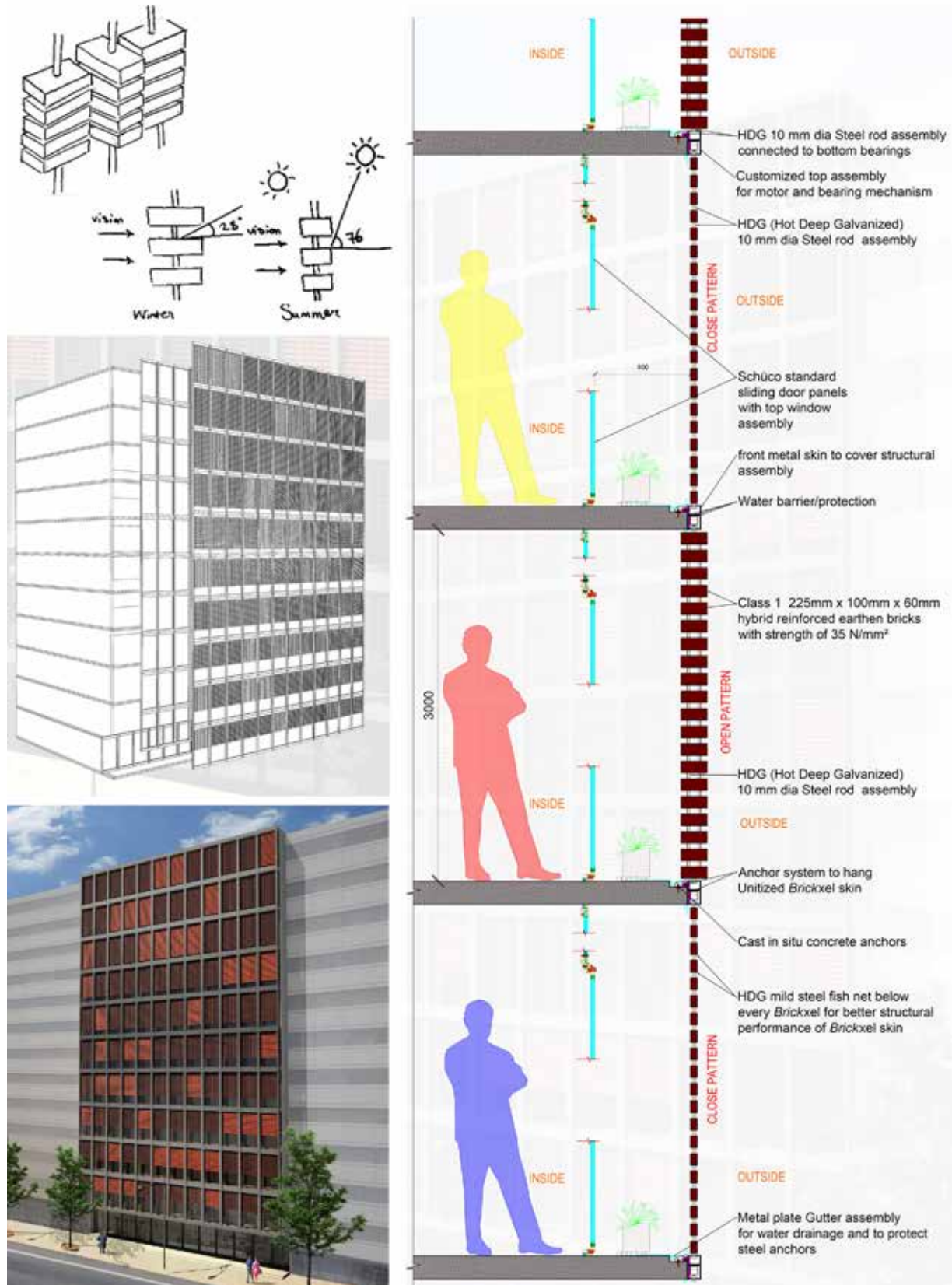
FIG. 3.14 Student Design Competition organising team members and the award-winning students in front of the poster exhibition. (image: ICBEST 2017 - ITÜ)



FIG. 3.15 Award-winning students while presenting their facade proposals. (image: ICBEST 2017 - ITÜ)

In the assessment of the proposals, the level of both innovativeness and improvements provided in the listed/selected performance headings were considered, among other issues evaluated. The selection was made considering the averages of the individual assessment grades of the following international specialist jury members; Ana-Maria Dabija – *Ion Mincu University University of Architecture and Urbanism*, Cem Topkaya – *Middle East Technical University*, Inês Flores-Colen – *Universidade de Lisboa Instituto Superior Técnico*, Jorge de Brito – *Universidade de Lisboa Instituto Superior Técnico*, Nuri Serteser – *Istanbul Technical University*, Sabarinah Sheikh Ahmad – *Universiti Teknologi MARA*, Volkan Gur – *Mimar Sinan Fine Arts University*. Five proposals, introduced briefly in the following pages in the alphabetical order of project mottos, were finally selected by the organising core jury without ranking them.

BRICKXEL SKIN



BRICKXEL SKIN

WHO	Urvashi Tuli, Mahsa Shafighnia, Ankit Patel
FROM	Hochschule Ostwestfalen-Lippe University of Applied Sciences, Masters in Integrated Design – Façade Design
PROJECT CITY	Ahmedabad, India
BUILDING FUNCTION	Office
BUILDING HEIGHT	Middle-rise (5-15 stories)
INNOVATION STRATEGY	General improvement in all performances listed

THE FACADE SYSTEM PROPOSAL IN BRIEF

Brick, which is expressed by the entrants as a cell of a building body since prehistoric human civilization era and described to be an invention that continuously innovated and diffused since prehistory to current, is the fundamental component of the proposal. Their intention is stated as ***“to take this simple yet great idea, a brick, into little more interdisciplinary arena of construction for future facades, [and] with integrated architecture approach, ... giv[ing] a new identity to a mid-rise building in terms of skyline appearance, and indoor comfort”***.

Brickxell skin is said to be derived from ***pixel skin***, and the bricks are defined to be rotating at various angles by the help of rod passing in between. The architecture is expressed to be ***“constantly alive, from both inside and outside creating dynamic architecture which plays with the shadow and light.”***

The system is described to be proposed as pre-manufactured panel and to be considered as unitized façade system for every phase till it becomes whole façade system of building. It is remarked that structural members of the panel frames should be chosen and selected per local standard for better optimisation of design, architecture, and construction aspects, where they chose customised steel box sections for Ahmedabad, as explained by the entrants ***“to blend architecture and engineering aspects, and to achieve better functional design”***. As noted additionally; ***“As per Indian National Building Code (NBC) part-4, material used for façade shall be non-combustible, and Brickxel façade system components are either non-combustible or with high-melting temperature.”***

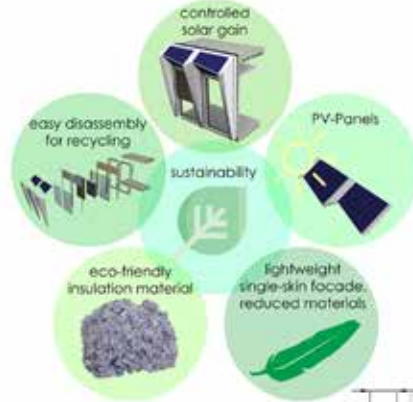
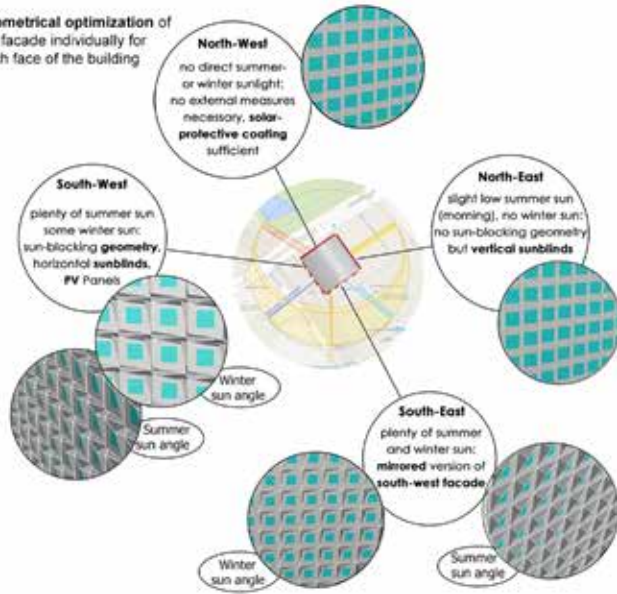
The dynamic façade is explained to be totally depending on a small motor at top (within frame) and bearing + gear mechanism for bricks installed on vertical steel rods, and the rotation of each facade told to be controlled and done according to the users' requirements. It is described to function as an openable second skin of a double skin façade ideology, where, as told, ***“firstly, it allows user to rotate Brickxels at desired angle and get a more daylight inside space. One module/panel covers almost 63% and 15% area with Brickxels when it is close and open position, respectively. Secondly, change in opening or closing position help to get more of diffuse sunlight, which helps to achieve desired daylight per user's need, [and] it also helps to block radiation up to some extent which help to choose adequate glazing system after Brickxel skin.”***

SUMMARISED JURY COMMENTS

The design proposed a 'pixel skin' on the building façade which is unique yet simple. This façade treatment is able to appreciate the fundamental design of bridging the gap between existing and new building. The infusion of old in the new is reasonable and sustainable, and the use of classic materials that have proved to be viable is appreciable. The system is not complicated to operate, and it can have advantages for the user according to the usability at a certain level. It also respects the environment as the façade component itself can be reused in other construction if needed. Due to the heat retention capability of the dense brick material, outer skin temperature would be high along daytime. The gained excessive heat energy would affect the inner skin by thermal radiation. Effective natural ventilation should be provided regularly. Arrangement of skin having gaps between bricks provide a good contribution to exhaust of the smoke and toxic gases from inside to outside. Special consideration for the high temperatures due to fire should be taken at the bottom side of the customised top assembly for motor and bearing mechanism. The constructability of the rotating brick and the interaction with the frame has some difficulties that can condition the construction process. Maintainability could be further detailed and discussed, for instance the reason why it needs less maintenance. The innovative façade system's assumptions could be highlighted in the design report. Further information could be provided in relation with its self weight and how it was taken into account.

ENVIRONMENT-ADAPTED FAÇADE

geometrical optimization of the facade individually for each face of the building



Type I
(south-east + south-west)



- ventilation through operable window
- suitable for integrating operable solar blinds due to wind-blocking baffle panel
- sun blocking geometry with integrated (PV)panel

Type II
(north-west)

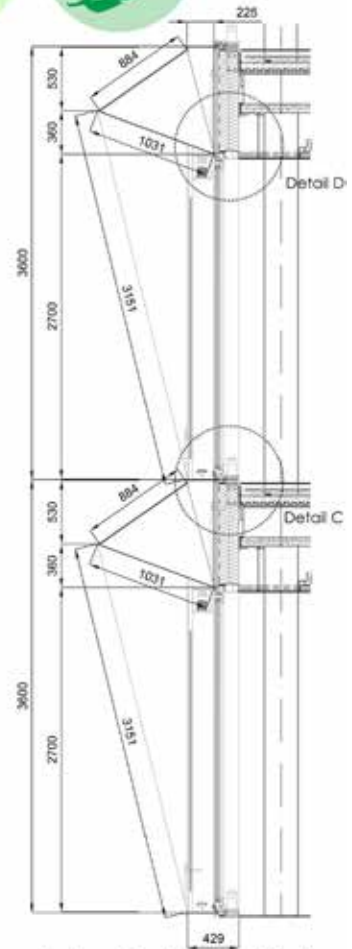


- ventilation through vent behind perforated aluminium
- perforated aluminium acting as wind shield
- fixed non-operable glazing
- dark blue spandrel for uniform look with Type I (no PV-panel)

Type III (hybrid)
(north-east)



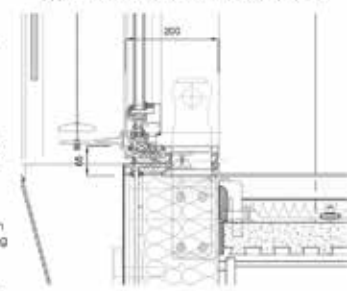
- ventilation through operable window
- suitable for integrating operable solar blinds due to wind-blocking baffle panel
- dark blue spandrel for uniform look with Type I (no PV-panel)



Easy Disassembly



Type I south-east / south-west facade



Detail C: Horizontal Panel - Panel Joint

ENVIRONMENT-ADAPTED FAÇADE

WHO	Ozhan Topcu
FROM	Technische Universiteit Delft, Faculty of Architecture and the Built Environment, MSc. Building Technology
PROJECT CITY	The Hague, Netherlands
BUILDING FUNCTION	Multi-purpose
BUILDING HEIGHT	High-rise (> 15 storey)
INNOVATION STRATEGY	Significant improvement in environmental sustainability, indoor environment related performance and usability/user related functionality

THE FAÇADE SYSTEM PROPOSAL IN BRIEF

The environment-adapted façade is expressed to be designed for a building of at least 180 meters high and including five different programmatic groups/ functions, namely; a temporary space for the Dutch Parliament while the permanent one is being refurbished, a hotel with conference rooms, offices, housing and general services, where each of these functions is stated to require a different indoor environmental quality regarding temperature, air quality, acoustic and lighting. Strong seasonal dependency of the sun at the selected location, i.e. at the Netherlands is also stated as an additional aspect to be considered in achieving project goals, which, as told by the entrant, **“can have a decisive impact on the solar heat gain and therefore to the user comfort, especially in a high-rise building that is completely exploited to direct sunlight”**, and the facade concept is explained to be developed **“to tackle both challenges of different functions and seasonal change, while making use of the energy potentials”**, where ‘exploiting differing sun angles according to season’, ‘reduction of solar heat gain in summer’, ‘increase of solar heat in winter’, and ‘harvesting solar energy from facade to the challenge into an opportunity’ were set as goals.

The façade panels are explained to be designed for being adjustable according to function and orientation of the room with differing transparency rates, where the structural parts of the panels mainly consists of aluminium frame structure suspended on the concrete slabs of the upper floor with steel brackets that allow for sufficient tolerance for expansion and compression due to temperature fluctuations in all directions. It is highlighted that **“due to the colossal size of the building and the large amount of façade area, the unitized façade system was chosen, ... not only [to] drastically reduce the on-site fixing time but also the manufacturing cost, since the large batch size would reduce the cost for moulds and production processes”**. Additionally, concerning the degradation of the materials due to external factors, the façade is told to be designed in such a way that it can be easily disassembled, and single elements can be exchanged.

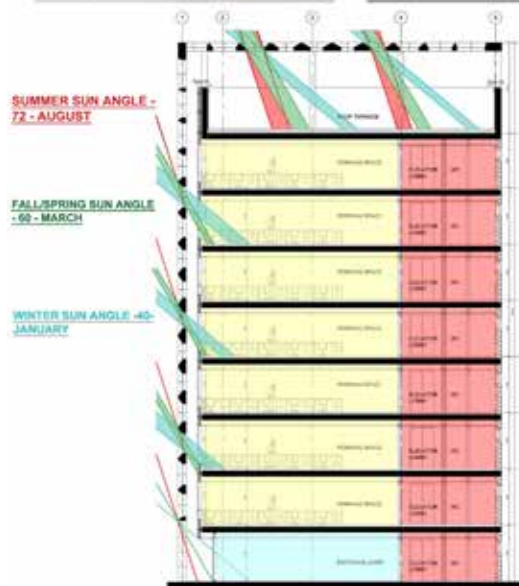
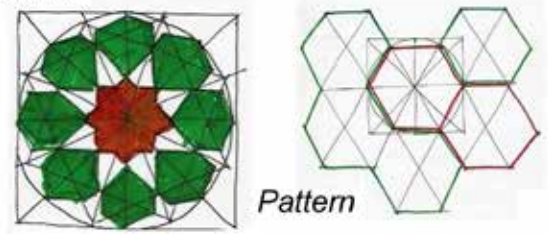
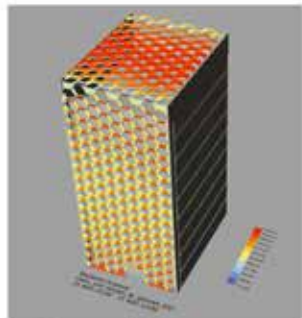
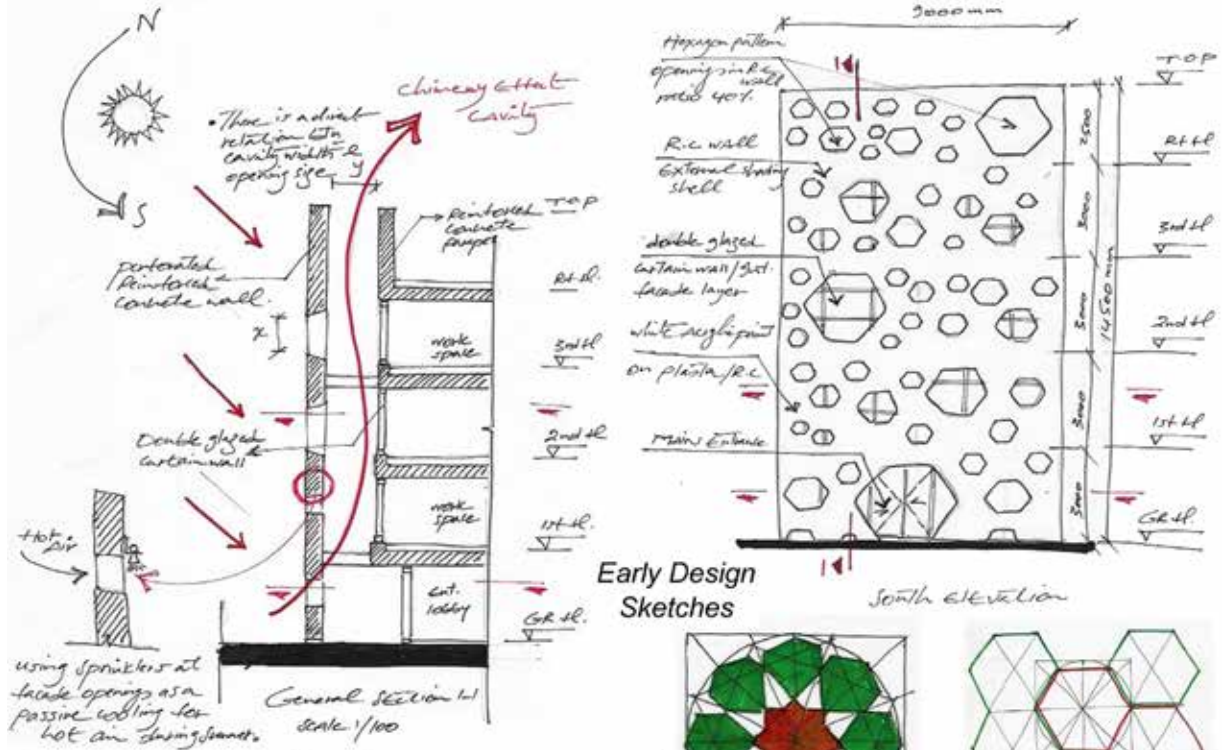
The temperature is explained to be controlled with operable external sunshades on all sides, except the north-west face, where the horizontal sun shading at the south-east and south-west oriented windows are defined to block the sunlight coming from a steep angle of incidence in summer, while still enabling views to the outside. The north-west side, that is expressed to be exposed mainly to early morning sunlight in summer, is defined to be equipped with horizontal sun blinds that can be shut during early morning hours and half opened in mid-day, when the sunlight is entering from the side. As stated additionally, **“regardless of the orientation, sun protective coating is applied on all sides to limit the heat entrance in hot days through diffuse light, along with a low e-coating to keep the heat inside in winter”**.

Concerning water and airtightness of the façade, it is stated that **“at the directions where the windows are exposed to a high wind pressure, which is mainly the south-west face, a baffle panel is placed in front of the airtight barrier to avoid too high pressures, Placing these panels also prove to be convenient, since the south face of the building is the one that is mostly exposed to direct sunlight. Therefore, the baffle panels also act as a wind protection for the external operable sun shading devices”**. It is also highlighted that **“as fixed baffle panels create a cavity between two glazings with some space in-between, they can pose a challenge for cleaning....[but] the facades provided with a baffle panel can be equipped with an openable window. This makes it easier to clean both, the inside and outside glass panel”**.

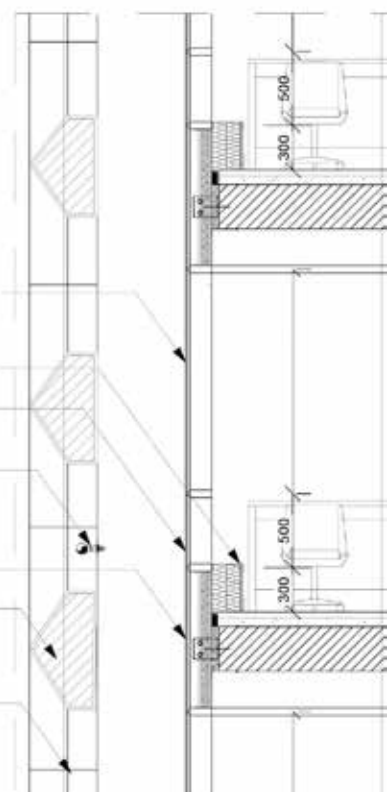
SUMMARISED JURY COMMENTS

The design proposal suggests an environment-adapted façade system for a high-rise block in the Hague. The directions and the environmental conditions are analyzed and different façade types are suggested for different directions. The façade system supports energy conservation/ gain and natural ventilation for the user in demand. The overall approach for the design of the façade in terms of indoor environmental performances is good. The overall facade system is practical and unique as the facade geometry is based on exploiting the sun angles and also adjusted its features towards the local climatic condition. It is good in terms of environmental design as the façade system able to reduce energy consumption from heating, cooling and lighting during the daytime. BIPV on the vertical sides, on the other hand, lose 25-30% of the performances, and thermal bridges are present at the thermal insulations set in aluminium panels. Structural details are well presented. Sufficient fire isolation in perimeter area between curtain wall and structure is provided. Special care might be enhanced by using flame retardant silicones in the connection of suspended ceiling and curtain wall. The constructability of the facade’s relevant elements is well presented at design brief and design report, despite the difficulties of the construction process (due to building height and façade elements). The modularity of the solution is a plus. Reference to maintainability should be made, as well.

HYBRID DOUBLE SKIN FAÇADE IN CAIRO, EGYPT



- INSULATED TEMPERED DOUBLE GLAZED PVF3 COATED ALUMINUM CURTAIN WALL
- ALUMINUM SILL EXTRUSION BY CURTAIN WALL SUPPLIER
- FULLY TEMPERED IMPACT SAFETY GLASS
- SPRINKLER HEAD VICTAULIC MODEL V2703/V2704
- GLAZED SPANDREL SHADOW BOX
- 20 mm ACRYLIC PAINT ON PLASTER
- 400 mm R.C. WALL



HYBRID DOUBLE SKIN FAÇADE IN CAIRO, EGYPT

WHO	Radwa Abouelseoud, Jameela Eranpurwala
FROM	Hochschule Ostwestfalen-Lippe University of Applied Sciences, Architecture and Interior/Master of Façade Design and Construction
PROJECT CITY	Cairo, Egypt
BUILDING FUNCTION	Office
BUILDING HEIGHT	Middle-rise (5-15 stories)
INNOVATION STRATEGY	Significant improvement in environmental sustainability, and indoor environment related performance

THE FAÇADE SYSTEM PROPOSAL IN BRIEF

A hybrid double façade system with perforated reinforced concrete wall as the outer shell for shading purposes is proposed by the entrants, by expressing that **“office buildings commonly use large surfaces of glass on their façades in order to reflect a luxurious appearance while maximizing the natural light penetration to the interior space”**, and they quoted that **“though glass façades provide plentiful natural lighting, the amount of energy needed to maintain indoor thermal comfort in hot and cold climates poses a great challenge to office building designers”**.

The project's aim is explained to be **“studying the climatic and environmental conditions along with the vernacular and cultural architecture of a hot, dry region, which showed that in extremely hot climates, natural ventilation is not preferable, and using a hybrid double façade system allows sun protection, reduces cooling loads and also will be effective in controlling noise”**.

The perforated concrete screen is expressed to be inspired by the vernacular lattice screens known as **Mashrabiya**s, where the perforations of the outer shell are in the form of a 'Hexagonal Pattern' which is explained to be simplified from the commonly used Islamic pattern. The Pattern's openings are defined to be differing in size to maintain optimal visual contact from inside to outside and also to provide shading. The inner layer of the system, as explained by the entrants, **“consists of a double glazed curtain wall façade, which is supported by aluminium structural frames fixed by brackets at the edge of each concrete slab floor, where the loads are transferred to the slab, ... and the exterior layer of concrete protects the inner curtain wall layer from the load of the winds and the frequent dust storms”**. The 600 mm cavity between the inner and outer façades is stated to be stimulating the natural chimney effect, allowing hot air to rise and cools the glazing surface, where the sprinklers used behind the openings are stated to passively cool down the air by evaporation.

In consideration with being located in a hot climate, the exterior perforated concrete wall is stated to be designed to provide shade and block the heat and glare. It is defined to be coated with white acrylic paint to reflect the radiation from the sun, thereby reducing solar gain. Solar and visual optimisation of the openings in the perforated outer skin is told to be done for the noon of 21st of August using typical weather data file of Egypt. An input equation on maximum shading and maximum daylight quality is stated to be supplied to the Grasshopper software to get one façade out of fifty, with a specific opening configuration that fulfils both requirements; good daylight quality and shading. The solar analysis done for the hottest month in Cairo, for August 21st from 10 am till noon is expressed to be showing that the roof is the most affected area to the solar radiation due to the high sun angle during summer, and therefore the roof is also told to be protected with another perforated shading element to reduce the solar heat gain and the cooling loads.

SUMMARISED JURY COMMENTS

The design proposal suggests a double skin façade for Cairo. There is a respect for the traditional building systems, at a contemporary level. According to solar control, it has some advantages for the user. The proposal responded well to the building condition and overcomes issues regarding environmental and climatic factors based on the grasshopper simulation analysis. The perforated shell is a well designed system, which combined daylighting, reduce cooling load and also create stack ventilation effect to the interior façade. Expansion under temperature needs further details. Reinforced concrete façade may be a very heavy option that can adversely affect the cost. Sealing up the perimeter slot with a fire insulation material is good, but a firestop coating should also be added on the upper side of the isolation and curtain wall to provide a seal for movement of smoke and hot gases upwards. The design philosophy of the outer skin is positive in terms of providing daylighting, noise reduction, shading effect and contribution to the cooling of inner skin. The maintenance access is well illustrated; however maintenance needs should be discussed too. Issues related with constructability, such as the ones concerning the construction of the perforated reinforced concrete façade and roof, and the interactions with columns and concrete beams and aluminium frames, can be further described as well.

SAILS IN THE OCEAN



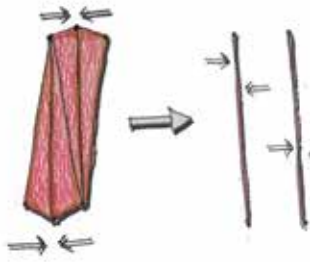
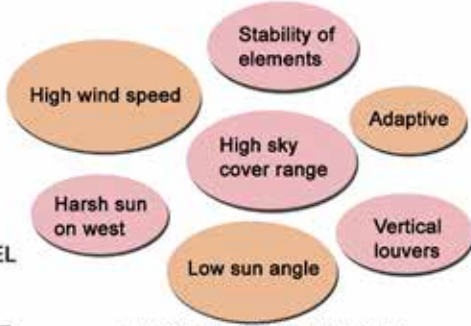
INSPIRATION FOR CONCEPT



ARRANGEMENT OF SAILS



SINGLE PANEL

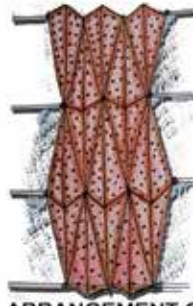


MOVEMENT OF FACADE ELEMENTS



MOVEMENT VIA ROLLERS

LIGHTING



ARRANGEMENT OF FACADE ELEMENTS

IMPORTANT CONSIDERATIONS



PROPOSED ELEVATION (CLOSED FACADE)



SECTION



FACADE ELEMENT

GREEN PANELS



SINGLE PANEL



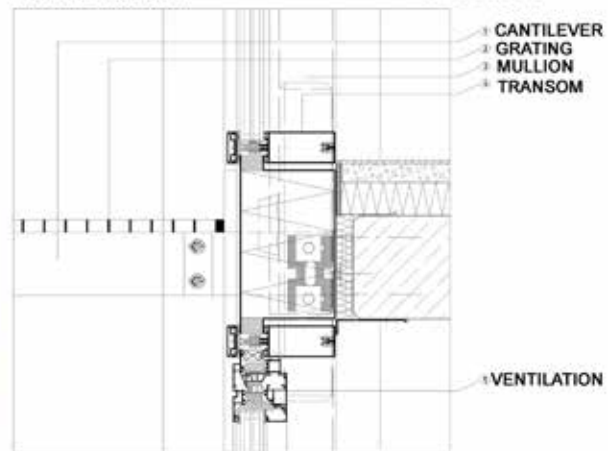
SIDE ELEVATION



SECTION



DETAIL WALL ATTACHMENT



SAILS IN THE OCEAN

WHO	Tavishi Rana, Tuba Ela Cinar
FROM	Hochschule Ostwestfalen-Lippe, Detmolder Hochschule für Architektur und Innenarchitektur – FB1/MIAD (FD)
PROJECT CITY	Melbourne, Australia
BUILDING FUNCTION	Office
BUILDING HEIGHT	Middle-rise (5-15 stories)
INNOVATION STRATEGY	General improvement in all performances listed

THE FACADE SYSTEM PROPOSAL IN BRIEF

'Sails in the Ocean', the façade for Melbourne, as explained by the entrants, ***"is inspired by sails which can be commonly seen in the waters near the city. Melbourne being a port city can be directly related to the sails and using the same story the façade idea has been developed"***. The west façade, which was chosen for the design, is told to need vertical louvers because of the angle of sun remains low for most time of the day. To this end, it is stated that ***"a single element of façade is constructed in such a way that it folds up to form vertical louvers when the façade is open and when the façade is closed then these elements act as shading devices, [and] these adaptive elements are made up of PTFE membrane"***. Fixed elements holding green plantings and allowing the building to breathe are also stated to be used for making a functional healthy façade, where the arrangement of the green elements and the adaptive elements is defined to be such that the building gets enough light.

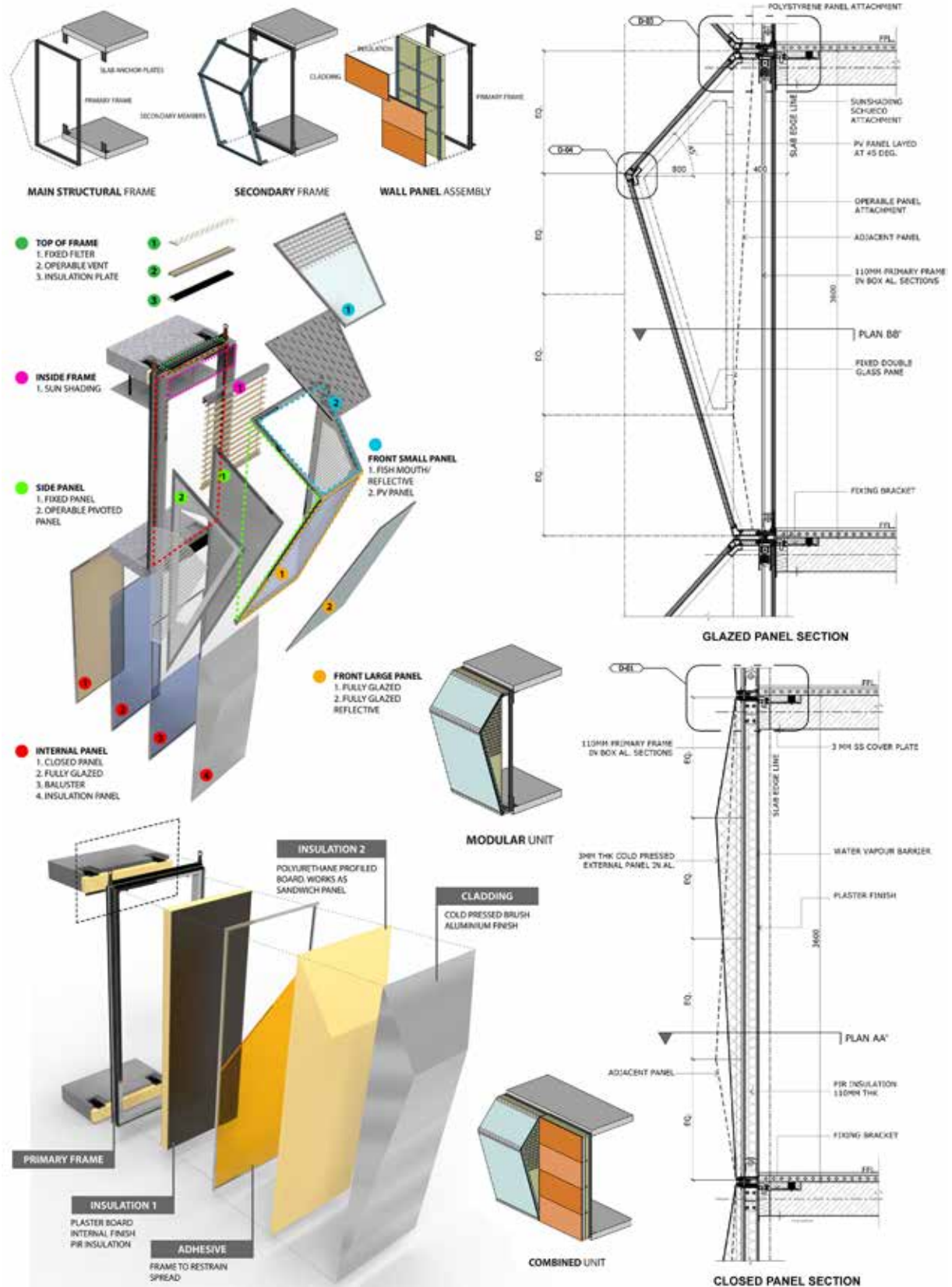
The structural system of the inner façade is explained as a stick system, where the fixing of which is on each floor. A gap is told to be left on the top connection of the façade as an expansion joint for the expansion of the façade elements, and the glass is fixed with a pressure plate. On the other hand, the PTFE panels on the outer skin are told to be prefabricated, and before fixing the glass on the inner skin the supports for the outer skin are constructed on site. The area between the facades is stated to be structurally supported by a beam which is connected to the internal structure of the building, and on the top of this beam a steel grating is placed to carry human loads during maintenance work, while the panels are fixed on the rails by means of rollers. Each single panel of PTFE membrane is told to have a frame around it which keeps it fixed at a point. The panels with plantings on them are described to be irrigated using rain collectors that are placed on the top of the building. From this rain collector the water goes to different pipes which finally go to the panels and the plants. The sensors that are told to be placed inside the panels are defined to be a deciding factor about how much water is needed by the plants. The PTFE panels that are explained to be used for shading the building are controlled by a computer operated system and can also be controlled by people sitting inside the building on different floors. As explained by the entrants, ***"when the light is too bright then the panels open and during the evening close so as to let the light inside the building. Since many systems of the façade are computer operated the movement will be carried out by the means of wires and electrical connections which can be placed inside the rails and the mullions"***.

An effort has told to be made additionally to integrate the roof and the façade, considering that the roof being the fifth façade is an important aspect of the design as maximum heat gain is through it. The roof has explained to be designed as a garden that can be used in the evening and night as an interaction space. In order to shade the roof, the same façade elements are stated to be used but they are not designed to be adaptive and can only be moved on a fixed rail system. The movement is considered to be important by the entrants, since it is important to shade different areas of the roof at different times according to the sun position.

SUMMARISED JURY COMMENTS

The design proposal suggests an adaptive façade system for an office building in Melbourne. The operable membrane elements control the sunlight. Additionally, natural ventilation can be possible via openable elements. According to the usability, the system has some advantages for the occupants. The basic concept behind the proposal is an interesting approach especially on the adaptive movement of facade element that uses sail-like design. The addition of vertical green plants into the façade system is considered a good effort as the overall façade could buffer the air pollution and also reduce energy consumption. Control mechanism of translucent elements on the façade should also be clarified. The structural details were explained in detail. However, no information is given about wind and earthquake loads in the design report. Flame and smoke propagation is a critical issue in double-skin façades. Sufficient natural or mechanical ventilation for smoke exhaust should be provided on top of the façade gap. Compartmentation is a good solution including cat-walk or grating areas to prevent smoke and flame propagation between floors. The constructability and maintainability are well discussed. However maintenance needs can be further detailed, for example the type of maintenance on green panels. Noise reduction function of the façade elements can be mentioned too.

THE FLEXIBLE FAÇADE



THE FLEXIBLE FAÇADE

WHO	Aashish Ravindra Vipat
FROM	Delft University of Technology (TU Delft), Architecture, Master of Science Architecture, Urbanism and Building
PROJECT CITY	Den Haag, Netherlands
BUILDING FUNCTION	Multi- purpose
BUILDING HEIGHT	High-rise (> 15 storey)
INNOVATION STRATEGY	Significant improvement in technical functionality and durability, environmental sustainability, indoor environment related performance, constructability/ maintainability, and usability/user related functionality

THE FAÇADE SYSTEM PROPOSAL IN BRIEF

The 'Flexible Façade' system, as explained by the entrants, *"is envisioned with a view of meeting the variable demands of the future buildings, [where] the system is designed around a hypothetical 'House of Parliament' building in the city of Den Haag, Netherlands... compris[ing] of different programs namely: offices, residential apartments, a hotel and space for re-housing the parliament of Netherlands, [and] the different programs mean different requirements, which in terms of the façade mean diverse needs of ventilation, natural light, functionality (insulation, type of glass etc.) and add-ons (blinds, windows, balconies)"*. The goal set in relation is told as *"to have a singular façade system that not only meets the diverse nature of demands but also controls the cost, provides ease of assembly and maintenance"*.

The construction of the 'Flexible façade' is stated to allow this by having a primary frame, which supports a secondary frame, which in turn supports the infill panels. The layered system is explained to be installed like a unitized façade system, but possessing interfaces between the components that allows disassembly and replacement much like a stick façade system, thus forming a 'hybrid system'. A modular and transformable system is told to be proposed allowing ease of replacement and re-configuration of infill panels (which are expressed to be essentially responsible for functional variance) over the primary frame structure, and the sizes of the panels are defined to be in multiples of 0.5m in width.

Concerning the energy use, introduction of as much natural ventilation into all programs of the building is told to be preferred to reduce the load on mechanical air-conditioning and heating systems, where temperature-driven and wind-driven ventilation strategies are told to be employed at the offices, and at the residential units and hotel (to a certain extent) respectively. The former strategy is stated to be put into use by fish mouth ventilation either at the top or at the bottom of the panels in an alternating order horizontally, and the latter one is by mechanically controlled ventilation louvers within the upper part of the side panels. Additionally, the façade is explained to be designed to support installation of PV panels for reducing the loads of air conditioning and lighting, where a 45° angle at the top part of the inclined panel is made to maximize the efficiency of the panels. The calculations given shows that a total of 1147 MWH of energy will be produced per year.

SUMMARISED JURY COMMENTS

The modular facade system in this proposal is a well thought design approach, which respects the overall building outlook and also improve the environmental performance as well. This system is not just practical in terms of application but also energy efficient as the modules are able to generate clean energy from the use of PV panels. The façade modules enabling the production of electricity with PV modules and natural ventilation are both positive sides of the project. However, different façade directions are omitted in the project. The manual operation of the opening panel on the unit can be difficult due to its position and the operation side. The system is easy to assemble. It is a design proposal with good construction details, and the constructability of the facades is well presented at the design report; the sequence and construction details. The maintainability issue is covered; however the maintenance needs of exterior surfaces could be discussed more. Economical provisions are not clear too. The overall approach for the design of the façade in terms of indoor environmental performances is good. The design principals and application of isolation material for fire penetration between floors are successful. The use of the specific thermal insulation materials is a hazard for the fire safety requirements. As the wind loads increase towards the top of the building, measures should be taken for dealing with it.

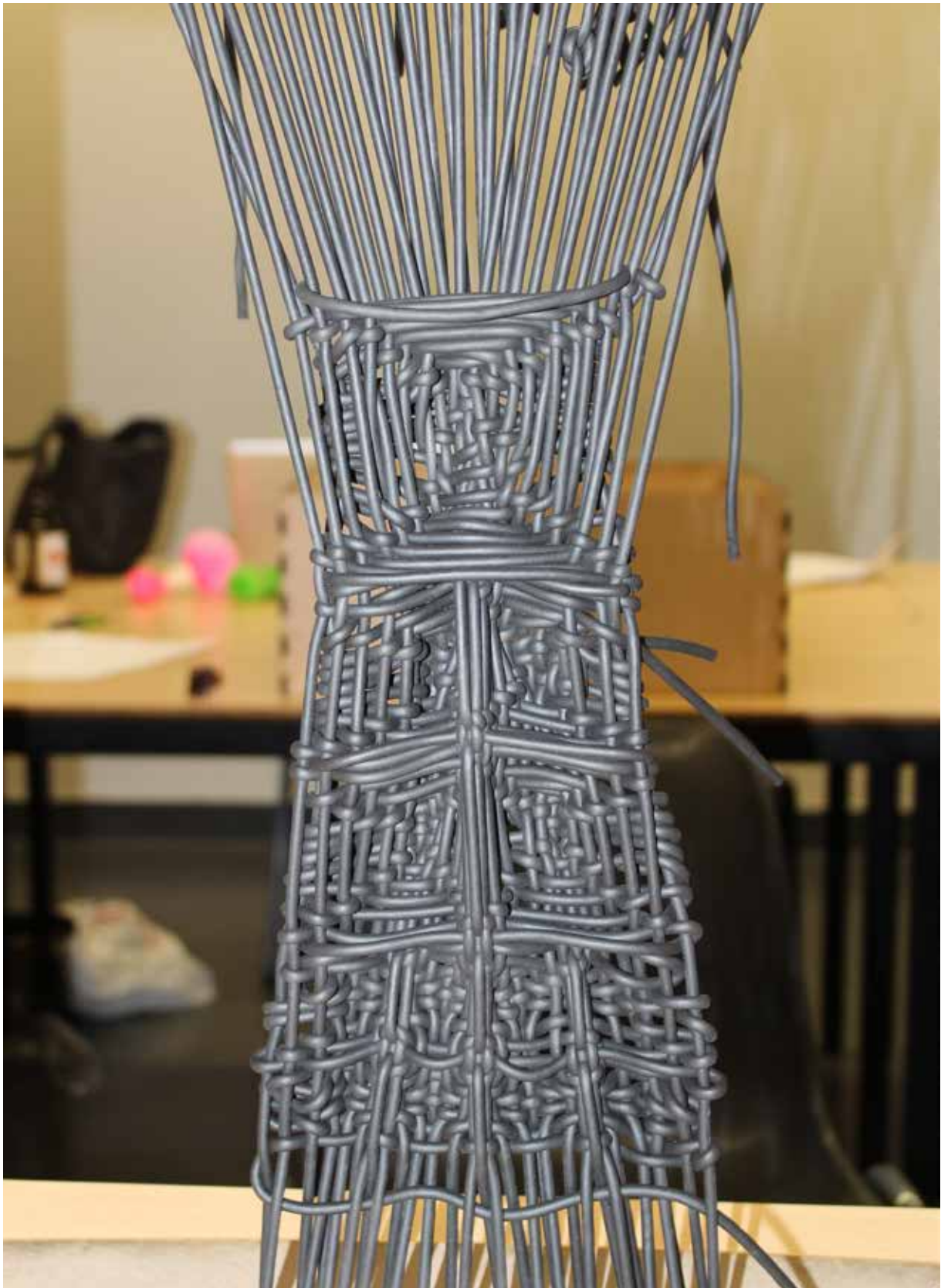


FIG. 3.16 Textile Handmaking during the efnMOBILE-Workshop in Antwerpen in May 2017. (image: P. Denz)

3.3 Improving the Praxis. Make before you code

Anthony Chen, Society of Façade Engineering / Hong Kong Chapter (SFE/ HK), for efnMOBILE

Re-visit the Values of Handmaking in pedagogic Research for Façade Design

Based on the experience of “Smart Textile Workshop for Building Skin” organized in May 2017 by efn (European Façade Network) with an aim to investigate textile application for building envelope system, it is observed that traditional value of handmaking is significant to inform creative cognition and especially from “learning-by-doing” (Ozkar 2007) and “creating-by-making” perspectives. In the age of digital coding, design professionals are keened to code with parametric tools straight away for the iterative design exploration. Without physical engagement, individual approach to the problem of materials, processes and products is lost. Implicit/ tacit knowledge, as constructed through hands-on experience (Lehmann 2012), is hard to codify and largely unseen in the creative process which is vital for research as well as for other material- or process-designated disciplines. There is a need to re-visit the value and to incorporate handmaking exercise and performance to promote the awareness of tacit knowledge within the pedagogical and research framework. This paper presents a framework to integrate the implicit knowledge component, through handmaking performance, into Knowledge-Based Engineering (KBE) process for smart textile and other material related research in a building envelope context. The aim of the framework, as well as of the efnMOBILE-workshops, is to bring two different knowledge domains together to the research process, both explicit and implicit, in a contemporary digital coding environment. Ideas have also been borrowed from the Bauhaus original conception with which hand experimentation is at the centre of the design education to drive creative thinking and innovative ideas.

Introduction

For traditional textile production it is a physical making process which essentially involves techniques such as weaving, knitting, knotting, braiding, coiling, felting, crocheting and embroidery. Each type of production techniques embraces and possesses an unique construction algorithm, system, cultural origin and correlates to a specific textile artefact which is worth further exploring the variety and diversity for potential application in a building envelope context. Such as “Soutache” is a decorative braid produced by braiding technique with a herringbone pattern; crocheting is employed to produce “Manila Rope”; basketry is commonly produced by coiling technique.

For contemporary architects and designers using digital coding forms an integral part of their creative and design process and for idea exploration. Visual programming software and scripting language like Grasshopper, Dynamo, Python and Ruby Scripting become increasingly accessible as design medium and being utilized in the design processes to various extend. Proficient to code becomes a necessarily for architects and designers both in practice and academia. Young researchers, who have grown up in using coding in many aspect of their lives, are likely to have less traditional handmaking skills. Additive or robotic prototyping is extensively used nowadays and enable directly realise the final product from code. They are less physically connected and may have little or no physical bodily contact with the textile or other materials and processes in developing the initial concept. Preliminary outcomes are perceived and manipulated through adjusting the algorithm and coding in a digital environment. As such the young researchers lack the interaction with the physical material through which tacit knowledge is constructed. Treadaway (2006) indicates that through direct engagement in material and process, tacit knowledge acquired will help exploring the material potential further. It is the physical characteristics of the material and the process that stimulate new ideas through the sensory information it conveys. This experiential learning process is also in line with the Bauhaus weaving practice with which its education is emphasised on material-focused understanding and hands-on experience. Gaining experiential knowledge through handmaking forms an integral part of the school’s conception.

In the present pedagogical research framework there seems an isolation of the implicit/ tacit knowledge gained through experiential learning. But it should inform back to the coding environment for design iteration and especially in the field of smart materials and processes research application. A collaborative approach to researching the topic is seen to be necessary. It requires both implicit / tacit knowledge (experiential learning) and the explicit knowledge (coding) as medium and tools for innovative ideas exploration.

This section gives a brief introduction and background to the problem, and the handmaking practice. Section 2 differentiates the concept of explicit, implicit and tacit knowledge. Section 3 highlights the significance of the embedded tacit knowledge in traditional handcraft makers. Section 4 describes the importance of handmaking as a medium of physical engagement and thinking process. Section 5 reviews the rise of coding application for the architecture and design disciplines. Section 6 compares handmaking against coding in the creative and design process. Section 7 illustrates the disembodiment with material in the creative process. Section 8 reviews the debate if tacit knowledge can be codified to explicit knowledge. Section 9 reviews the current research directions for Knowledge-Based Engineering and computational design with material and traditional crafts focus. Section 10 proposes a research framework with integration of tacit knowledge component in the KBE process. Capturing and representation of individual tacit knowledge is explained and delineated. The extracted tacit knowledge will then be codified in the expert system for explicit modelling and 3D prototyping for materialisation. Finally conclusions are drawn and future work outlined.

The concept of explicit, implicit and tacit knowledge

Explicit knowledge: this type of knowledge is articulated knowledge, expressed and recorded as words, numbers, codes, mathematical and scientific formulae, and musical notations. It is also the process of calling up information (patterns) and processes (patterns in time) from memory that can be described accurately in words and/or visuals (representations) such that another person can comprehend the knowledge that is expressed through this exchange of information (Anderson 1983). Many theoreticians regard explicit knowledge as being less important (e.g. Cook & Brown 1999, Bukowitz & Williams 1999, etc.). It is considered simpler in nature and cannot contain the rich experience based know-how that can generate lasting competitive advantage.

Implicit knowledge: implicit, by definition, is something that is hidden. As opposed to formal, codified or explicit knowledge, it is the kind of knowledge that is much about “knowing how” to do something but it is something that we may not be able to explain or describe explicitly. Under this interpretation, implicit knowledge corresponds roughly to Polanyi (1967) calls “Tacit Knowledge”: “We can know more than we can tell”. Generally it is considered to be the embedded knowledge in-between explicit and tacit Knowledge.

Tacit knowledge: the term was first coined by Polanyi, and popularised by Nonaka and Takeuchi (1995). It means “extraordinary knowledge possessed by humans that cannot be expressed in explicit and formal ways”. Tacit knowledge is a growing research domain and has been studied by different fields, including but not limited to philosophy, psychology, sociology, cognitive science, business, education and artificial intelligence. Different fields have focused on different dimensions. This has resulted in numerous classifications and distinctions based on philosophy and research interest. According to different research disciplines, tacit knowledge is regarded as “skill”, “special know-how”, “working knowledge”, “expertise”, or ability to perform a task (Salazar-Fierro & Bayardo 2015). However, to give a formal or scientific definition is rather difficult. This is because researches often adopt different representations to define tacit knowledge. Iba (et al 2011) defines re-usable problem solutions along with the scenarios or contexts as tacit knowledge. Those researches are emphasised on how to capture and reuse of tacit knowledge for material-based product development. The goal of those researches is to transfer tacit knowledge to explicit knowledge so as to improve reasoning and decision-making in the design process. This approach shares the same interest and research focus for smart textile application. This also explains why tacit knowledge has attracted many research attentions by engineering design/ manufacturing discipline recently due to the potential application for Knowledge-Based Engineering (KBE).

From design professionals’ perspective, the difference between tacit knowledge and implicit knowledge is subtle and sometimes the terms are used interchangeably in the field of design and engineering. For coherence of terminology, the term “Tacit Knowledge” will be used throughout this paper to cover both the meaning of implicit, embodied and tacit knowledge.

Embedded tacit knowledge in traditional handcraft makers

In traditional textile and handcraft making cultures, knowledge derived through engagement with materials and processes. These hands-on experiential knowledge, according to Niedderer & Townsend (2014), is impossible to articulate and largely remains tacit - embodied in the handmaker. A Cognitive Scientist with research interest on creativity and material engagement, Malafouris (2005) states that “Verbal description, however detailed, can hardly capture the phenomenological perturbation of real activity”. Architect and computational designer Noel (2016) points out that the workflow has little separation between design and fabrication. The handmakers usually have the embedded knowledge to materialise their ideas without externalisation via 2D presentations.

Cultural crafts such as wire-bending decorative structures in Republic of Trinidad and Tobago, ringal-weaving artefacts in India, coiled baskets in Uganda, rush-weaving artefacts in Taiwan, just to name a few, are handmaking artefacts enriched with culturally significant tacit knowledge. Due to globalisation, technology advancement, however, these traditional craft cultures are declining and potentially disappearing. This tacit knowledge, if made explicit, will be a good source of references to be reinterpreted for material-designated research and product innovation. As Lehmann (2012) asserts that “analysis of existing techne (craftsmanship/making) can lead to the creation of episteme (knowing/knowledge)”.

Handmaking as physical engagement & thinking process

Textile and also other craft making practices are characterised by knowing-through-making. Much textile design practice nowadays is still carried out intuitively, informed by tacit knowledge acquired through tactile, sensational exploration of materials (Philpott 2010). Our knowledge of textile is largely perceived by the sense of touch. Traditional handmaking techniques for textile artefact employ the whole body in the process of production where eye, hand, sensation and physical materials all come together. In the handmaking process, it is the importance of physical interaction, the sense of touch sought an association between the vision in mind and the material in hand. Touch provides insight as to how these elements are connected and come into play. The hands-on experiential knowledge derived through experience is hard to articulate and therefore remains tacit in the handmaker. Gray & Burnett (2009) describe that handmaking performance is a dynamic process of learning and understanding through material experience. Handmaking process from Nimkulrat's (2010) view point is not only as a way of attaining tacit knowledge through physical engagement, but also as a way of intellectual thinking through the hand manipulating a material. It is a means for logical thinking through senses.

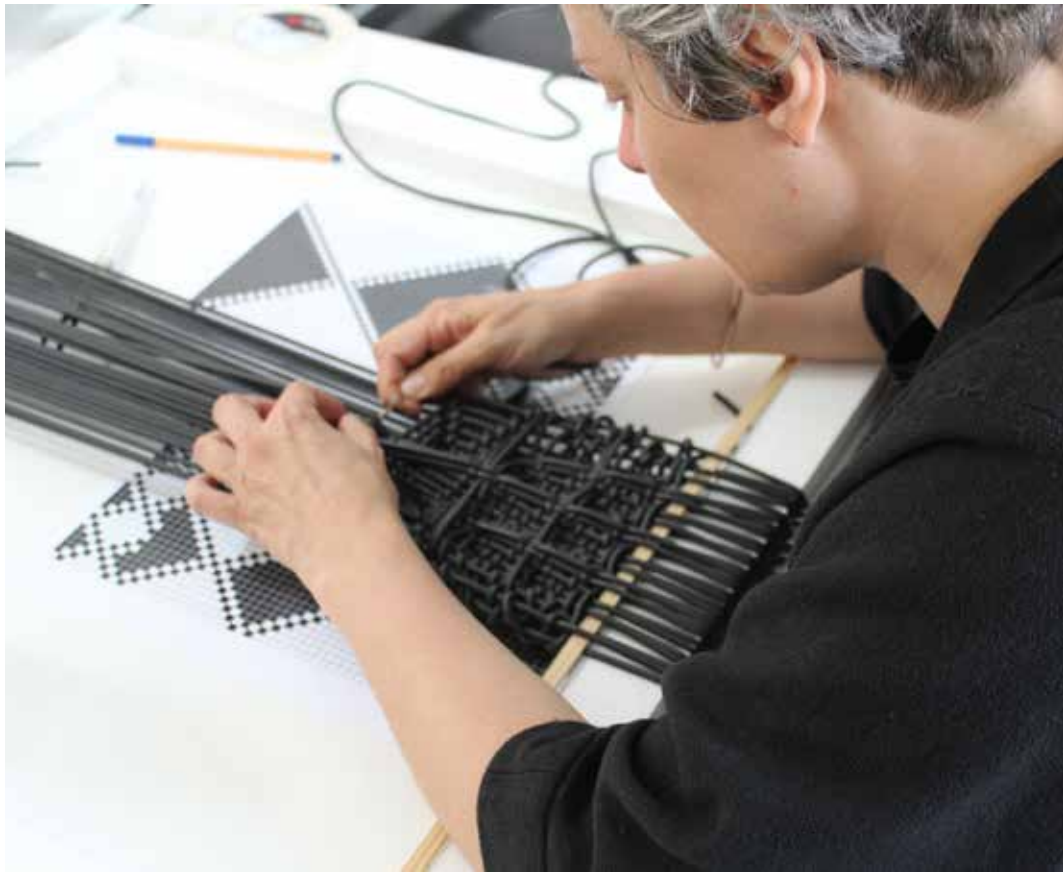


FIG. 3.17 The knowledge of textile is largely perceived by the sense of touch. The handmaking of textiles is as a way of attaining tacit knowledge through physical engagement and a way of intellectual thinking, (image: P. Denz)

(Digital) Coding in the architecture and design practices

The wider-spread adoption of visual programming tools and scripting languages is providing a great point of entry into the world of coding for the visually minded. Architects and designers in the digital spectrum realize that their work and material, which exists in the world is CODE. Coding has become the norm in design and architecture professions. It has touched every aspect of the design and architecture discipline. In the technical way of thinking, coding trains one to think in a structured way, which also helps in problem solving. There are many advantages of learning to code for architects and designers. According to Pandit (2017), coding knowledge gives design professionals “complete control over the whole form generation process”. It helps to expand the design capabilities. He further states that “if ones know exactly what these algorithms represent and how they influence the outcome of a geometry, they can make much more conscious and efficient decisions in the design process”. Hence, it is not far from reality that design professionals and programmers are crossing paths with each other.

Creative and design processes: handmaking vs. coding

All the work of the hands is rooted in thinking. The movement of hand making the material into artefact facilitates the process of thinking (Heidegger 1978). Physical handmaking process involves the interaction with a material and it is the physical characteristics of that material that inspire the creative process. Architect and textile artist Worden (2017) states that when it comes to design with textiles, he rarely uses a sketchbook or digital model. Instead he will try to use physical material as much as possible. He considers sketches or digital counterparts can be used to help define top-down process, while in the process of making physical artefact enables a bottom-up approach which facilitates imagination.

Treadaway who researched on craft and digital design indicates that physical material can act as carriers of memory through a variety of sensory properties: sight, smell, sound as well as touch (Treadaway 2009). Each sensory prompt enables imagination building through physical proximity or bodily contact. The physical manipulation of materials is a crucial act to inform creative cognition and feeds the imagination. This theory also corresponds to the conception of “material thinking”. According to Carter (2004), material play an active role in the creative process and interact with the handmaker’s intelligence when the hands, mind, and eyes are connected and come into play. Through physically handling of material, a form of tactile sensory information acquires.

Educator Cabrinha (2010) refers the development of innovative idea due to direct engagement with material as material imagination. He criticises the current design culture has become more a coding culture as a result of lack of material imagination in the design conceptualization stage. He highlights that material imagination is more than a pragmatic means to develop coding skill, but a more epistemic way of engagement with the analog world. Oxman (2012) shares similar viewpoint with Cabrinha on the current phenomenon in the digital discourse towards design. She describes “owning to the priority of geometrical representation over physical material considerations, a phenomenon that has led to streamlining the design process: “form first, material later”. In Cabrinha’s design studio, he emphasis the “material first” approach to excite material imagination through developing coding skills. His intention is to cultivate the material sensibility enabled through the precision and geometric development in coding technology.

Substantiated by research findings, Treadaway reveals the importance of time for reflection in order to develop new ideas. She describes the physical bodily experience and the time related factors involved in making by hand are essential within the creative process. It is the slow process of handmaking an artefact that facilitates imagination space (Treadaway 2009). Harris points out the slowness of making can free the mind of the maker to reflect on the creative process and to stimulate insights (Harris 2005). Creative process in handmaking performance is simply a process of translating sensory experience from physical to cognitive condition. This primarily involves sense, experience, time, and response which are largely remained tactile and embodied in the handmaker.

Code, on the other hand, is a rule-based of making (Worden 2011). Design mainly progresses by working on the code itself. Working with code as design medium requires constant refinement and evaluation of the algorithm rather than with design intuition. It is entirely the use of explicit knowledge; tacit knowledge is completely absent in the design process. The design process is highly rational and the feedback is non-intuitive. The process is actually a re-structuring the flow of the data or how the code is related to one another.

Cannaerts (2016) describes that the elements for structuring code are highly hierarchical. They are geared toward modularity and repetition, meaningful variation, and splitting up a design task into reusable components. Ultimately the efficiency of code structuring determines the flow of instructions passed to the digital system. As design complexity develops, code develops incrementally by building on working previous blocks of code. The reuse of code is gradually increased in complexity. For the design involves repetition and variation, code can be operated on collections, lists or array of elements. Burry (2011) points out that in designing with code the focus tends to be shifted to systematic and multiple rather than unique outcome. The major different with the handmaking process in terms of fine-tuning the result is largely based on the implicit knowledge.

Disembodiment with material in the creative process

Our sensory experience has linked to material world. If the maker is isolated from the material contact, physical bodily experience is broken and there will be no senses of touch to stimulate creative thinking. Using code as design medium, assumption is to be questioned and explored by just manipulating input and output of instructions according to the logic of algorithm, no tacit knowledge is involved in the process. It is the algorithm behind the coding that deprives the designer from physical contact. It is a separation of hand, mind and materials. Moloney and Pallasmaa criticize that the sensory link to the material is weakened by coding technology as it drives the design professional to the direct manipulation of abstract geometry rather than material itself. (Moloney et al 2003, Pallasmaa 2000). Coding disembodies handmaking experience and inhabits creative process development.

Time for reflection is also a contribution factor to the creative process. According to Hodes, during the handmaking process that is slow to perform and facilitate thinking space in which ideas can be associated and refined (Hodes & Treadaway 2008). Following the same concept with Treadaway, Harris and Hodes, describe that the fast response of generating multiple ideas with coding techniques inhabits creative thinking.

For coding as design medium, on the contrary, the material artefact is the outcome of the direct conversion of the digital algorithm. This reduces the “experiential delay” between conceiving and making. Ideas are generated and iterated faster. However, the downside is that design professionals become keen on developing abstract geometry before exploring the material consequences (Harrop 2004). It is the speedy response from computer that makes thinking unimaginative.

DeLanda reveals the source of this disembodiment when he describes interaction with material as a negotiation. He describes that there is a physical resistance when the handmaker tries to shape and construct a material in accordance with their goals. To deal with this “confrontation”, the handmaker has to adjust their goal in order to achieve the desired result. He describes that it is the process of give-and-take and through this process ideas are gradually enriched and refined. However, if a material is powerless to counteract the handmaker, there will be no negotiation and the artefact turns out to be less creative (DeLanda 2004).

Can tacit knowledge be codified to explicit knowledge?

There are debates among scholars on “whether tacit knowledge can be made explicit or codified”. The theoretical foundation of coding tacit knowledge is still not well formulated due to the various research focuses and disciplines. So can we codify tacit knowledge to explicit knowledge? Rowley (2007) points out that what people try to present as explicit knowledge is actually information rather than any sort of human knowledge. There is no such thing as “explicit knowledge” but one should rather say “explicit information”. In line with the same argument, Laine (2017), a researcher on Human-computer Interaction from Aalto University, points out that those who “codify tacit knowledge” are misusing the terminology. He further states that “Codification of tacit knowledge to explicit knowledge” is impossible, but it would be possible to “Codify hints about acquiring tacit knowledge to a form of information”. Tacit knowledge becomes explicit knowledge when a set of rules and experiences can be recorded on paper. In this regard that would resolve contradictions and follow the fundamental definitions about data, information, knowledge and wisdom.

Based on the literature, Murphy (et al 2004) summarises that tacit knowledge can be divided into seven aspects, they are namely: implicitness, non-measurability, context (social & cultural), experiential, interactiveness, show-how, and personal. The four latter are more relevant to the material and process-designated research context and can potentially be codified to become reusable information for design iteration and to provide design-decision support.

Experiential: this aspect of tacit knowledge is identified as accumulative knowledge (Grant & Gregory, 1997), and experiential knowledge (Wong & Radcliffe 2000). This tacit knowing is acquired through experiences, and through trial and error (Howells 1996). Polanyi (1962) identifies that “this features cannot be learnt from books”. It is through experience that the user will be able to decide on the best course of action to pursue. Polanyi (1966) states “experiential knowledge guides integration of clues to discoveries”.

Interactiveness: this feature of tacit knowledge is described as being culture bound. (Grant & Gegory 1997). It is acquired through direct interaction among workmates in a socialization (Robert 2000), (Fleck 1997), (Baumard 1999, Nonaka et al 1996).

Show-how: an integral part of the tacit knowledge. Show-how has been identified as learning-by-making, learning-by-using and learning-by-watching (Grant and Gregory 1997). It can be codified into local practices (Wong & Radcliffe 2000), and it is through imitation (Baumard 1999) and practice (Nonaka & Konno 1998) that this feature of tacit knowledge can be expressed and made explicit to others.

Personal: this aspect of tacit knowledge has been described as possessing personal characteristics and defined as individual-embodied (Howells 1996, Polanyi 1961).

The above “Experiential” and “Show-how” aspects of tacit knowledge also follows the essential aspects of Bauhaus education model of material investigation and experiential learning. Learning-by-doing, a hands-on experience, a direct contact with the material and the tool are the indispensable elements of the pedagogy.

Current research directions for knowledge-based engineering and material-based computational design

Knowledge-based system helps to support design and automate knowledge-intensive design processes from different and multidisciplinary sources. This approach also refers to as Knowledge-Based Engineering (KBE). It proves to be successful in aerospace, automobile and shipbuilding industries (La Rocca 2012). It also supports new product introduction, development and product lifecycle management (Park 2017).

Utilising KBE strategy in building envelop design and development has yet to be the mainstream routine (Montali et al 2017). There has been relatively limited literature available for reference. Although there is documented literature in the area as early as in the late 80's by Fazio (et al 1989), the main focus of the implementation covers performance only. Subsequently the research community has employed and developed techniques to focus on energy efficiency and case-based reasoning (Iliescu 2000). Recent directions in this research area are to integrate BIM as a tool to facilitate decision making and collaboration based on the shared database system. The work of Fazio et al. (2007) uses International Foundation Class (IFC) schema to store and transfer design information in a system with a database of benchmark to indicate the building envelope performance. The study focus mainly on thermal and environmental design issues. Voss and Overend from Cambridge University develop a tool that combines KBE and BIM (Building Information Modeling) to evaluate the manufacturing limitations of the facade elements (Voss & Overend 2012). The aim of the tool is to assist design professionals to capture, storage and use of design constraints of the facade elements. The constraints are primary in relation to geometry and manufacturability. With the application of these constraints, design team is able to identify areas, together with process mapping methodologies, of design necessary for modification which in turn improves manufacturability. In the very recent work of Montali (et al 2017), a digital tool that includes the "Façade Product Model" or ontology is developed for design and production knowledge reuse and automatic rule validation. The emphasis is on the evaluation of prefabricated products for their manufacturability at the early design stage. The output of the work also includes a proposal to consider façade systems as closer to make-to-order types of product in which the design team can explore different options against the manufacturers' capabilities. Both Voss & Overend and Montali et al highlight the importance of understanding manufacturing constraints as a way to support early design integration and subsequently to impact on design and manufacturing process of building envelope products. All of the above studies, explicit knowledge like environmental requirements, energy efficiency, physical performance and manufacturing constraints are the key components to be integrated in the expert system and digital tool for the KBE process. Embedded tacit knowledge from the individual expert and practice is largely unseen in the studies due to the different research focus.

While in other research community with interest on craft techniques and material-based computation, several studies have been investigated to combine traditional craft principles with digital prototyping technologies. Early work in this area are Lasch & Aranda (2006) and Palz & Thomsen (2009) that expand the concept of traditional weaving principles and knitted structures with digital tools. With reference from the classification system for textiles (Emery 1966), Felecia Davis from MIT has translated 3 traditional textile structures to digital code and generated 3D printed artefact as a way to understand a context for structuring textile code for explicit modeling application. In one of the publications, a methodology has been presented to work with modularised code through the process of writing algorithms, and validating through several 3D textile prints. This method allows design professionals to consider the relationships between geometry, behaviour and material in a 3D printed textile environment (Davis 2012). This digital approach, albeit based on traditional textile principles, lacks human traits and the embodied tacit components from the expert handmaker.

Muslimin's (2010a; 2010b; 2014) researches on traditional weaving techniques, on the other hand, include the analysis of the weaver's intuition or haptic system. Based on the perception studies, he develops a new assembly principle and a weaving grammar, extending the language of architectural weaving. In an effort to preserve traditional craft of wire-bending, Noel (2016) reinterprets the crafting techniques with digital technology for fabricating artefact. The newly defined rule for digital fabrication is "Bailey- Derek Grammar" which is named after and based on the study of the handmaking processes of expert wire-benders. The rule provides a means through which other interested in wire-bending can begin to appreciate the craft techniques and use the computational algorithm to generate artefact in a culturally-relevant manner. The above studies only cover certain aspects of tacit knowledge codifications for design innovation. For example, Muslimin's works is essentially combined the weaver's intuition with traditional principles whereas Noel's investigation is focused on revitalising cultural techniques based on the bender's expert experience. In considering the seven aspects of tacit knowledge as mentioned in section 8, the tacit component with respect to the personal traits of the expert handmaker is the most difficult one to articulate. It is also the metaphorical fingerprint of that particular handmaker. If these tacit components be extracted and then codified, it has the potential to be used to develop highly individualised artefact or product.

A framework to integrate tacit knowledge for material and process-designated research and product development

This framework for the pedagogic research is built upon tacit and explicit knowledge domains with which the tacit components extracted from handmakers are integrated into the KBE process and materialized through iterative design and 3D prototyping. It serves as the starting point to bridge the possible gap between KBE and material-based computational research communities. The sequences and the methodologies are as follows:

Capturing of tacit knowledge

Tacit knowledge capture indicates the process that extracting tacit knowledge out from the mind of experts. Though it is complicated, there are some existing methodologies to cope with this problem, for example: Community of Practice (COP) (Yu et al 2010), Analogy (Kothari et al 2012, Busch et al 2001, Koskinen 2000), Protocol Analysis, Expert Interview, Observation, Metaphor, Card Sorting Data, Storytelling, Limited Information (Ryan & O'Connor 2009, do Rosário et al 2015) and Repertory Grid Analysis (RGA) (Abdul-Rahman 2011, Mahmud & Ridgman 2014).

All of the above literature have given directions and described how tacit knowledge to be captured and has been used in a wider disciplinary context. In this paper the main investigation is the embedded tacit knowledge of handmaker as a result of physical engagement of materials. It has a great deal with the subjective judgement and perception of the individual towards the "creation" of artefact. To this end, RGA is proposed as it tends to be more relevant to the analysis of personal character among other methodologies. RGA is regarded as a structure interview and analysis tool. To understand repertory grid, Personal Construct Theory (PCT) (Reynolds 2013) is to be studied in the upfront. In PCT theory it states that every individual tends to construct a rational world according to their own experiences. The experiences will be composed to different patterns, which is called "Constructs". With the accumulation of experiences, each individual possess a set of "Constructs". It is only based on the personal interpretation and predication of the event that the individual can decide on the best course of action to pursue (Persson 2009). The use of RGA serves as the underlying method to capture tacit knowledge in the handmaking context (FIG. 3.18).

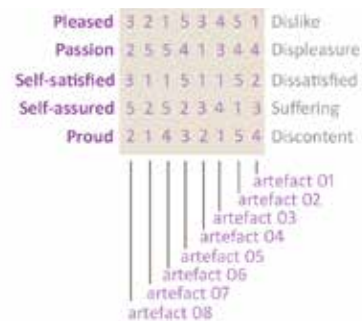


FIG. 3.18 Preliminary example to illustrate how Repertory Grid to be used in the handmaking context, more factors to be incorporated in a real case study. (image: A. Chen)

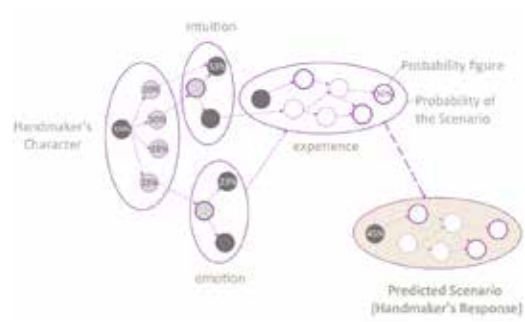


FIG. 3.19 Preliminary example to illustrate how Bayesian Network to be used in the handmaking context, more factors, such as cultural background, sensory to the materials, to be incorporated in a real case study. (image: A. Chen)

Representation of tacit knowledge

To utilise tacit knowledge, it has to be first outputted to a formal structure and then represented in digital compatible format. The nature and aspect of the tacit knowledge will determine the representation methods and subsequently the CODE. According to a number of scholars, tacit knowledge representations are divided into 3 types (Hao et al 2017) as below:

Symbol-based representation: for tacit knowledge in relation to domain knowledge, the symbols which include Ontology and Knowledge Map (Hao et al 2014) have its own way of interlinked concepts. Graphical representations of the network help visualising the overall network and the correlation between different concepts. For example, the use of Knowledge Map to categorise textile production methods which correlates the patterns to specific cultural or historical backgrounds of the handmakers. It provides the basis for this aspect of tacit knowledge for visualization, analysis and validation.

Ruled-based representation: for tacit knowledge associated with logic between several objects. For example, in Muslim's (2010b) study, the weaver's "sense of touch" to the material has both a passive role to feel the stress and strain of each knot and an active role as fabricator of the artefact.

Number-based representation: this method is suitable for the situations where experts' tacit knowledge is difficult or even impossible to articulate formally (Takagi & Ohsaki 2007). The number-based representation represents tacit knowledge by numerical value (probabilistic figures) and embeds into mathematical algorithms for problem solving (Pei et al 2015) and scenario analysis. The underlying idea of this method is to present personal's preference, intuition, emotion and psychological aspects into computational processes. One of the common approach borrowed from the field of Artificial Intelligence for behavioural prediction is the Bayesian Network. This method (Kim et al 2016) is well-known to model the uncertainly with causal relationship among events. It is a probabilistic graphical model (a type of statistical model) that represents a set of random variables contained in a Node and their conditional dependencies. The Node links from one structure (scenario) to another. This can then be used for inference (Bayes Server 2017, Wikipedia 2017), as shown in FIG. 3.19.

Proposed framework

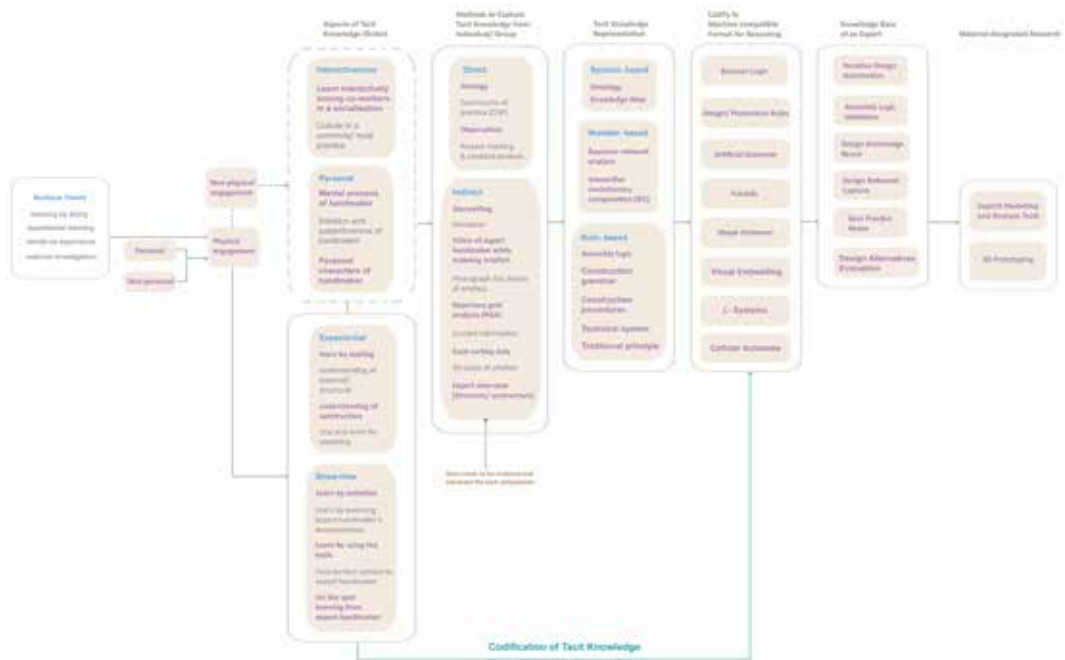


FIG. 3.20 Flow chart shows the logic of the framework. (image: A. Chen)

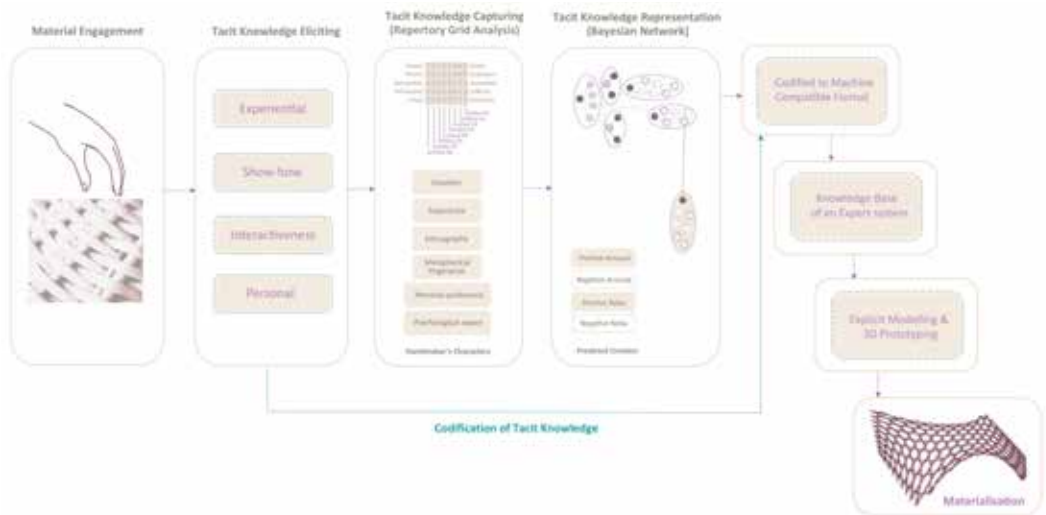


FIG. 3.21 Proposed pedagogic framework. (image: A. Chen)

Conclusions and outlook

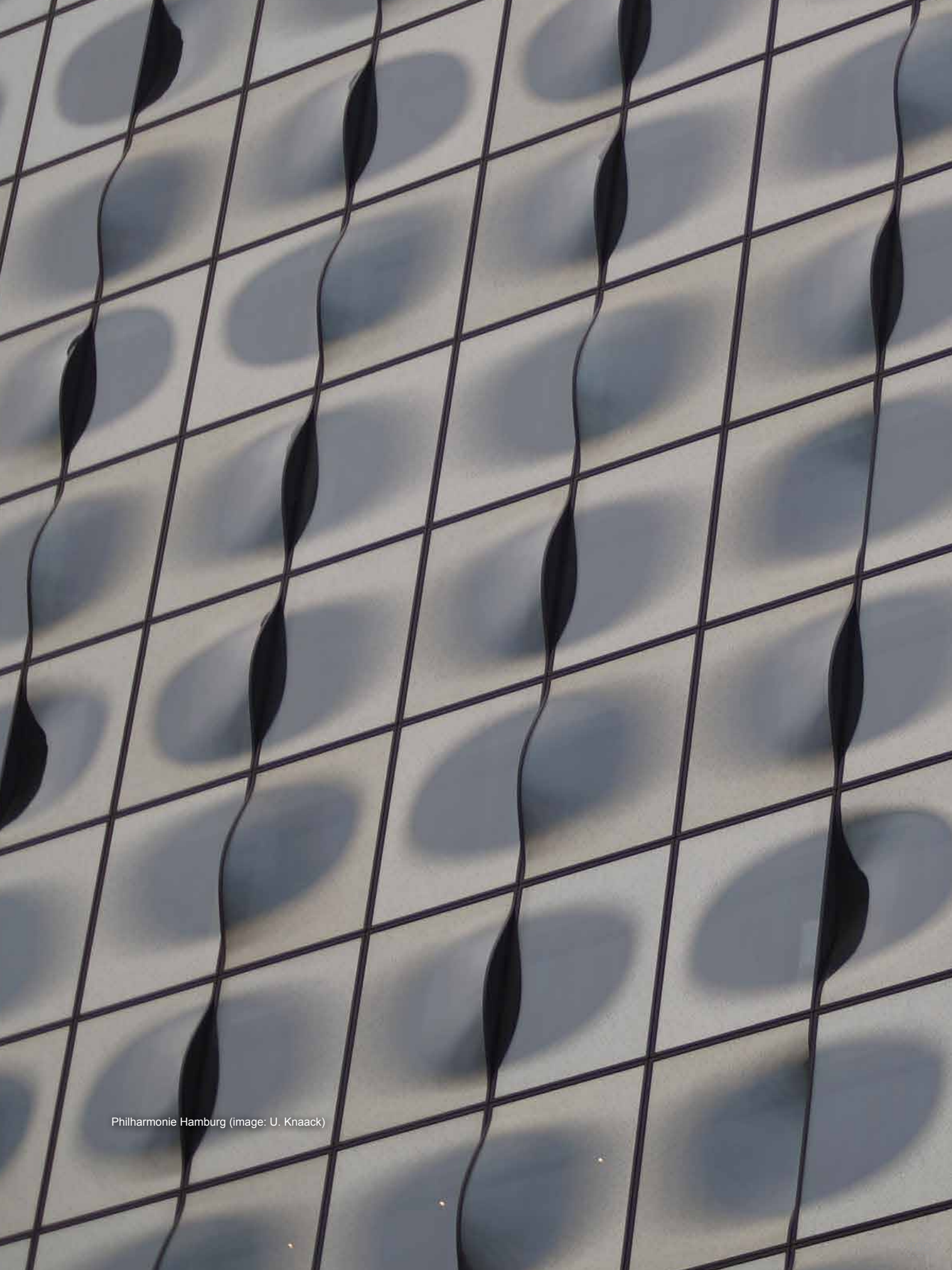
This paper has re-visited and recognised the importance of hands-on experience and its associated tacit knowledge in relation to pedagogic research. Physical engagement of materials is considered to be the prerequisites. It has highlighted the possible gap in the current research communities for the domains of Knowledge-Based Engineering (KBE) and Material-based Computational Design. The integration of tacit knowledge, especially the handmaker's individual characteristics, continues an opportunity and provides insights to develop building envelope components and systems with personal traits. It is also challenging of how these tacit components to be extracted and to be used cumulatively in a novel expert system for design innovation. Future work will include borrowing techniques from the domain of machine learning and develop an expert system which incorporates metacognitive strategies. Possibility for establishing a global (open-source) database of the extracted tacit knowledge will also be explored.

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Philharmonie Hamburg (image: U. Knaack)

4 Biographies

Daniel Aelenei

Daniel Aelenei is a professor of building physics and building technical services at the Department of Civil Engineering of the Universidade Nova de Lisboa, Portugal, since 2005. He is responsible for taught graduate and postgraduate courses in energy efficiency of buildings and for coordinating the Postgraduate Course on Façade Engineering. He is co-author of around 50 peer reviewed publications (journal, book chapter or conference proceeding) and responsible for supervision of 40 MSc theses. The research of Daniel Aelenei is focused on the low-energy buildings and in particular on net zero energy performance of buildings and on the physical characteristics of buildings affecting the indoor environment and in turn the occupant's comfort and health. He is Member of Committee of COST Actions TU1403 "Adaptive Facades Network" and co-subtask leader of Annex 67 - Energy Flexible Buildings of active of the International Energy Agency Energy in Buildings and Communities Programme (EBC).

Daniel Arzmann

Daniel Arzmann studied Architecture at the Hochschule für angewandte Wissenschaften und Künste in Holzminden (HAWK) with a focus to metal construction and facades. After his Diploma in 2003 he worked as a project engineer and team leader for customized solutions for international markets at the Schüco Int. KG. In 2010 he obtained his M.Eng. in Façade Design and Construction from the HS-OWL, University of Applied Sciences in Detmold. At the same time, he became Head of Research and Development for Emerging Markets at Schüco International KG until 2011 and continued to specialize in building physics and construction. Today, he is in charge of the department Building Physics International Projects in the Global Engineering of Schüco. Since 2010 he is teaching in the facade master program in Detmold and since 2016 in the new MIAD program. Since 2017 he is Professor "Façade Construction" at the OWL University of Applied Sciences - MID program, where he teaches the following courses: Façade Design and Construction, Integrated Building Façade Design, Climate and Comfort; Planning, Detailing and Production, Materials, Surfaces and Safety and Master Thesis.

Carlo Battisti

Sustainable Innovation Consultant and Project Manager. Degree in Civil Engineering from the Politecnico di Milano, about twenty years of experience in construction companies, with different roles. Master in Management and Organizational Development at MIP, the Business School of Politecnico di Milano. LEED®, Living Future and WELL Accredited Professional. Certified Project Manager IPMA®, USGBC® Faculty™, WELL Faculty™. Since 2009 he is working with IDM South Tyrol as a project manager in the Ecosystem Construction, where he has discovered the strategic importance of innovation. For IDM he is coordinating a "Façades Working Group", established in 2012, including the top players in South Tyrol in the field of complex facades for buildings: general contractors, specialised suppliers, designers, clients, research centres and laboratories, universities. Website: <http://www.face.bz.it> The Façades WG operates as an incubator of ideas and innovation projects in the field of complex facades. Member companies enjoy the possibility of cooperating in the strategic development of this sector, strengthening specific local excellences. Among the main activities: "A matter of façades" conference (4 editions), "FACE" advanced course (2 editions) and R&D projects like "FACEcamp", that aims at creating a long-term Italy-Austria transnational cooperation among companies and R&I entities in the field of advanced façade systems.

Oguz C. Celik

Oguz C. Celik is a professor for Structural & Earthquake Engineering at the Istanbul Technical University. His research interests lie mainly in various topics of structural and earthquake engineering. His current research has focused on analysis, design, and development of seismic energy dissipation members. He has both research and application experience on seismic assessment and retrofit of existing buildings and bridges. Following the past devastating earthquakes in Turkey, he was in charge of design and retrofit of numerous damaged private and government buildings. Professor Celik's projects are funded by research institutions as well as by the construction industry. He made reconnaissance visits to earthquake stricken areas in Turkey and Italy. He teaches courses on statics, strength of materials, structural analysis, reinforced concrete structures, steel structures, and earthquake resistant building design. He has authored/co-authored 160+ journal papers, books, conference papers, and seminars. Oguz C. Celik delivered invited talks in USA, Japan, South Korea, China, and Turkey. Recently, he co-chaired ICBEST Istanbul and co-authored the conference proceedings titled "Interdisciplinary Perspectives for Future Building Envelopes". He is the member of many national and international professional institutions. In addition, he is in the editorial board of Journal of Steel Structures (Springer), guest edited two special issues in other journals, and is an active reviewer of many international journals.

Anthony Chen

Anthony Chen is a Senior Project Manager at Gehry Technologies (Hong Kong Office) and currently managing BIM-enabled projects across Hong Kong, Korea, Japan, Singapore and UAE. He is specialized in Integrated Project Delivery (IPD) approach with particular focus on the façade sector. Anthony studied architecture and façade design in UK, Austria, Germany and Switzerland. He received his master's degree from the ETH Zurich of Switzerland. Currently he is serving as the committee of the Society of Façade Engineers, Hong Kong Chapter.

Paul Rouven Denz

Dipl. Ing. Paul Rouven Denz (*1986) studied architecture and urban planning at the University of Stuttgart and the E.T.S.A. Madrid with a focus on "resource-efficient construction" and "building construction". Mr. Denz has gained a wide range of experience during showcase building and research projects on sustainability in Germany and abroad. He also successfully participated in architectural and innovation competitions. Paul-Rouven Denz worked among others at Foster & Partners (London), Werner Sobek (Stuttgart), Fraunhofer IAO (Stuttgart), IBK2 (University of Stuttgart, Stuttgart), Gutierrez-delaFuente Arquitectos (Madrid) and ATOL architects (Shanghai). At Façade-Lab, the competence center of Priedemann Façade Experts group, Mr. Denz focuses as Head of R&D on research on new façade technologies, materials, systems and planning processes. Since 2017 Paul-Rouven Denz is also a PhD guest researcher at TU Delft, Faculty of Architecture and the Built Environment, investigating Smart Textile Skin solutions for material and energy efficient building envelopes.

James Doerfler

James Doerfler, AIA is Professor of Architecture and the Director of the four Architecture Programs at Thomas Jefferson University. James received a Bachelor of the Arts degree in Art History (concentration in architectural history) from the University of Hartford and a Master of Architecture degree from Syracuse University. While at Syracuse, James was fortunate to have studied under distinguished educator Werner Seligman.

Professor Doerfler has building envelope systems expertise with experience leading multi-disciplinary collaborative teams in practice and academia. James has team-taught interdisciplinary classes and this innovative joint teaching and research has been presented at multiple national and international conferences. These classes have received numerous awards and grants including: Autodesk Worldwide BIM Experience Award, Arup Foundation Award, the NCARB Award 2010 and the Schuco Building Healthy Buildings Award. James was previously on the faculty and interim head of department at the University of Technology, Sydney, and at Cal Poly San Luis Obispo. He is a board member of the Façade Tectonics Institute and the International Association of Structures and Architecture.

James has more than 25 years of international practice experience along with his academic experience. He has worked with Raphael Vinoly, Richard Gluckman and Fox & Fowle in New York City and PTW in Sydney and his own practice in New York, Sydney and California. James is a registered architect in New York and New South Wales Australia.

Anica Dragutinovic

Anica Dragutinovic is a PhD candidate at University of Antwerp, Belgium since 2016/17. Her PhD research is focusing on Modern architecture of Belgrade (Serbia) that is disintegrating due to disrepair or being altered beyond the recognition, and therefore urges repair and re-use strategies. She is a research assistant and a coordinator of the Master Program MIAD/MID – Façade Design at OWL UAS since 2016; and a member of the "Re-use of Modernist Buildings" (RMB) project. She obtained Master of Architecture in 2016 at University of Belgrade – Faculty of Architecture in Serbia, and Bachelor of Architecture in 2014 at the same Faculty. During the studies she was a student teaching assistant at the Faculty of Architecture - different courses at Department for Architecture and Department for Technologies, had different internships on international level, and won several prizes.

Ecem Edis

Ecem Edis studied architecture at Istanbul Technical University (ITU) Department of Architecture, and received B.Arch. degree in 1995. From the same institution's Graduate School of Science, Engineering and Technology, she received her M.Arch. degree in 1997, and in 2006, a Ph.D. degree with her thesis focusing on the design of building elements. She has been working at ITU Department of Architecture since 1998, and she teaches courses in building and construction technology. During this period, she spent a year at Universidade de Lisboa - Instituto Superior Técnico, as a visiting post-doc researcher with TUBITAK scholarship. In 2015, she received the title of Associate Professor. She has undertaken studies on building technology education, constructional design in architecture, environmental sustainability, and infrared thermography.

Caner Göçer

Caner Göçer studied architecture at Istanbul Technical University (ITU) Department of Architecture, and received a B.Arch. degree in 1993. From the same institution's Graduate School of Science, Engineering and Technology, he received his M.Arch. degree in 1997, and, in 2006, a Ph.D. degree with his thesis focusing on precast concrete external wall systems. He began working as a researcher in 1995 at Istanbul Technical University, Faculty of Architecture, Department of Architecture, and Building Elements Unit. He still works as a lecturer in the same unit. His works and publications are on building element design, prefabricated external wall systems, green roof systems, earthquake performance analysis of masonry buildings, detail design and performance analysis of building elements.

Ricarda Jacobi

Ricarda Jacobi M.A. (*1986) studied interior architecture and architecture in Detmold and Gainesville, USA. During and after her studies she worked for architects in Germany and Switzerland. After her Master degree, she worked as a freelance interior architect and started teaching and researching at the 'Detmold School for Architecture and Interior Architecture', a faculty of the University of Applied Sciences OWL. She is a member of the 'Perception Lab', has been teaching in the field of human factors and has done researches on the development of competences, which lead to the concept of the 'Detmold Campus Agency'. The agency is a network-based organization that makes cross-disciplinary projects possible, provides practice-oriented support with funding, connections and knowledge. Its focus is to create opportunities for students to develop their own ideas and skills to let them test their project as a virtual company. Since beginning of 2017 she is also head of office for the incubator of the University of Applied Sciences Ostwestfalen-Lippe 'knOWledgeCUBE'.

Tillmann Klein

Tillmann Klein studied architecture at the RWTH Aachen, completing with a degree in 1994. From then on he worked in several architecture offices, later focussing on the construction of metal and glass facades and glass roofs. Simultaneously he attended the Kunstakademie in Düsseldorf, Klasse Baukunst, completing the studies in 2000 with the title "Meisterschüler". In 1999 he was co-founder of the architecture office rheinflügel baukunst with a focus on art related projects. In 2005 he was awarded the art prize of Nordrhein-Westfalen for young artists.

Since September 2005 he leads the Facade Research Group at the TU Delft, Faculty of Architecture and since 2008 he is director of the façade consulting office Imagine Envelope b.v. in Den Haag. Tillmann Klein organises the international façade conference series 'The Future Envelope' at the TU Delft and is editor in chief of the scientific open access 'Journal of Façade Design and Engineering'.

Ulrich Knaack

Prof Dr.-Ing. Ulrich Knaack (1964) was trained as an architect at the RWTH Aachen in Germany. After earning his degree, he worked at the university as a researcher in the field of structural use of glass and completed his studies with a PhD. In his professional career Knaack worked as an architect and general planner in Düsseldorf, Germany, winning several national and international competitions. His projects include high-rise and office buildings, commercial buildings and stadiums.

In his academic career Knaack has been professor of Design and Construction at the Hochschule OWL, Germany. He also was and still is appointed professor for Design of Construction at Delft University of Technology (Faculty of Architecture), Netherlands, where he established the Facade Research Group. In parallel he is professor in Facade Technology at TU Darmstadt (Faculty of Civil Engineering), Germany, where he participates in the Institute of Structural Mechanics + Design. He organizes interdisciplinary design workshops and symposiums in the field of facades and is the author of several well-known reference books, articles and lectures.

Andreas Luible

Andreas Luible (1971), Dipl. Bauing. TU/SIA, 1993-1999 civil engineering study at the Technical University Munich, 1999-2004 research assistant at the Steel Structures Laboratory (ICOM) at the Ecole Polytechnique Fédérale de Lausanne (EPFL), 2004 Doctorate Degree at the EPFL, 2004-2011 Senior façade engineer for the international façade companies Schmidlin Fassaden Technologie AG, Josef Gartner Switzerland AG und YUANDA Europe Ltd., since 2010 Head of the competence centre for façade engineering and metal construction and lecturer in civil and façade engineering at Lucerne University of Applied Science and Arts, School of Architecture and Engineering, since 2010 Business owner of Luible - Engineering & Consulting GmbH, since 2016 Chairman of COST Action TU1403 "Adaptive Facades Network".

He finished his dissertation with the title 'Integral Facade Construction – towards a new product architecture for curtain walls' in 2013. Since 2015 he is guest professor for Design and Building Envelopes at the Technische Universität München.

Andrew Peters

Andrew Peters BSc, DipArch, MSc (Facade Eng), ARB (UK). After a few career changes that included television sound engineering, magazine illustration and furniture making Andrew studied architecture at Bath University. In 2001 he undertook the MSc Facade Engineering programme at Bath to become one of its first graduates.

After 15 years in architectural practice, including 8 years at Feilden Clegg Architects in Bath he set up his own practice and began teaching part-time at the University of the West of England in Bristol.

He now leads the MSc Facade Engineering degree having managed its move from Bath in 2016/17 working closely with CWCT. Andrew also coordinates the technical core for the undergraduate architecture degrees and tutors in the graduate year studio of the BSc Architecture programme.

Sandra Marques Pereira

PhD in Sociology (2010). Currently, Post-Doc fellow (Foundation for Science and Technology/FCT) and invited Professor in ISCTE-IUL (teaching in the Integrated Master of Architecture and PhD - Architecture of Contemporary Metropolitan Territories). Has developed research in the area of housing and urban change with focus in Lisbon. Recently has a special interest in the new processes of urban regeneration of Lisbon's inner city and its correlated aspects such as the internationalization of the local housing market (investment and property) and gentrification. Co-coordinator of the Working Group Southern European Housing of the European Network for Housing Research/ENHR. Co-Coordinator of the thematic line 'Modos de Habitar, Sociedade e Cultura Arquitectónica (Ways of Inhabiting, Society and Architectonic Culture of the Research Group Cities and Territories of DINÂMIA'CET -IUL. Co-supervisor of several Master Thesis in Architecture. Visiting fellow at Institut National d'études Démographiques/ INED - Paris (different periods between 2012 to 2014). Author of several publications. Prizes IHRU 2011 and André Jordan 2012 for best PhD Thesis.

David Metcalfe

David Metcalfe, BSc, MSc, MSFE, Director, CWCT. David became Director of CWCT in January 2014. He is a physics graduate with an MSc in Façade Engineering from the University of Bath. As Director he is responsible for all of the Centre's technical and training output.

Recent work has included guidance on fire and facades and the writing of a comprehensive guidance document on the use of built-up walls in modern construction.

He lectures on the MSc in Façade Engineering and on CWCT's courses on building physics, glass and fire.

David has worked with industry on various aspects of thermal performance, condensation analysis, automated facades and double skin facades and has authored CWCT Technical Notes and Updates.

Uta Pottgiesser

Prof. Dr.-Ing. Uta Pottgiesser (*1964) was trained as an architect at TU Berlin in Germany. After her degree, she worked as a practicing architect, mainly for office and administration buildings. Her academic career started as research assistant at TU Dresden where she obtained her PhD in the field of "Multilayered Glass Constructions. Energy and Construction". She has been Professor of Building Construction and Materials at Detmold School of Architecture and Interior Architecture in Germany. Here she has established the research platform ConstructionLab and was successful in several research projects with SME. She also was appointed Professor for Interior Architecture at the University of Antwerp in Belgium. With her multidisciplinary background in architecture, civil engineering and interior architecture.

Uta Pottgiesser is internationally active as a board member and reviewer of international journals (e.g. JFDE, JID, Strategic Design Journal), in PhD commissions and as author of book and journal publications. Besides her academic career she acts as a jury member in architectural competitions. As Chair of the DOCOMOMO International Scientific Committee of Technology (ISC-T) she is concerned with the protection and adaptive reuse of Modern Movement Architecture.

Alejandro Prieto Hoces

Alejandro Prieto Hoces (*1984) is an architect and MSc in Architecture from Pontifical Catholic University of Chile (PUC), specializing in energy efficiency and climate design. Currently he is following a PhD as part of the Façade Research Group in the Department of Architectural Engineering and Technology of TU Delft, focusing in the integration of solar cooling technologies into the building envelope. His professional interests revolve around climate responsive façade design, energy efficiency in office buildings, and low energy cooling strategies and systems. Alejandro was born in Santiago, Chile and he resides in the Netherlands since 2014. Throughout his professional career he has performed functions in architectural design and climate design consultancy, along with research and teaching activities in the field of building technologies.

José Miguel Rico Martínez

Architect by Architecture School University of the Basque Country (UPV/EHU)	2002
Stay at School of Architecture in Copenhagen	1998-1999
Distinction in the final project of Architecture studies	2002
City planning Diploma	2006
PhD research about daylight performance of expanded metal.	2015

Teacher at the School of Architecture, University of the Basque Country (UPV/EHU). Soil Mechanics, Foundations, Architecture-Law and Project Construction. Director of the graduation projects of 20 architects. Teacher in Light Facade Architecture Master and Sustainable Construction Master, University of the Basque Country. Author of several architecture projects in residential, commercial, industrial and office buildings from 2004. Conferences and communications in several conferences and symposiums about building envelopes and article publication in books and journals. Member of the Scientific committee of the Light Facades Master by UPV/EHU from 2007, the 5th and 6th Congress on Light Facades Architecture by Cidemco-Tecnalia, the Journal of Façade Design and Engineering (JFDE) and the EFN committee, (European Façade Network) www.facades.ning.com.

Hans Sachs

Prof. Dipl.-Ing. Hans Sachs (*1980) studied architecture in Karlsruhe and San Sebastian, Spain. During and after his studies he worked for architects in Australia, Ghana and Germany. After his diploma project in 2008 he co-founded the 'responsive design studio'. From then to 2014 he also held research and teaching positions at the ifib – Institut für industrielle Bauproduktion at the KIT – Karlsruhe Institute of Technology' and the 'CIAD – Cologne Institute for Architectural Design'. Furthermore, in 2010, he co-founded the Cologne-based network DIYDA – Do It yourself Design & Architecture and was involved in setting up the first Cologne FabLab, the Dingfabrik e.V. His teaching and research activities at universities and institutes such as the KISD (TH Cologne), ETH (Zürich), PBSA (FH Düsseldorf) and KIT (University of Karlsruhe) have focused on Computer Aided Design and Manufacturing. Since 2015 he works as Professor for CAAD, Computer Aided Architectural Design' at the 'Detmold School of Architecture and Interior Architecture'. He is also director of the specialization 'Computational Design' of the international and interdisciplinary master program 'Integrated Design' and 'Integrated Architectural Design' and member of the 'Construction Lab' and 'Perception Lab' of the University. In his practice 'responsive design studio' he particularly works as expert and consultant on complex computational design, modeling and CNC manufacturing processes and projects.

Jens-Uwe Schulz

Prof. Dipl.-Ing. Jens-Uwe Schulz (*1959) was trained as a civil engineer at University of Kassel in Germany. After earning his degree, he worked at first at the University of Kassel as a researcher in the field of nonlinear simulation of reinforced concrete constructions and later at the TU Berlin. He is Professor of Structural Engineering and Design at University of Applied Sciences/ Detmold School of Architecture and Interior Architecture in Germany. In parallel he is partner of a civil engineering office. He is a member of the DIN norm committee for "Construction materials made of earth".

Aslihan Tavil

Aslihan Tavil graduated from Istanbul Technical University (ITU) with a Bachelor's degree in Architecture in 1986. She received her Master's and PhD degrees from the same institution. She has continued her academic career at ITU and received her "Full Professorship" in 2014. In 2003-2004, she served as a visiting researcher at the Lawrence Berkeley National Laboratory of the University of California where she completed her research project titled "Energy and Visual Performance Appraisal of Electrochromic Windows Integrated With Overhangs In Different Climates"; this visit was made possible by the TUBITAK NATO – B2 Scholarship Program. Being a Fulbright Fellow, she worked and taught as a Visiting Professor at Roger Williams University, School of Architecture, Art and Historic Preservation at Bristol, Rhode Island between 2012-2013. Professor Tavil has taught several PhD, master's and undergraduate classes on building technology in general and has conducted extensive research on sustainable building technologies and construction, performance evaluation, and façade and window systems. She has been continuing her academic career as a professor of Building Technologies at Istanbul Technical University Department of Architecture.