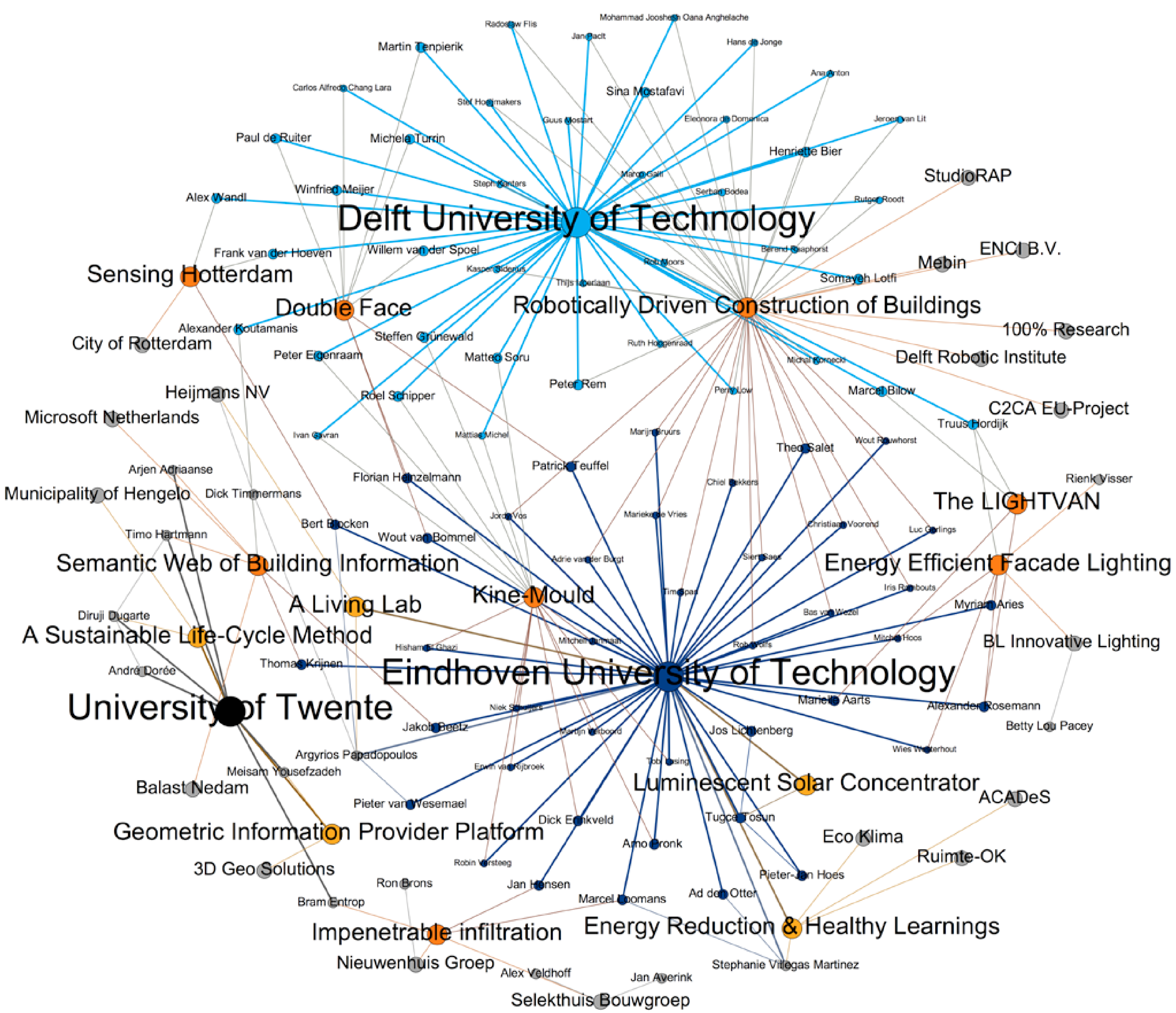

3TU.Bouw center of excellence for the built environment
'Week van de Bouw' February 2015

Most of the more persistent man-made structural assets that surround us in everyday life as well as their reliable structural services are normally taken 'as a law of nature' by the general public. Compared to consumer products the service levels of structural assets are extremely high. Bridges with a structural failure rate comparable to that of normal office printers would be considered completely unacceptable, while a tunnel would never be built if they had a service life expectance comparable to the most long lasting functional products such as (certain) washing machines or Hi-Fi-systems. The same holds for all build structures, including houses, public and commercial buildings.

Meanwhile these structural assets together exceed in financial terms the balance of any global financial institution, or the yearly budget of e.g. the Dutch government many times. Thus, the importance and impact of the broad field of science and engineering related to the built environment - which includes architecture, architectural engineering, civil engineering, process management and policy - is not be underestimated, both economically and socially.
Notwithstanding the evident importance of the Built Environment sector, the public perception of this sector is not that positive, a trend that has been developing in the past few decades. The public perception of the sector often leans towards non-innovative, somewhat clumsy, disorganised and conservative.

It is often forgotten that inventions and innovations from any field of science and engineering are finally applied in the context of the built environment. Developments with respect to e.g. energy comfort, new building materials and systems are spectacular. For instance, no other innovation has increased life expectancy of people as much as the broad application of developments in sanitary engineering. It is even so, that the difference between developed and developing countries can be largely attributed to the quality of public sanitation systems. Apparently, the development of an adequate and efficient sanitation system requires the effective collaboration within the so-called 'Golden Triangle', i.e. stable and facilitating governments, trained people and innovation originating from educational and scientific institutions and energetic application by these innovations by the market.

The building sector is at the forefront of addressing great societal challenges related to sustainability, scarcity and availability of raw materials.

Moreover, the environmental impact of the 'building sector' is huge, given the enormous usage of raw materials. Together with the energy sector, the building sector is at the forefront of addressing great societal challenges related to sustainability, scarcity and availability of raw materials as well as the transition towards a circular economic model, based on recycling and upcycling of waste materials and structures.

Another development is the need for true multidisciplinary and cross-disciplinary collaboration on these challenges. Almost every field of science and engineering has found its application in the built environment. Developments within quantum mechanics has led to diverse developments like energy efficient lighting (LED), precise positioning and cutting (laser technologies) and of course to the revolutionary introduction of ICT in the built environment. Developments in (micro-) biology has led to the aforementioned sanitation revolution, whereas new insights in the mathematics of planning and operations research allowed building processes at scales that would have never been possible before.

An effective and multidisciplinary approach faces grand challenges ahead, requiring dedication and collaboration. Therefore the three technical universities decided to collaborate – amongst others – as 3TU.Bouw Center of Excellence for the Built Environment. The 3TU.Bouw Center of Excellence consists of the Department of the Built Environment at Eindhoven University of Technology, the faculty of Engineering Technology at Twente University, and the faculties of Architecture and Civil Engineering and Geosciences at Delft University of Technology.
The overall goal of this 3TU initiative is to promote close collaboration between Dutch universities in order to increase competitiveness in international research and education, and to concentrate research and education efforts to improve efficiency and scientific excellence.

At present 3TU.Bouw concentrates on two major developments: innovation with respect to energy efficiency in the built environment, and providing dedicated professional education programmes to deliver young professionals that are able to bridge the gap between academia and the market.

The latter is achieved by the so-called PDEng–programme. PDEng is a two-year professional, post-academic degree, where university graduates work in close collaboration with the industry on an urgent and industrially relevant topic. Within 3TU.Bouw a dozen of these projects have been started in 2014 and a similar number will be initiated in 2015. Industrial partners are always welcome to propose PDEng projects that can be jointly pushed forward within the context of the 3TU.Bouw PDEng-programme.

PDEng is a two-year professional, post-academic degree, where university graduates work in close collaboration with the industry on an urgent and industrially relevant topic.

The 3TU.Bouw focus on innovation with respect to energy efficiency in the built environment is achieved through a programme that is called the '3TU.Bouw Lighthouse Projects' programme. 3TU.Bouw 'Lighthouse Projects' aims at promoting and starting up imaginative research projects that are related to the theme 'Energy and the Built Environment'. The 'imaginative' nature of the research as well as the delivery of tangible results (e.g. prototypes, test environments, and so on) distinguishes Lighthouse Projects from other funding schemes. The relatively short project term of 3TU.Bouw Lighthouse Projects – tangible results within a year – appeals to 'fast-track' and 'high-risk' proposals. 3TU.Bouw Lighthouse projects aim at various levels of integration with industry and end-user parties.

The preliminary project ideas and results of a series of Lighthouse projects, started only in the second half of 2014, are presented in this publication together with the context of a few of the PDEng-projects started in the same year. It should be noted that success of 3TU.Bouw does not mean that (all) initial project goals are met: a good failure can be a huge success and may generate, in the long run, more impact than a successful project with a more limited scope.

The 'Week van de Bouw' is one of those opportunities where we can stand together; academics and industry, contractors and asset owners, students and experienced professionals. Let's synergise, combine and cross-fertilize our expertise to solve future challenges, while being grateful and proud with everything achieved already by our colleagues of the past generations.

The relative short project term of 3TU.Bouw Lighthouse Projects – tangible results within a year – appeals to 'fast-track' and 'high-risk' proposals.

3TU.Bouw
center of excellence for the built environment
www.3tubouw.nl | info@3tubouw.nl

Scientific Director - **Ulrich Knaack**
Executive Director- **Alexander Schmets**
Curator - **Siebe Bakker**

Ambassadors
Delft University of Technology - Architecture: **Frank van der Hoeven**
Delft University of Technology - Civil Engineering and Geosciences: **Jan Rots**
Eindhoven University of Technology - Built Environment: **Bauke de Vries**
University of Twente - Engineering Technology: **André Dorée**

INFO & CONTACT **Lighthouse Projects 2014**
Double Face: **Michela Turrin** - m.turrin@tudelft.nl
Energy Efficient Facade Lighting: **Alexander Rosemann** - a.l.p.rosemann@tue.nl
Impenetrable Infiltration: **Bram Entrop** - a.g.entrop@ctw.utwente.nl
Kine-Mould: **Roel Schipper** - h.r.schipper@tudelft.nl
Robotically Driven Construction of Buildings: **Henriette Bier** - h.h.bier@tudelft.nl, **Peter Rem** - p.c.rem@tudelft.nl, **Theo Salet** - t.a.m.salet@tue.nl
Semantic Web of Building Information: **Timo Hartmann** - t.hartmann@utwente.nl
Sensing Hotterdam: **Frank van der Hoeven** - f.d.vanderhoeven@tudelft.nl
The LIGHTVAN: **Truus Hordijk** - g.j.hordijk@tudelft.nl

INFO & CONTACT **PDEng Projects**
Energy Efficient and Healthy Learning 2.0: **Stephanie Villegas Martinez** - s.villegas.martinez@tue.nl
Geometric Information Provider Platform for Renovation of Building to Lower Energy Costs: **Meisam Yousefzadeh** - m.yousefzadeh@utwente.nl
A Living Lab: **Argyrios Papadopoulos** - a.papadopoulos@tue.nl
Luminiscent Solare Concentrator: **Tugce Tosun** - t.tosun@tue.nl
A Sustainable Life-Cycle Method: **Diruji Dugarte** - d.dugartemanoukian@utwente.nl

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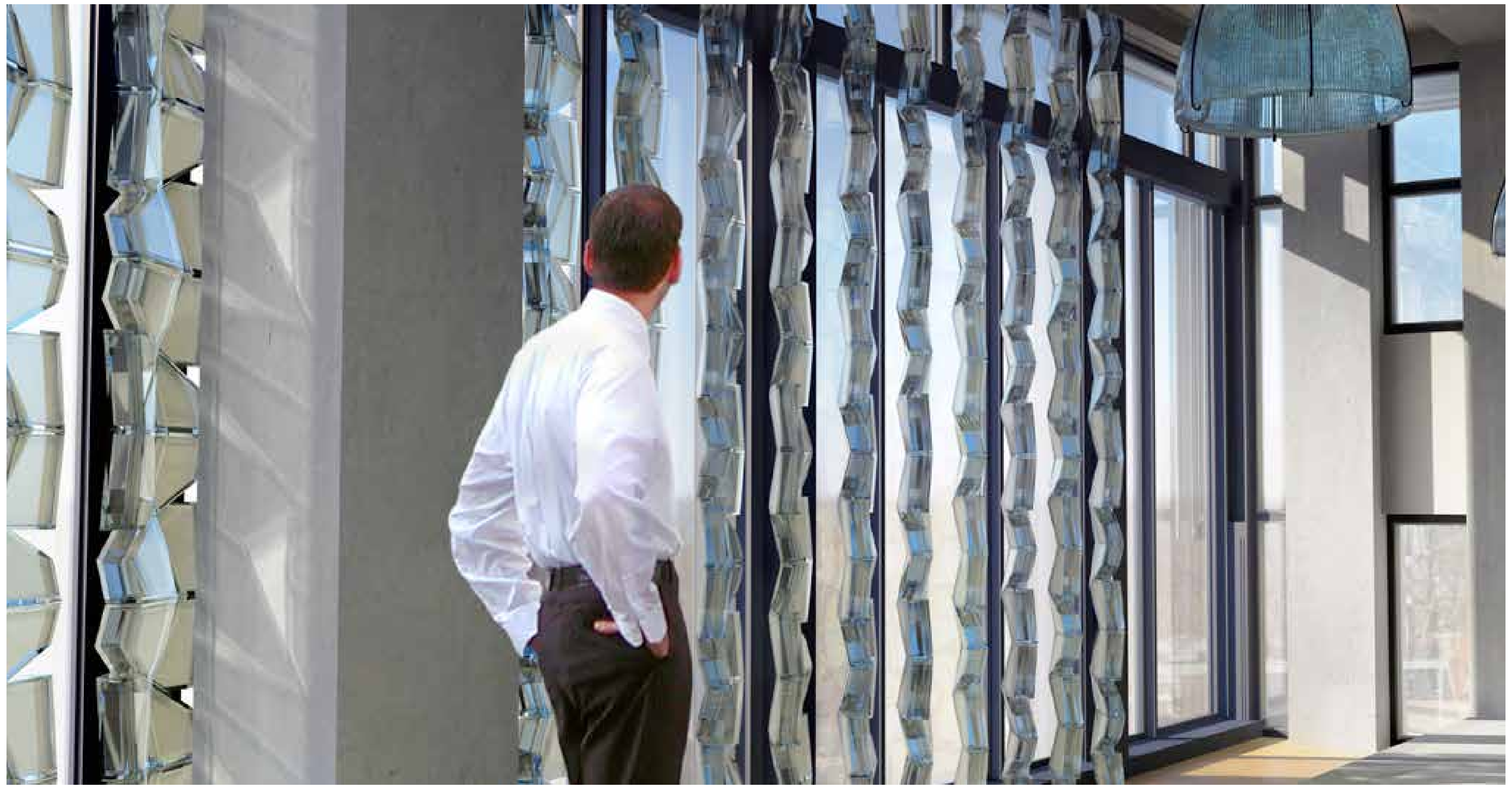
TU Delft Delft University of Technology TU/e Technische Universiteit Eindhoven University of Technology UNIVERSITY OF TWENTE.

adjustable translucent system to improve thermal comfort



The DoubleFace project aimed at developing a new product that passively improves thermal comfort of indoor and semi-indoor spaces by means of lightweight materials for latent heat storage, while simultaneously allowing daylight to pass through as much as possible. Specifically, the project aimed at designing and prototyping an adjustable translucent modular system featuring thermal insulation and thermal absorption in a calibrated manner, which is adjustable according to different heat loads during summer- and wintertime. The output consists of a proof of concept, a series of performance simulations and measurement and a prototype of an adjustable thermal mass system based on lightweight and translucent materials: phase-changing materials (PCM) for latent heat storage and translucent aerogel particles for thermal insulation.

The adjustable Trombe wall system leads to an energy reduction of roughly 40%.

Thermal benefits and translucency

The system is based on an innovative approach to thermal principles of Trombe walls. As compared to traditional Trombe walls, the system is about five times lighter than traditional Trombe walls in order to avoid structural overloads in buildings; is translucent in order to benefit from daylight; and is adaptive in order to calibrate the thermal effects. Lightness and translucency are achieved by means of the applied materials. Instead of using heavy and opaque materials like concrete, a novel application of PCM and aerogel is proposed. Several products and technical systems are currently available on the market for applying PCM by integrating them into walls, containers, or ventilations systems or in facades. Double Face proposes a system based on interior design elements, taking advantage of the dynamic behaviour of PCM as well as its appearance. As such, the system is also meant to contribute to aesthetical design criteria in the design of interiors. The elements are translucent; are meant to be located in front of a (full) glass façade, where the largest heat impact from outside happens to be; and can be developed into various design options for new buildings as well as retrofitted into already existing buildings. Additionally, the system is adaptive in order to enhance the thermal benefits. Exposing thermal mass to winter solar radiation (passive heat gain) and protecting it from the summer one (passive cooling) and therefore acting as thermal buffer. This happens by rotating the elements towards the source of incoming heat or the sink for heat release. In winter, the PCM side would face the exterior and be thermally charged during the day by the low winter sun. During night times, oriented towards the interior, it releases the accumulated heat. In summer, during the day in combination with external sun shading, it would store the heat from interior heat loads and during the night release this heat to the outside environment by means of night ventilation, thus acting as a cooling plate.

Ajustable Trombewall

The research process started with a wide inventory of existing PCM; an analysis of their properties; and a consequent short-list of selected materials. For each of the selected PCM, digital simulations were conducted to analyse the thermal behaviour. They were conducted for single layers of PCM in various thicknesses; and for combinations of two layers, one of PCM in various thicknesses and one of translucent insulation, also in various thicknesses. The translucent insulation was simulated as a layer of Aerogel; and as a system of cavities trapping air within a translucent 3D printed material. Based on the digital simulations, the system of layers was pre-dimensioned for a total thickness of 7cm (5 cm PCM, 1 cm aerogel and 1 cm container wall thickness). Several samples (17x17x7cm) were made for a number of selected PCM. These samples were tested in the laboratory for Building Physics at Eindhoven University of Technology for their thermal behaviour; and at Delft University of Technology for their light transmittance. The measurements allowed for finetuning the dimensions as well as for narrowing down the list of selected materials. As a result, PCM thickness was reduced to 4 cm. Furthermore, using the measured properties as input, simulations of the thermal behaviour of a standard room equipped with this Trombe wall system were run in DesignBuilder to study several variations including PCM layer thickness, insulation layer thickness, extra cavities and percentage of holes in the wall. These simulations showed that an opening percentage of roughly 10% was ideal for this Trombe wall system. Because of the limitations of simulating the rotation of the wall panels, a new simulation model was developed in Matlab/Simulink. These new simulations, which included the rotation, showed that the adjustable Trombe wall system leads to an energy reduction of roughly 40% as compared to the 'no Trombe wall situation'.

Exposed technical systems

Parallel to the research, a number of design alternatives were drafted, based on the thermal principles. For this project, one design option was chosen to be developed and prototyped. The option shows the potential of exposed technical systems contributing to aesthetical design criteria within interior design, while remaining within feasibility constraints in order to realize a prototype within the timeline of the project. To realize the prototype, the translucent container for the layers of PCM and insulation, additive manufacturing was considered initially, in order to cope with the complexity of the form. A number of tests were made by 3D-printing translucent PLA and PET via the rather cost effective filament fused deposition modelling (FDM) method. However considering the challenge of obtaining translucent parts that have high structural strength and maximum light transmittance without the need of falling back to expensive 3D printing techniques (like Stereolithography), additive manufacturing was later used only to produce moulds to cast transparent resin, in order to get a more glass-like appearance. An option for a laser-cut transparent sheet of Perspex was developed, leading to satisfactory results as well.


prototype container resin-perspex

Contingent conditions

The thermal behaviour of the prototype is now being measured using heat-flow sensors and thermocouples at Delft University of Technology. Additionally, further performance simulations are being run in order to model the behaviour of the modular and adaptive system under different climate conditions and in various room environments. Current simulations include fine-tuning of the rotation schedule of the elements in order to orient the insulation according to contingent conditions (day/night – winter/summer). The ambitions of the team include tuning this prototype and exploring other design alternatives, for which further development and testing are intended. A number of companies have been contacted during the process especially regarding existing PCM and their architectural applications.

Delft University of Technology
dr. Arch. **Michela Turrin**
dr. ir. **Martin Tenpierik**
ir. **Paul de Ruiter**, ir. **Winfried Meijer**
dr. ir. **Willem van der Spoel**
Carlos Alfredo Chang Lara

Eindhoven University of Technology
Dipl.-Ing. **Florian Heinzelmann**
prof. Dr.-Ing. **Patrick Teuffel**
ing. **Wout van Bommel**

The project set out to proof that a conventional optical fibre lighting system for highlighting the structure of a façade can be operated more energy-efficiently through the substitution of the projector using a metal halide reflector lamp by a laser. This is investigated by looking into the photometric assessment of such systems as well as the electric power draw during operation. In preparation for a potential exterior demonstration installation, an additional focal point of the research was the design and testing of a weatherproof case that provides protection to the laser and the ballast. The final stage brought the different aspects of the research together and resulted in a temporary experimental setup (pilot installation) in order to showcase the validity of this novel approach.

The investigated system is an adequate energy-efficient alternative to conventional fibre lighting systems, resulting in savings of at least 80%.

Throughout the project there was active communication between the partners. Meetings took place in Eindhoven, Delft, and Den Haag. At the TU/e two students were recruited to participate in the research project, and at both universities the possibilities for demonstration projects were explored. During the discussions, ideas for details on the overall approach and the setup were developed. The brainstorming continued with the students at their regular project update meetings. They developed the research questions and mapped out their approach in a measurement plan. The student project results were presented at an intermediate workshop and to the project partners.

The weather proofing of the box is being tested for its performance under various exterior conditions, using a climate chamber, by measuring: the interior temperature in the box, the humidity in the box, and the protection against simulated precipitation (snowfall and rain).

After energy performance determination, the photometric assessment focused on two main sets of measurements; illuminance measurements indicating the relative luminous flux coupled out from the fibre and luminance measurements under different observation angles.

The illuminance measurements were carried out along the fibre as well as around the fibre. This produces an indication over the attenuation of the extracted light and also the uniformity of the light extraction. The illuminance at a defined and constant distance is a measure for the relative luminous flux leaving the fibre. In addition to that, the luminance from different observing directions was recorded to evaluate the expected brightness perception. The photometric assessment was done for three laser types: red (λ = 655 nm), green (λ = 532 nm), and blue (λ = 447nm).

Power consumption measurements

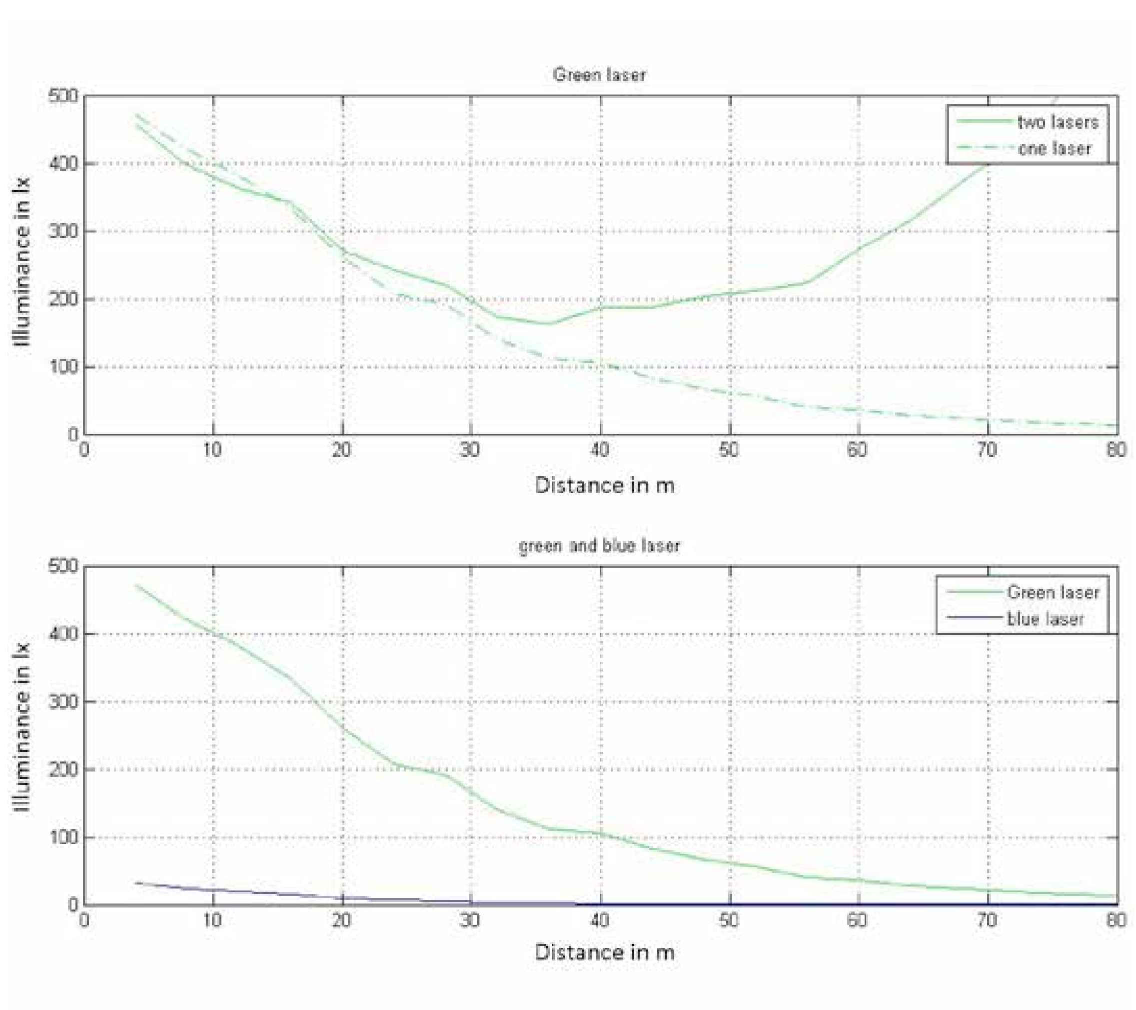
A BL Innovative Lighting fiber is connected to a metal halide (MH) lamp of about 190 W; either on one or two sides of the fiber. Currently, the maximum commercially available length of this fiber is 80 meters, and would require at least four MH lamps to light the full fiber length, with a total energy consumption of 764 W. However, if a MH lamp were to illuminate the fiber from a single end the maximum lenght would be about 13 meters (including visible light loss). With the laser installation, the power consumption over the first 15 minutes after starting the laser was recorded. The results for the three laser types tested are showing a stabilized power draw for the red, green, and blue laser of 59 W, 71 W, and 54 W respectively. The difference in power consumption of the least efficient laser system (2*71 W) compared to a system lit with MH lamps over a comparative fiber length of 80 meters would be five times lower (142 W vs. 764 W), resulting in a savings of approximately 80%.

Photometric measurements

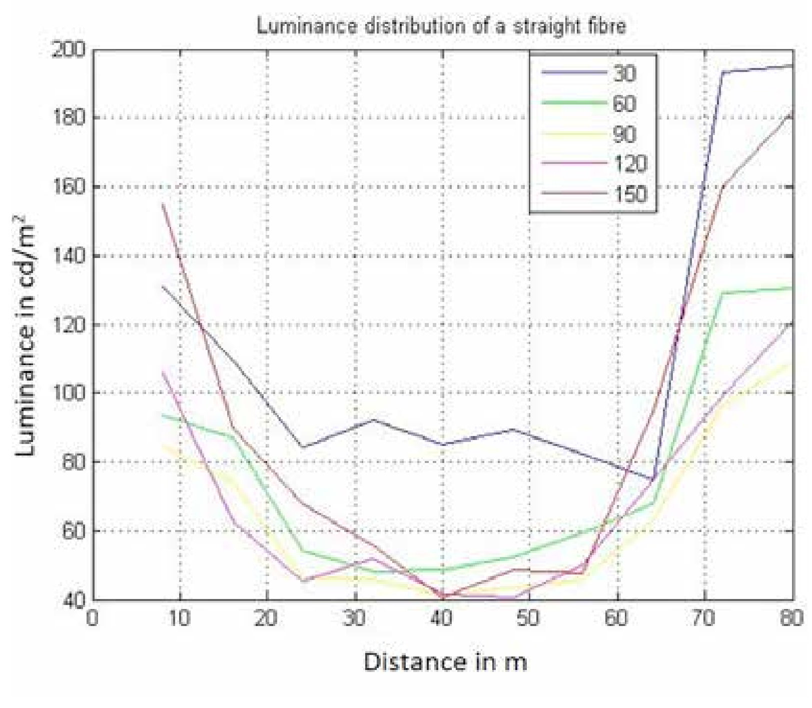
The illuminance was measured at a constant distance from the fibre. This was achieved through the use of a device that was designed and built for this purpose. It can wrap around the fibre and holds the photo element in place. The measurement distance was approximately 1 cm to get the maximum dynamic range. The illuminance measurements are an indicator for the relative luminous flux leaving the fibre. Luminance measurements have been taken under different observation angles around a measurement point. The results give an indication on the brightness perception when viewing the installation from different positions. As a rule of thumb, differences in brightness occur when the luminance difference is approximately one order of magnitude.

Measurement along the fibre

The measurements along the fibre show that the relative luminous flux coupled out is attenuating over the length of the fibre. The data for a system fed by one laser shows that the relative luminous flux drops by one order of magnitude at a distance of approximately 55 m. A fibre system that is fed by two lasers shows the expected symmetric behaviour. The minimum occurs in the middle of the fibre. There the relative luminous flux is approximately 40% of its initial value The measurements for a one-laser system can be mirrored to calculate the relative luminous flux along the fibre. The calculations results match the measurements very closely.



relative luminous flux along fibre



Luminance along the fibre

Measurement around the fibre

As a measure for the uniformity in all directions, the illuminance was measured on the four spots around the fibre every 8 m along the fibre (0, 90°, 180° and 270°). The most noteworthy non-uniform light extraction can be observed at the beginning of the fibre. This is likely caused by slight misalignments of the laser axis and the axis of the fibre that are believed to cause non-uniform light losses at the beginning

Luminance measurements

The luminance measurements were taken for two situations: the fibre being fed by one laser and the fibre being fed by two lasers.

As expected, the luminance drops along the length in a similar manner as the relative luminous flux. This effect is reduced in a system fed by two lasers. The luminance is relatively similar for all viewing angles (ranging from 30° to 150° with 90° indicating the surface normal). For a two-laser setup, the minimum luminance drops from approximately 200 cd/m² to approximately 40 cd/m². This drop is not leading to a perception of brightness difference according to the rule of thumb mentioned earlier. The laboratory measurements indicate that no visible difference along the fibre system would be noticed.

Temperature dependence

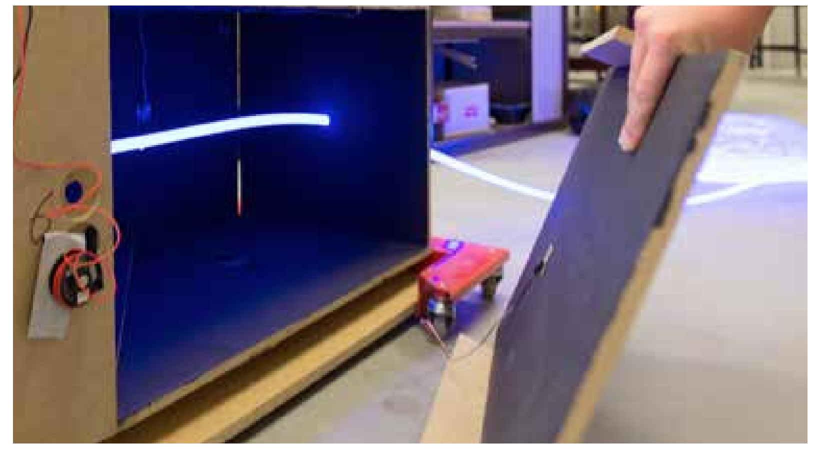
According to the manufacturer's data sheets, the laser systems consisting of a power supply box and the laser module itself need to be operated in ambient temperatures between 10°C and 35°C. A few experiments investigated the influence of the ambient temperature on the light output. The first measurement series looked at the system's performance when ramping up the ambient temperature slightly beyond the upper boundary of the recommended temperature range and letting it cool down afterwards. The illuminance measurements indicated the impact on the overall light output. The ambient temperature in the upper part of the recommended temperature range has no significant impact on the light output. Normal operation within an enclosure can often lead to a fluctuating ambient temperature. Such a temperature profile was simulated in the laboratory and also leads to no significant changes in light output. After the lighting system is stabilized, the illuminance values ranged between 55 lx and 56.5 lx which corresponds to a maximum variation of 1.1%.

Pilot installation

A working prototype of the laser/fibre system has been demonstrated on the roof of the Vertigo building on the TU/e campus in December 2014. The 80 m long fibre was installed along the inside and outside of a roof rail resulting in a 40 m long light installation that could be seen from the building as well as from the ground.

80% Reduction of energy

The results of this project show that the fibre system fed by lasers is a feasible technology to highlight facades of buildings. The photometric data shows that the system can be operated in such a way that no noticeable brightness differences can be sensed along the fibre. The energy consumption of the lasers are much lower compared to the conventional solution, resulting in a savings of at least 80%. This means that the investigated system is an adequate energy-efficient alternative to conventional fibre lighting systems. Recommendations for the future include following technology developments to see if such laser systems can be reduced in size for a better integration into the overall system. The current laser system was not developed for a fibre lighting system but rather for measurements/experiments on optical benches. Some of the features and requirements that are currently part of the product may not be required for usage in combination with fibre optics. This can lead to a reduced size and cost for a laser system that would positively impact the economics of real installations.



Eindhoven University of Technology
dr. **Myriam Aries**, prof. Dr.-Ing. habil. **Alexander Rosemann**
Wies Westerhout, Mitchel Hoos

Delft University of Technology
assoc. prof. dr. **Truus Hordijk**

Lighting designer
ing. **Rienk Visser**

BL Innovative Lighting - Vancouver
Betty Lou Pacey

Het is wenselijk dat gebouwen beschikken over voldoende en de juiste mogelijkheden om te ventileren. Buiten de benodigde ventilatievoorzieningen is het echter de bedoeling een gebouw zo luchtdicht mogelijk te maken ten einde comfortklachten en onnodig energiegebruik te voorkomen. In het Bouwbesluit zijn eisen met betrekking tot de luchtdoorlatendheid – het tegenovergestelde van luchtdichtheid – opgenomen. Met betrekking tot een heel gebouw wordt in Art. 5.4 lid 1 het volgende geëist: De volgens NEN 2686 bepaalde luchtvolumestroom van het totaal aan verblijfsgebieden, toiletruimten en badruimten van een gebruiksfunctie is niet groter dan 0,2 m³/s. De Universiteit Twente en de Technische Universiteit Eindhoven hebben samen met het bouwbedrijf SelektHuis gewerkt aan de uitvoering van het onderzoek "Impenetrable Infiltration". Dit onderzoek naar de luchtdoorlatendheid van woningen kent drie onderdelen, namelijk:

A. Een veldonderzoek waarbij luchtdichtheidsmetingen worden uitgevoerd op vrijstaande woningen om zo te bepalen tegen welke keuzemogelijkheden luchtdichtheidsmeters en uitvoerende bouwondernemingen aanlopen om de luchtvolumestroom te beïnvloeden;
B. Een deskstudie waarbij rapportages van luchtdichtheidsmetingen worden bestudeerd om zo te bepalen wat de huidige stand van zaken is betreffende de luchtdichtheid van woningen;
C. Een vergelijkend praktijkonderzoek naar het bepalen van de luchtdichtheid, waarbij drie partijen de luchtdichtheid van dezelfde duurzaam gebouwde vrijstaande woning zullen vaststellen.

Om de veldstudie en het praktijkonderzoek uit te kunnen voeren, is de nodige apparatuur aangeschaft. Er is gebruik gemaakt van een blower door, een ventilator en een digitale manometer. Tevens is er tijdens de metingen gebruik gemaakt van twee dataloggers om de luchtdruk, binnen- en buitentemperatuur elke minuut vast te leggen. Er werd een anemometer gebruikt om de windsnelheid op locatie te bepalen. Om inzicht te krijgen waar eventuele lekken zich bevonden, werden een rookmachine en een infraroodcamera ingezet.

Veldstudie

De veldstudie heeft betrekking op negen verschillende cases, welke in 2014 zijn opgeleverd. De omvang van de thermische schil en het netto vloeroppervlak van deze woningen zijn vastgesteld aan de hand van de EPC-berekening.

Resultaten metingen

Voor het bepalen van de luchtvolumestroom is, in lijn met EN 13829, het gemiddelde van twee meetseries genomen; één op onderdruk en één op overdruk. Het drukverschil over de gevel liep hierbij op van 20 tot 90 Pa. Elke meetserie bestond uit het bepalen van een baseline met tien meetwaarden vooraf, twaalf debietmetingen en tot slot een baseline met wederom tien meetwaarden achteraf. Vervolgens is met deze meetwaarden teruggerekend naar een luchtvolumestroom bij een drukverschil van 10 Pa. In totaal zijn er zestien metingen uitgevoerd op de negen cases. De gemeten luchtvolumestroom ($q_{v;10}$ in dm³/s) is gedeeld door het netto vloeroppervlak (in m²) van de woning om zo tot de karakteristieke luchtvolumestroom ($q_{v;10}$;kar in dm³/(s·m²)) van de woning te komen, welke kan worden vergeleken met de bij de vergunningsaanvraag gespecificeerde ambitie in de EPC-berekening. Bij vier cases is er een tussentijdse meting en een eindmeting uitgevoerd.

Analyse meetresultaten

Het Bouwbesluit eist een luchtdoorlatendheid die kleiner is dan 200 dm³/s en een EPC van maximaal 0,6. Een dergelijk lage EPC wordt bij deze woningen bereikt door onder andere een $q_{v10;spec}$ te behalen van 0,625 dm³/s per m² vloeroppervlak. Van de negen bemeten cases in de veldstudie, voldeden alle woningen aan het Bouwbesluit. Alleen Case 2 en 5 voldeden niet aan de ambitie, zoals aangeven in de EPC-berekening. Van de negen cases voldeed één woning, Case 5, vlak voor oplevering nog niet aan de in de EPC-berekening gestelde ambitie van 0,625 dm³/s per m² vloeroppervlak. Case 2 naderde op het moment van meten nog niet de oplevering, maar de stap om van 1,10 naar 0,625 dm³/(s·m²) te komen, is nog wel vrij groot. De aansluiting van het dak op de muurplaat verdient in de meeste woningen nog enige aanvullende aandacht.
Bij Case 1, 3, 4 en 5 is een tweede meting uitgevoerd om te bekijken wat het effect is geweest van de gegeven feedback aan de uitvoerders. De eindmetingen vonden rond de oplevering plaats, nadat de uitvoerders de tips uit de feedback ter harte hadden genomen. Na navraag te hebben gedaan bij de uitvoerders en zelf vier cases te hebben gecontroleerd, bleek 71,7% van de tips daadwerkelijk opvolging te hebben gekregen. In het geval van Case 1 is de gemeten luchtvolumestroom gereduceerd met 67%, waarbij notabene ten tijde van de eindmeting het niet mogelijk was om het ventilatierooster van het dakraam boven de hal te sluiten. Voor Case 3 is de reductie 22%. Bij Case 4 en Case 5 was de reductie respectievelijk 41% en 65%. Dat is dus voor deze vier cases een gemiddelde reductie van 49%. Bij Case 6 is eveneens een tweede meting uitgevoerd, maar ditmaal door een andere partij. Deze meting gaf een resultaat van 0,45 dm³/s per m² oftewel een verbetering van 24%. Bij deze tweede meting werd het ventilatiesysteem echter niet ter plaatse van de dakdoorvoer met opgeblazen ballonnen afgesloten, maar ter plaatse van de ventilatieopeningen in de woning. De blower door werd daarnaast in de voorgevel geplaatst in plaats van één van de twee tuindeuren aan de achterzijde van de woning. Deze twee veranderingen in de uitvoering van de meting zullen enige invloed hebben op het verschil.

Deskstudie

Er zijn in het verleden door het toenmalige SenterNovem in kader van het E'novatie programma al veel luchtdichtheidsmetingen uitgevoerd. Na circa twee decennia zijn het nu steeds vaker de opdrachtgevende en uitvoerende partijen zelf die om de zogenaamde blower door tests vragen om de luchtdichtheid van gebouwen te testen. Deze partijen zijn via email, oproepen op websites en oproepen in vaktijdschriften benaderd om de meetrapporten die zij in hun bezit hebben te delen met de Universiteit Twente en de Technische Universiteit Eindhoven. Deze oproepen hebben er toe geleid dat een database kon worden opgesteld met daarin de meetresultaten van meer dan 300 recent gebouwde woningen. Deze respons overtrof onze verwachtingen, waardoor het invoeren van de woningen langer duurde.

Praktijkonderzoek

Op 2 en 3 februari zijn onafhankelijk van elkaar drie luchtdichtheidsmetingen uitgevoerd op een duurzaam gebouwde vrijstaande woning in Sterksel. De wijze van meten en de resultaten van de metingen zullen met elkaar worden vergeleken. Op deze manier verwachten we meer inzicht te krijgen in hoeverre de resultaten van luchtdichtheidsmetingen met behulp van een blower door test kunnen worden gereproduceerd. Alle drie de metingen zullen op beeld worden vastgelegd. De luchtdichtheidsmeters zal worden gevraagd de luchtdichtheid van de woning te meten op basis van zowel onderdruk, als overdruk. Daarnaast worden ze gevraagd om een fotorapportage te maken van de lekken die zij zelf constateren in de woning.

Het is de bedoeling een gebouw zo luchtdicht mogelijk te maken ten einde comfortklachten en onnodig energiegebruik te voorkomen.

De resultaten van de eerste deelstudie, te weten de veldstudie, zijn beschikbaar en zullen worden gepubliceerd door TVVL Magazine. De resultaten van de deskstudie en het vergelijkend praktijkonderzoek laten helaas nog even op zich wachten. De interesse naar dit onderzoeksproject "Impenetrable Infiltration" vanuit het werkveld van luchtdichtheidsmeters en de aandacht vanuit de media is bemoedigend en heeft ons blij verrast. We hopen dat deze interesse blijft en dat de nu uitgezette onderzoekslijnen kunnen worden gecontinueerd. Geïnteresseerde partijen om het vervolgonderzoek (financieel) te ondersteunen kunnen uiteraard contact blijven opnemen met de projectleider van dit onderzoek.

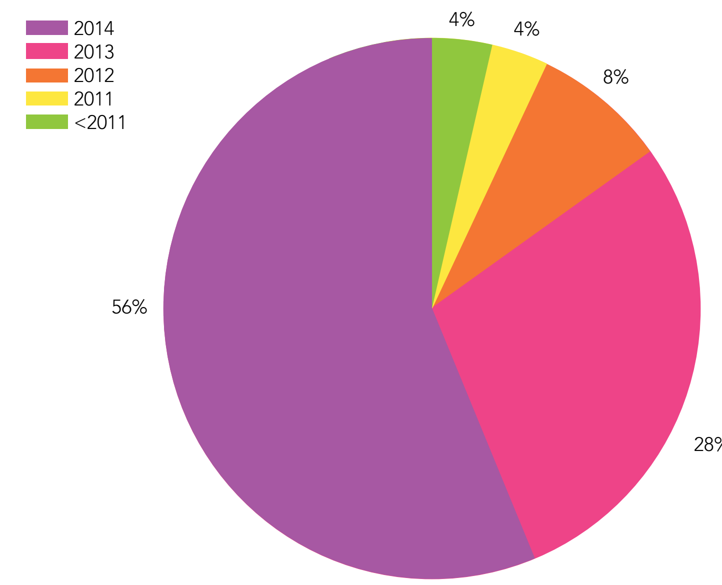
warmte opnames case study woningen

#	Case nummer en locatie	Datum meting	Netto-volume (m3)	Nettovloer-oppervlak (m2)	Gemeten lucht-volumestroom $q_{v;10}$ (dm³/s)	Karakteristieke luchtvolumestroom $q_{v;10;kar}$ (dm³/(s·m²))
1	1. Radio Kootwijk	06-10-2014	682	2656	290,28	1,09
2		08-12-2014			95,83	0,36
3	2. Doorn	28-10-2014	451	171	194,58	1,14
4		28-10-2014			188,75	1,1
5	3. Rijssen	28-10-2014	391	156	134,03	0,86
6		17-12-2014			94,58	0,61
7	4. 's-Graveland	12-11-2014	339	135	95,97	0,71
8		08-12-2014			56,81	0,42
9	5. Soest	12-11-2014	482	191	430,56	2,26
10		12-11-2014			234,31	1,23
11		08-12-2014			150,56	0,79
12	6. Bruinisse	01-12-2014	509	196	115	0,59
13	7. Teteringen	01-12-2014	*622	*217	133,06	0,61
14		01-12-2014			129,17	0,6
15	8. Waddinxveen	18-12-2014	550	215	113,19	0,53
16	9. Brielle	18-12-2014	646	260	158,47	0,61

resultaten van luchtdoorlatendheidsmetingen in het veldonderzoek

Case	Datum meting	$q_{v;10}$ (dm³/s)	Oordeel Bouwbesluit	$q_{v;10;kar}$ (dm³/(s·m²))	Oordeel ambitie EPC-berekening
1	08-12-2014	95,83	Voldoet	0,36	Voldoet
2	28-10-2014	188,75	Voldoet	1,1	Voldoet niet
3	17-12-2014	94,58	Voldoet	0,61	Voldoet
4	08-12-2014	56,81	Voldoet	0,42	Voldoet
5	08-12-2014	150,56	Voldoet	0,79	Voldoet niet
6	01-12-2014	115	Voldoet	0,59	Voldoet
7	01-12-2014	129,17	Voldoet	0,6	Voldoet
8	18-12-2014	113,19	Voldoet	0,53	Voldoet
9	18-12-2014	158,47	Voldoet	0,61	Voldoet

beoordeling resultaten van luchtdoorlatendheidsmetingen



verdeling woningen naar bouwjaar in de rapporten voor de deskstudie

University of Twente
dr. ir. **Bram Entrop**

Eindhoven University of Technology
prof. dr. ir. **Jan Hensen**, dr.ir. **Marcel Loomans**

Nieuwenhuis Groep
ing. **Ron Brons**

Selekthuis Bouwgroep
ing. **Alex Veldhoff**, ing. **Jan Averink**

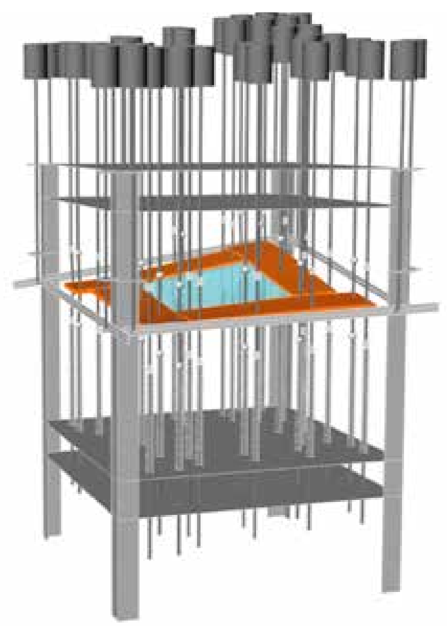
KINE-MOULD

Developing a flexible mould will encourage industrial companies to manufacture complex geometries in a cost efficient way.

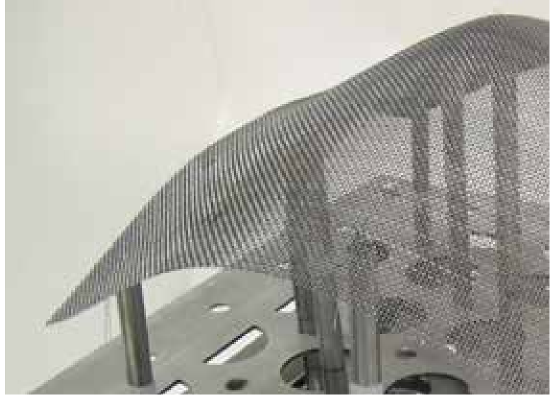
The Kine-Mould is a development that makes it easier to manufacture building elements with complex geometry. Since June 2014 the team has been working on a range of solutions and prototypes. Various building materials have been investigated such as concrete, glass and plastic composites. In a joint effort of TU Delft and TU Eindhoven the following prototypes were designed and built:

1. One for thermoplastic polymers;
2. One for concrete elements;
3. One for glass elements;
4. Several for inflatable mould surfaces.

Students carried out a significant part of the work. Companies were involved in the manufacturing process of the prototypes and application of the results.



fluid mould concept



mesh metal sheet

curved glass panel

Prototype for thermoplastic polymers

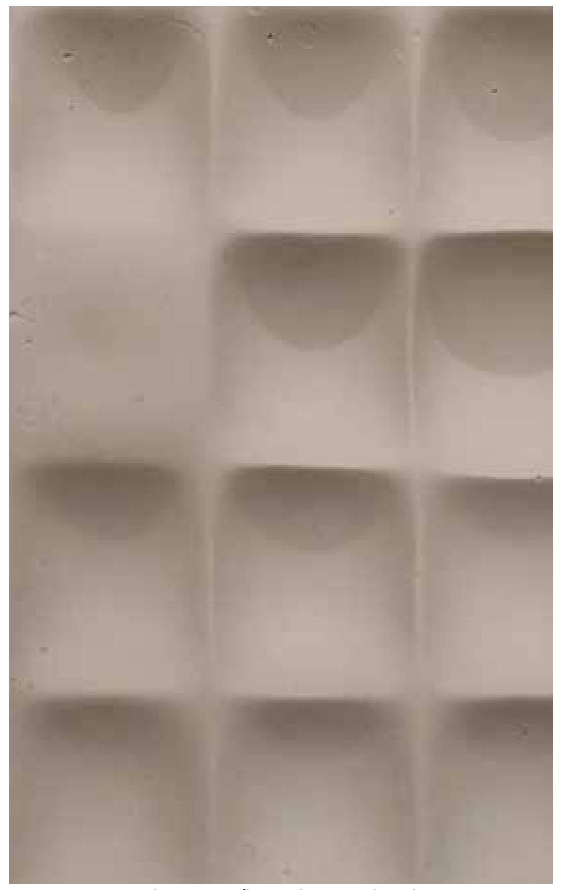
If a thin polymer plate can be thermoformed into the correct geometry, this plate can be used as formwork for concrete or directly as a façade cladding panel. A closed two-face mould with closed edges is needed when using it as formwork. After hardening the concrete, the polymer plate can be removed and recycled. Two principles for deformation were investigated; thermoforming with gravity and with vacuum. For thermoforming a thermoplastic panel edge is clamped by flexible edges on which actuators are attached. After heating the thermoplastic polymer above its glass transition temperature, the edge can be deformed by setting the actuators at desired height. The middle section of the panel is supported by a flexible layer, which can be manipulated by applying various tensions. The second principle relies on vacuum forming of thin acrylic plates. Here an air pressure difference is used after heating the thermoplastic to the proper temperature to control the exact edge shape. After cooling down to room temperature a two-face mould is constructed in a frame of edges, which can be filled with concrete. Since very thin plastic sheets are used, fluid or particles are needed to support the sheets under the concrete pressure.

Prototype for glass

The wish to create curved architectural glass elements has a history at both universities. At Delft, Dr. Karel Vollers was one of the first to succeed in manufacturing double-curved glass for architectural applications with a forerunner of the current flexible mould. At Eindhoven, Arno Pronk has been working on this topic for several years. In an earlier TU/e project students had already investigated the option to construct a small glass dome of double curved double glass units, joined together with vacuum-infused structural resins. This research projects presented the opportunity to align forces and knowledge to develop a state-of-the-art prototype and analyse the process in a more detailed manner.

The forming of curved glass is as challenging as it is promising. If successful, it opens a wide range of promising possibilities: imagine shell structures consisting of load-bearing glass elements or think of hybrid building envelopes consisting of partially glass and concrete elements. Challenging however since glass is a brittle material and residual stresses after deformation to a large extent influence the

flexible mould system opens up wide range of possibilities



concrete result and inflatable mould alternatives

structural behaviour and reliability of the curved glass element. Finally also the manufacturing process at high temperatures is challenging, since it requires heat resistant equipment.

After some initial experiments at small scale (Figure 5), a larger prototype was constructed for bending glass with accurate dimensions in an oven. Two methods were tested: 1) the 'pizza-shovel' method, that pre-heats a glass panel wrapped in an insulating blanket, and then, after taking it from the oven with a pizza-shovel, draping and pressing it into its final, curved, shape on top of a pre-installed flexible mould. 2) the in-oven draping method: put the initially flat glass panel together with the flexible mould in the oven, and heat it until the correct shape can be formed with the plastic glass sheet. After a careful annealing process, the panel will have the correct curved shape.

The prototype contains a mesh of elastic steel which is supported by a grid of 5 x 5 actuators is suitable for both methods. The actuators can be adjusted vertically in the desired height position, and allow horizontal displacement of the tips. An essential characteristic of the steel mesh is that the grid size and wire diameter are chosen in proportion to the actuator distance, as well as that it allows in-plane shear deformation.

Prototype for concrete

Before the start of the 3TU Lighthouse project, a small-scale prototype existed of the flexible mould for concrete, using a grid of flexible strips as interpolating surface. This prototype showed very promising results, but the team was curious to investigate scale effects and also manufacture larger concrete elements. A new and bigger prototype for the flexible mould therefor was designed and built in order to investigate the behaviour of the mould on larger scale (Figure 7). On a small scale effects like buckling of the strips in the interpolating surface are not likely to occur. For larger surfaces, though, this effect could potentially become more significant. The smoothness of the final panels is influenced by small details in the design of the mould. Dimensions and connections needed to be designed carefully to obtain accurate results. Apart from accurate the mould has to be robust to function well within a concrete factory environment. Simple, robust and easy to repair solutions are key to the success of the mould. A finished prototype was transported to a concrete factory in order to gain more experience in the production process. Based on these experiences a design for a professional version is made which will be used for first projects in practice.

The principle of deformation after casting brings along questions regarding the concrete: What is the right moment of deformation? What is the effect of the deformation? How can the concrete be reinforced? Apart from the design and assembly of the larger prototype, these aspects have been investigated as well in the PhD research of Roel Schipper that will be finished shortly. Finally, also a computational model has been worked out to predict the effect of certain parameter choices, such as actuator spacing, strip thickness and elasticity, etcetera. This work is on going and will need further development.

Inflatable mould

Instead of realizing a smooth interpolation surface, additional shape control or play with element texture could be realized by making parts of this surface inflatable very locally. This could result in architecturally interesting textures, and furthermore could lead to a technology that opens new possibilities. In his Master's thesis project that was already on going at the start of the 3TU Lighthouse project, Mitchell Janmaat now had the chance to carry out some experiments with various inflatable mould surfaces. Figure 8 shows some results of this work.

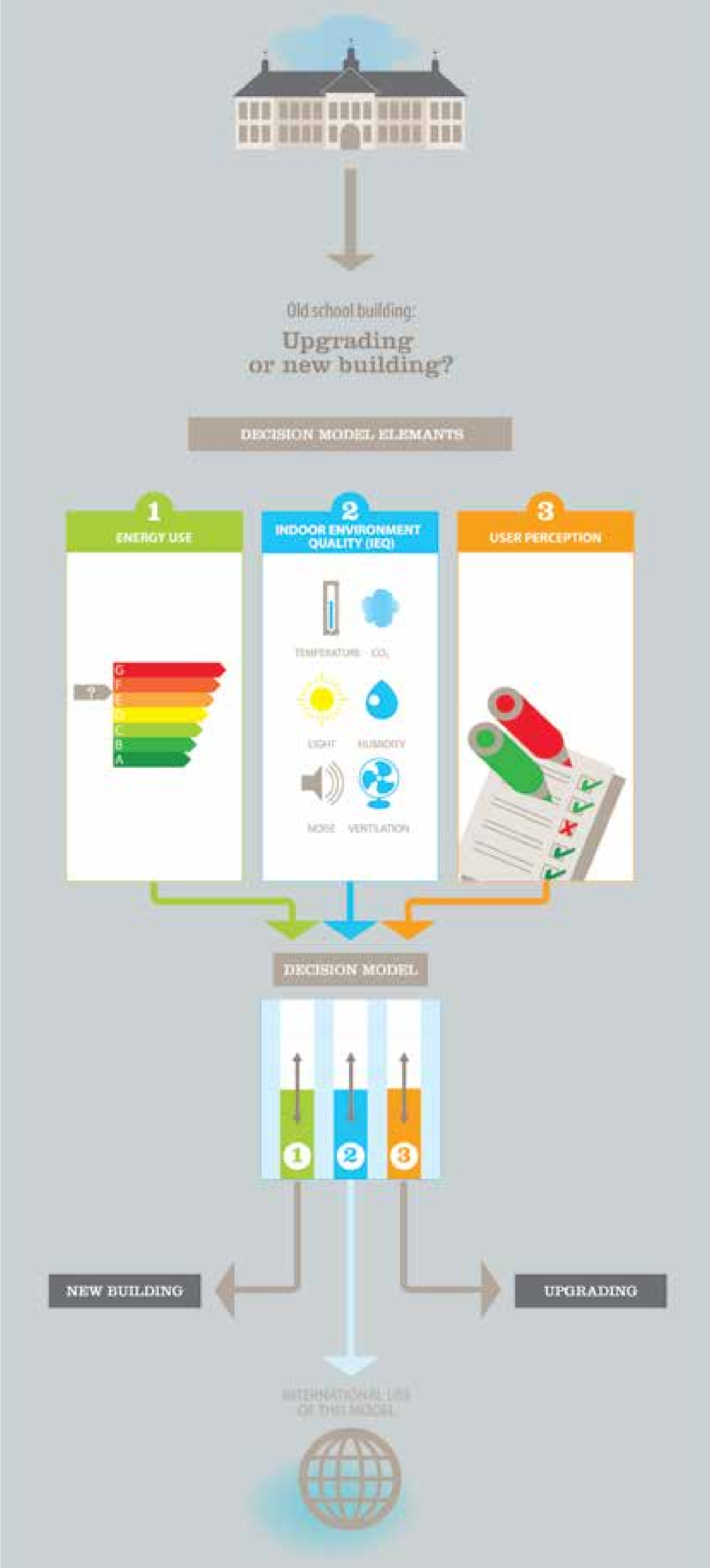
The 3TU Lighthouse project "Kine-Mould: material efficiency using a flexible kinematic mould system" has resulted in a range of coherent prototypes that demonstrate the feasibility of this manufacturing method for various architectural building materials. At the "Week van de Bouw" in February 2015, the prototypes will be shown. In the summer of 2015, more results and also elements produced with the moulds will be presented at the IASS2015 conference and exposition (see IASS2015.org Scientific publications will be written to give more in-depth descriptions of the results, including validation and testing. The work will be continue since many new ideas and possible solutions are waiting for further exploration as well as cooperation with industry. Further industrial partners are invited to contact us and discuss the possibilities.

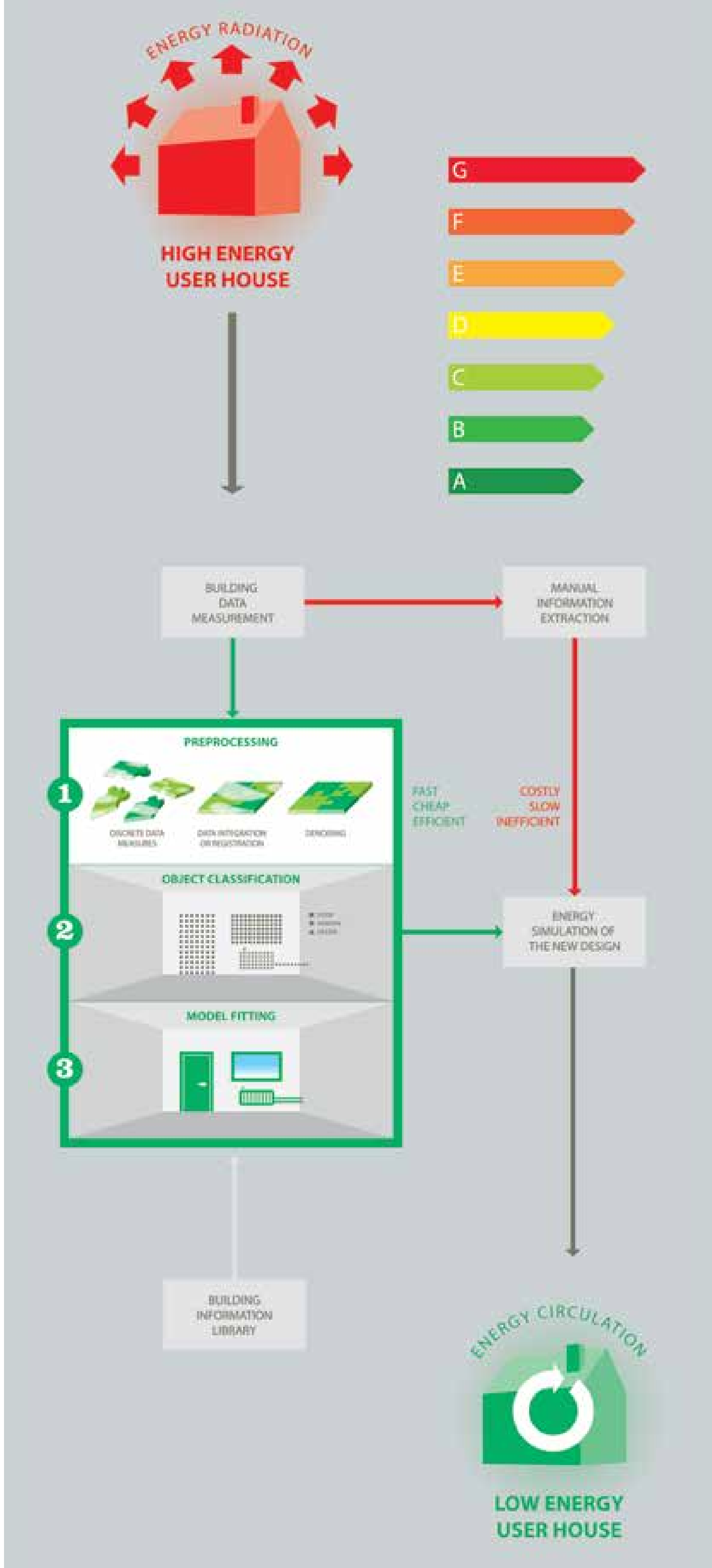
Simple, robust and easy to repair solutions are key to the success of the mould.

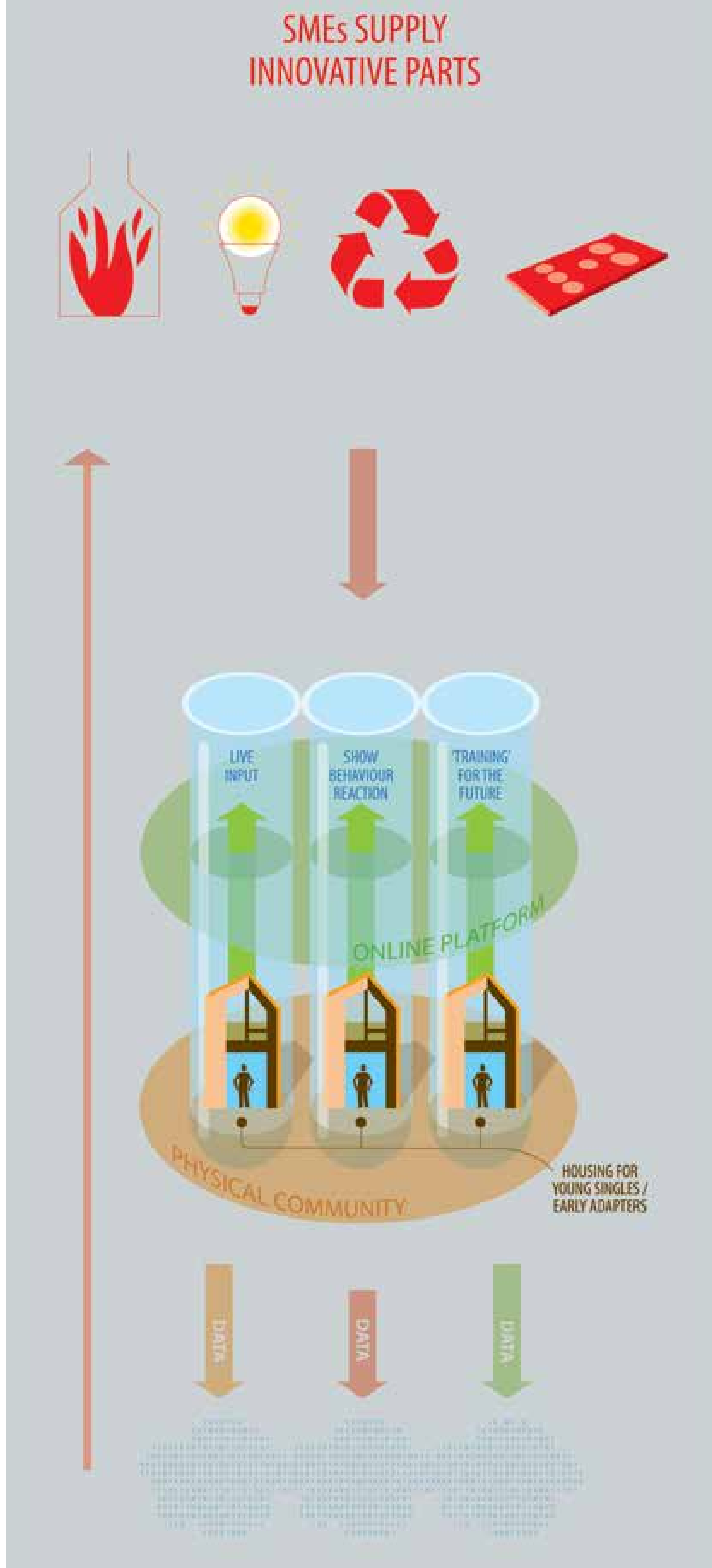
concrete prototype

Delft University of Technology
ir. **Roel Schipper**, MSc **Peter Eigenraam**, MSc **Matteo Soru**, dr. ir. **Steffen Grünewald**, **Ivan Gavran**, **Mattias Michel**

Eindhoven University of Technology
ir. **Arno Pronk**, **Dick Erinkveld (SolidRocks)**, **Hisham El Ghazi**, **Mitchell Janmaat**, **Tobi Lusing**, **Erwin van Rijbroek**, **Niek Schuijers**, **Martijn Verboord**, **Robin Versteeg**







ENERGY REDUCTION AND HEALTHY BUILDING 2.0
upgrading or new building

The project aims at developing a tool that helps School Boards in making a decision whether to renovate or to construct a new building. Three aspects will be taken into consideration: Energy use, Indoor Environment Quality (IEQ) and the perception of the users. By means of a 'Living Lab' situation, measurements will be taken of the most relevant parameters; the current energy consumption of the building, measurements of CO2 levels, ventilation, temperature, relative humidity, lighting and noise level of the installations; the perception of the end users will be measured by means of questionnaires. All three flows of information will be used for the creation of a model where a balance between energy use and indoor comfort will be found.

MSc. **Stephanie Villegas Martinez**
Eindhoven University of Technology
Smart Energy Buildings & Cities

ACADeS, Ruimte-OK, Eco KLima

Supervisors: dr.ir. **Marcel Loomans**, dr. **Ad den Otter**

GEOMETRIC INFORMATION PROVIDER PLATFORM
for building renovation to lower energy costs

Qualified energy modelling for building depends on proper definition of various parameters. Considerable part of these parameters are based on architectural and geographic characteristics of the building. Defining a platform which enables the user to extract required parameters from measured geo-data such as laser points or images and to transfer them to an appropriate format readable by energy modelling software is the main incentive of this proposal. By having this platform, user can directly manage a chain of the processes from measured data to energy analysis results and corresponding simulations. exceptional conditions has to be avoided as much as possible.

MSc. **Meisam Yousefzadeh**
University of Twente
VISICO

3D Geo Solutions

A LIVING LAB
for co-creations with small and medium sized enterprises

This project is focused on providing movable-temporary sustainable housing for young people in the Dutch market. The goal is to act as the missing link between innovative small and medium enterprises in the sustainability and energy efficient sector (SME's) and their target audiences i.e. residences. It is a new housing concept that provides residential solutions and living lab facilities for innovative energy technologies. It is a solid quality solution at affordable rental price, at central locations inside cities providing independent living. At the same time, it provides a low cost living lab facility for field testing, linking to market and showcasing to innovative companies which want to "market test" their products and produce performance data.

MSc. **Argyrios Papadopoulos**
Eindhoven University of Technology
Smart Energy Buildings & Cities

Heijmans NV

Supervisors: prof.dr.ir. **Bert Blocken**, prof.dr.ir. **Pieter van Wesemael**
Company Supervisor: ir. **Dick Timmermans**

LUMINESCENT SOLAR CONCENTRATOR
visual aspects

A luminescent solar concentrator (LSC) is a device that has luminescent molecules embedding or topping polymeric or glass waveguide to generate electricity from sunlight with a photovoltaic cell attachment. LSCs can be employed both in small and large scale projects, independent on the direction or angle of the surface with respect to the sun. It also promises more freedom for integration in urban environments and design choices compared to the traditional PV systems.The aim of the SEB&C company assignment is to investigate the visual aspects and to bridge the gap of knowledge linking societal, design and technological aspects, including;Colorization, application potential in the built environment and Visual Perception of the user.

MSc. **Tugce Tosun**
Eindhoven University of Technology
Smart Energy Buildings & Cities

Supervisors: prof.dr.ir. **Jos Lichtenberg**, dr.ir. **Pieter-Jan Hoes**

A SUSTAINABLE LIFE-CYCLE METHOD
for industrial parks & business parks

BIM is regularly used for vertical constructions where architects, engineers, contractors and even accountants are constantly exchanging information to get the most efficient results expressed in time and money. Vertical constructions and horizontal constructions are, in terms of the requirement of information, very similar one to each other. Each of these entities has its own policies and processes to make decision on. Therefore, horizontal constructions are exposed to the same degree of complexity in their processes to vertical ones, and have the potential to benefit in the same scale. Doing so will provide real-time assessment capability of project data and interdependencies as cost can be mitigated and schedule risks minimized.

Diruji Dugarte Arch.
University of Twente
Construction Management and Engineering

Municipality of Hengelo

Supervisors: dr. **Timo Hartmann** & prof.dr. **André Dorée**

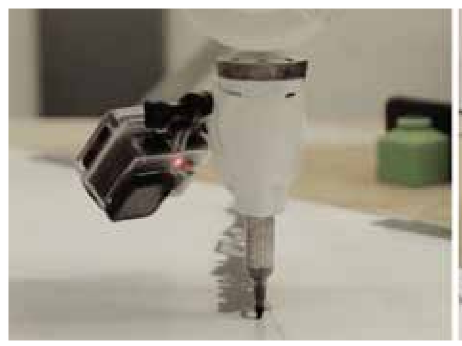
ROBOTICALLY DRIVEN CONSTRUCTION OF BUILDINGS

Robotically Driven Construction of Buildings (RDCB) is an exploration into holistic/integral design to production solutions for robotically driven construction of buildings by involving the disciplines of architecture, robotics, materials science, construction and building technology, and structural design. The team integrates knowledge from the individual disciplines in order to develop new numerically controlled manufacturing techniques and building-design optimizations for adding creative values to buildings in a cost-effective and sustainable way.

This project is in line with Europe's aims for improving material sustainability and energy efficiency of buildings and construction processes. Robotically driven construction and customized building material systems have the potential to realize this in a cost-effective way and at the same time reduce accidents and health hazards for workers in the building sector. In order to achieve this RDCB is distributing materials as needed and where needed. This requires exploration of a variety of techniques and implies working with customized materials while finding the best methods of applying materials in the logic of for example specific force flows or thermal dissipation patterns.
RDCB advances multi- and trans-disciplinary knowledge in robotically driven construction by designing and engineering a new building system for the on-demand production of customizable building components. The main consideration is that in architecture and building construction the factory of the future employs building materials and components that can be on site robotically processed and assembled.

At the Delft University of Technology (TUD) two groups of researchers and students have explored possibilities of implementation of robotics in architectural design and building material systems. While at the Civil Engineering Department the focus was to study the production of suitable recycled fine aggregates to be used in robotically aided construction processes, for the Hyperbody group at the faculty of architecture at TU Delft, the focus was on developing a robotic setup as an integrated design to production system for Additive Manufacturing supported by customized Computer Aided Design procedures.

The aim of the project at Eindhoven University of Technology (TU/e) was to create knowledge about robotically construction methods and possible applications of this methods. The process was divided into different stages: brainstorm sessions, design meetings and the realization of the product. It has been done with a team of students with different backgrounds: Structural Design (SD), Building Technology (BT) and Construction Technology (CT).



Robotically Driven Construction of Buildings is distributing materials as needed and where needed.

RDCB has profited from the support of:
Delft Robotics Institute (DRI)
Department of Architectural Engineering and technology (AE&T)
100% Research
C2CA EU-Project (Recycling of concrete to cement and aggregate)
Mebin (HeidelbergCement)
StudioRAP (production of the mold for TU/e)
ENCI B.V. (concrete composition and production for TU/e).

exploring on-demand building components production

Interdisciplinary brainstorm

The first meeting introduced the purpose of this project: a robotically created product for the building industry. Because of the variation in building industry disciplines the TUE group was divided into brainstorm teams with the specializations SD, BT and CT. Every discipline explored what they could do with robots within their own specialization. The directive given was: think about possible design-optimizations in order to improve for example sustainability, durability, material-usage and space-usage. In this process the students created their own visions about the new design possibilities considering different robot construction methods. This resulted in three different ideas with common points: building design adaptability, unique shapes (greater design freedom) and effective integration of different disciplines in construction components. The team of TUE continued with studio RAP a design and fabrication studio focusing on robotically controlled fabrication methods within the building processes, to design the possible scenarios for realization of the prototype with the robot.

At Delft, the process of experimentation with robotic arms started in the beginning of the project to inform the design processes at the very early stages to establish a direct link between design and production. This way the team was not only able to explore different design variations and possibilities to be produced only by robotic 3D printing, but also was able to adjust, customize and develop the required design tools to production system, considering both material behaviours and the evolving design outcomes.

Design development

At each university objectives and ideas behind making the prototpyes are:
TU/e;
- A façade of a building with a segment of a floor.
- optimizing the geometry based on structural behavior.
- Open parts of the optimized topology of the façade to be used as 'windows'.
- The floor-construction is inspired from a leaf's shape, and thicker parts in the floor can be used for tubes and installations.
- Using robotic subtractive methods of production to create complex moulds to cast the designed parts in concrete

TUD;
- Developing and establishing proper computational design methods for a compression-only structure considering the innate characteristics of the material.
- Translating the results of design and material distribution analysis into robotic motion paths for material deposition.
- Making a part of the designed pavilion with the developed robotic 3D printing system for extruding clay ceramics.
- considering porosity of material in different scales ranging from Macro(scale of architectural elements like openings and building envelop) to Micro (scale of material distribution or material architecture).

Results, prototypes and future steps

The results of the RDCB project can be discussed at two levels of fundamental and applied research, which are realized through making the prototypes by each university. Researchers at the civil engineering department of TUD have made studies on recycled concrete as well as studies on the use of possible natural materials on a fundamental level. The applied research of the Hyperbody group can provide the required supporting knowledge for further improvement of application of robotic additive manufacturing in the building industry. In combination, the results of on the one hand material based research as the development of computational and parametric design strategies can bridge the gap between early stages of design and production process.
At TU/e, analysis of the experienced design to fabrication process, using a robotic subtractive manufacturing method can lead to a comparison between CNC milling methods with robotically supported manufacturing techniques to specify the advantages of application of robots or robotization in some parts of building industry.

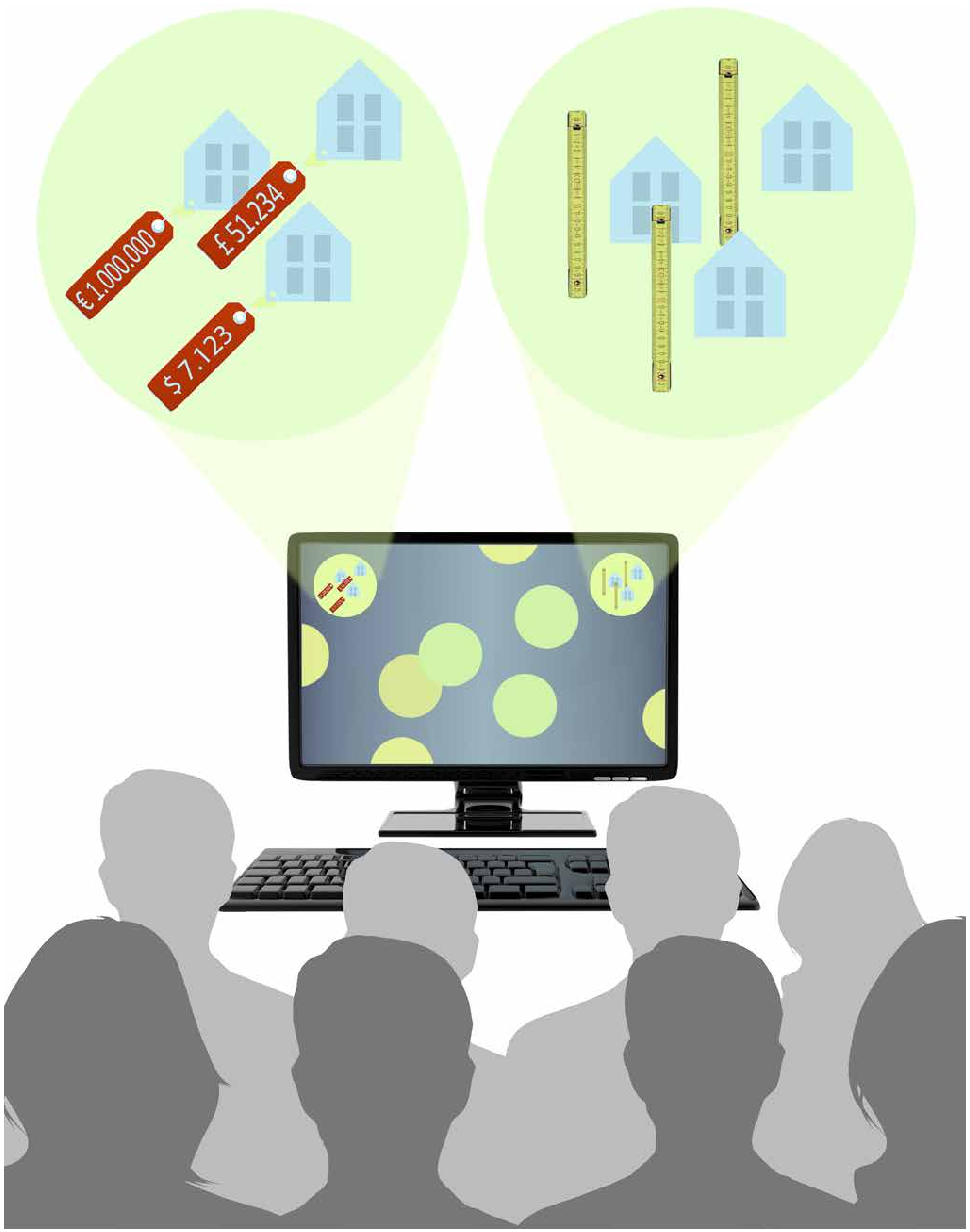
Using robotically driven tools enhances design adaptability, greater design freedom and effective integration of different disciplines in construction components.

Delft University of Technology
Dr.-Ing. **Henriette Bier,** M.Arch. **Sina Mostafavi,** ir. **Ana Anton,** ir. **Serban Bodea, Berend Raaphorst, Guus Mostart, Hans de Jonge, Jeroen van Lit, Jan Paclt, Kasper Siderius, Marco Galli, Michal Kornecki, Mohammad Jooshesh Oana Anghelache, Perry Low, Radoslaw Flis, Rob Moors, Rutger Roodt, Ruth Hoogenraad, Stef Hoeijmakers, Steph Kanters, Thijs IJperlaan,** Prof. dr. **Peter Rem, Somayeh Lotfi, Eleonora di Domenica**

Eindhoven University of Technology
prof dr. ir. **Theo Salet, Jordy Vos, Adrie van der Burgt, Bas van Wezel, Christiaan Voorend, Chiel Bekkers, Iris Rombouts, Luc Gerlings, Marieke de Vries, Marijn Bruurs, Rob Wolfs , Siert Saes, Tim Span, Wout Rouwhorst**

Eventually both series of experiments and prototypes - the casted concrete components of TU/e in robotically produced moulds and porous robotically 3D printed building prototypes of TUD in ceramics – specify to a certain degree what is possible and what is not and can define the future roles of robotics in building industry. In this context the next step for future explorations and prototyping can focus on simultaneous and/or sequential combination of these processes, supported by multiple robots to illustrate and define some of the characteristics of future programmable building factories.

SEMANTIC WEB OF BUILDING INFORMATION

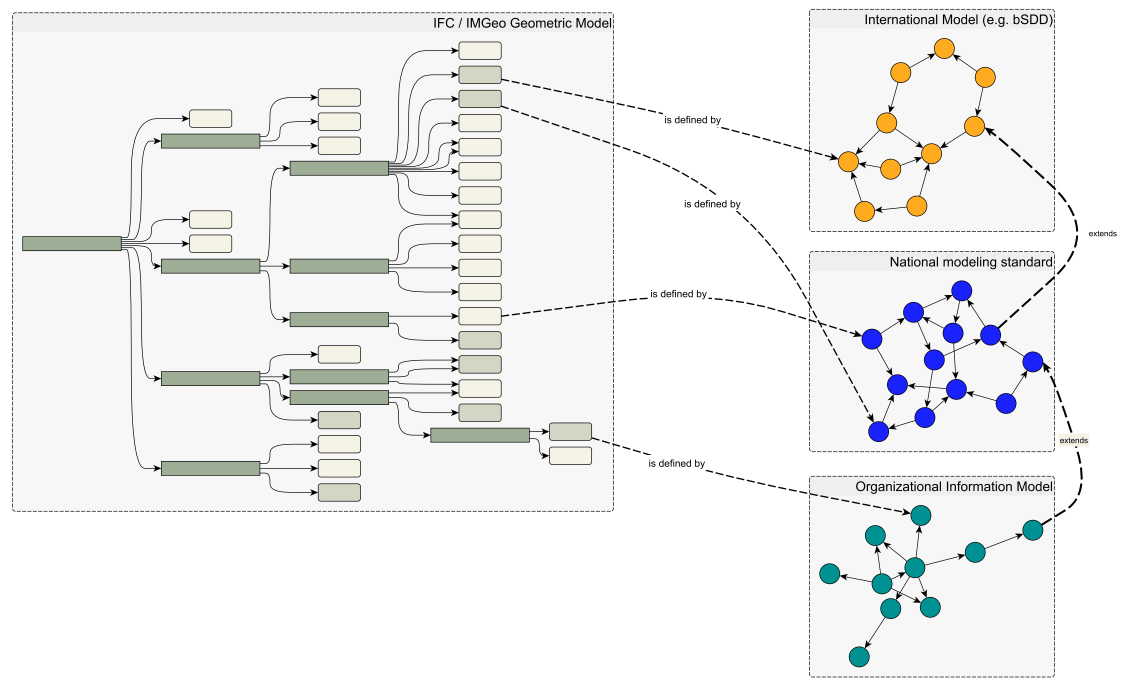


cloud based 'real world' building data

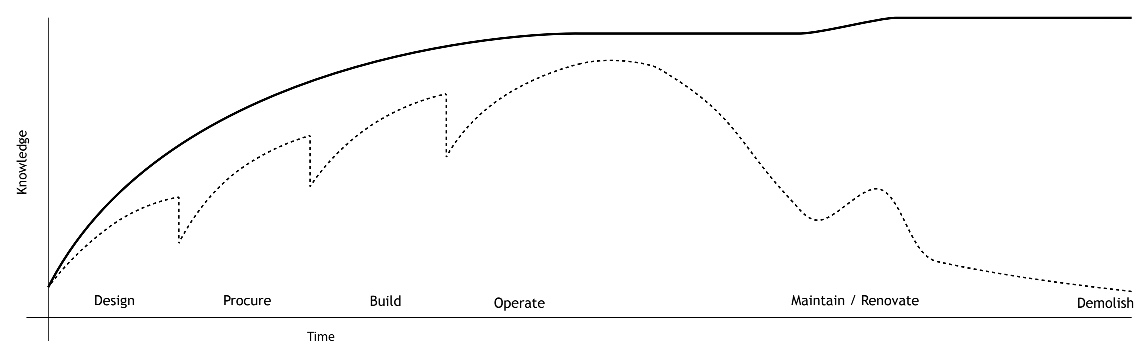
Information required by practicing architects, engineers, construction managers, building operators, asset managers, owners, and users becomes more and more distributed, detailed, and richer. BIG DATA is on the rise and this trend will not stop. We rather expect that this trend will further accelerate in the upcoming years as;

- **more and more sensor technologies will become widely available to access existing conditions in the built environment,**
- **more and more information streams will be combined for various purposes, e.g. mobile data access information to space use in order to evaluate wireless infrastructure performance but also to establish building use patterns in post-occupancy evaluations,**
- **advanced design tools will allow for more detailed data-driven simulation of an increasing number of design alternatives in shorter time spans, and**
- **participatory efforts will involve an ever larger number of specialists and non-specialists that all provide information that needs to be accounted for during design and construction planning.**

Humans will no longer be able to ensure the consistency of information and, more importantly, find the - for them - relevant data.



Semantically enriched building models with linked structured vocabularies and data sets



information and knowlegde loss and decay

The availability of the above described BIG DATA will mean that data sources in the future will be based upon an increasing amount of standards, information models, and semantic dictionaries. Additionally, data sources will become increasingly distributed across the web. Practitioners need to be supported in finding, combining, and acting on this distributed information. Already posing a problem for engineering practice today, in this changing world, humans will no longer be able to ensure the consistency of information and, more importantly, find the for them relevant information.

To this end, semantic web technologies are required that allow machines to readily interpret information and can perform much of the tedious and time consuming work involved in working with distributed BIG DATA repositories. After all, computers can support humans in indexing and searching data. We expect that this will be one of the most important and prominent areas for research in the upcoming years. In this lighthouse project we made a number of first important steps to enable such research:

3TU BIM Data Repository

We set up a repository structure for storing building related information within an archive. This archive will allow us to collect all data that students at the 3TUs developed in the last years and will develop in the years to come. In collaboration with the FP7 EU project 'DURAARK', a repository for the sustainable long term preservation of digital building information in different formats, including the Open Industry Foundation Classes (IFC) has been created and will be filled over time. The repository, made available in the Amazon cloud by project partner Microsoft, can then be used by researchers to develop indexing and search solutions and to empirically test them. We also expect that the repository can grow into a benchmark for testing developed indexing and search algorithms with respect to their performance in terms of speed, completeness, and stability.

Data format, standard, and dictionary map

We also made a first start for establishing a map of the available data formats, standards, and dictionaries to describe building related data. The map will provide an overview of the ontological spectrum within the field of civil engineering. The spectrum, in turn, will allow researchers to start developing different translation mechanisms between the different existing data formats, standards, and dictionaries to arrive at homogeneous indexing and search solutions in the long term.

Information use and exchange processes

A start was made to understand and develop future information use and exchange processes that assume a widely distributed information environment. This part of the research is important to provide the basis for developing practically applicable indexing and search workflows.

Automated indexing methods

A first step was made into exploring possibilities for automatically indexing the semantic information available within the large amount of existing data formats, standards, and dictionaries. Based on a selected number of case projects, first indexes have been extracted and explored according to their utility to support engineering work.

The above summarized four steps, even within the quite early stage of development they are in, provide a strong foundation for semantic web research at the 3TU in the years to come. The steps provide a platform and an initial research framework for academic research at the Bachelor, Master, and PhD level.

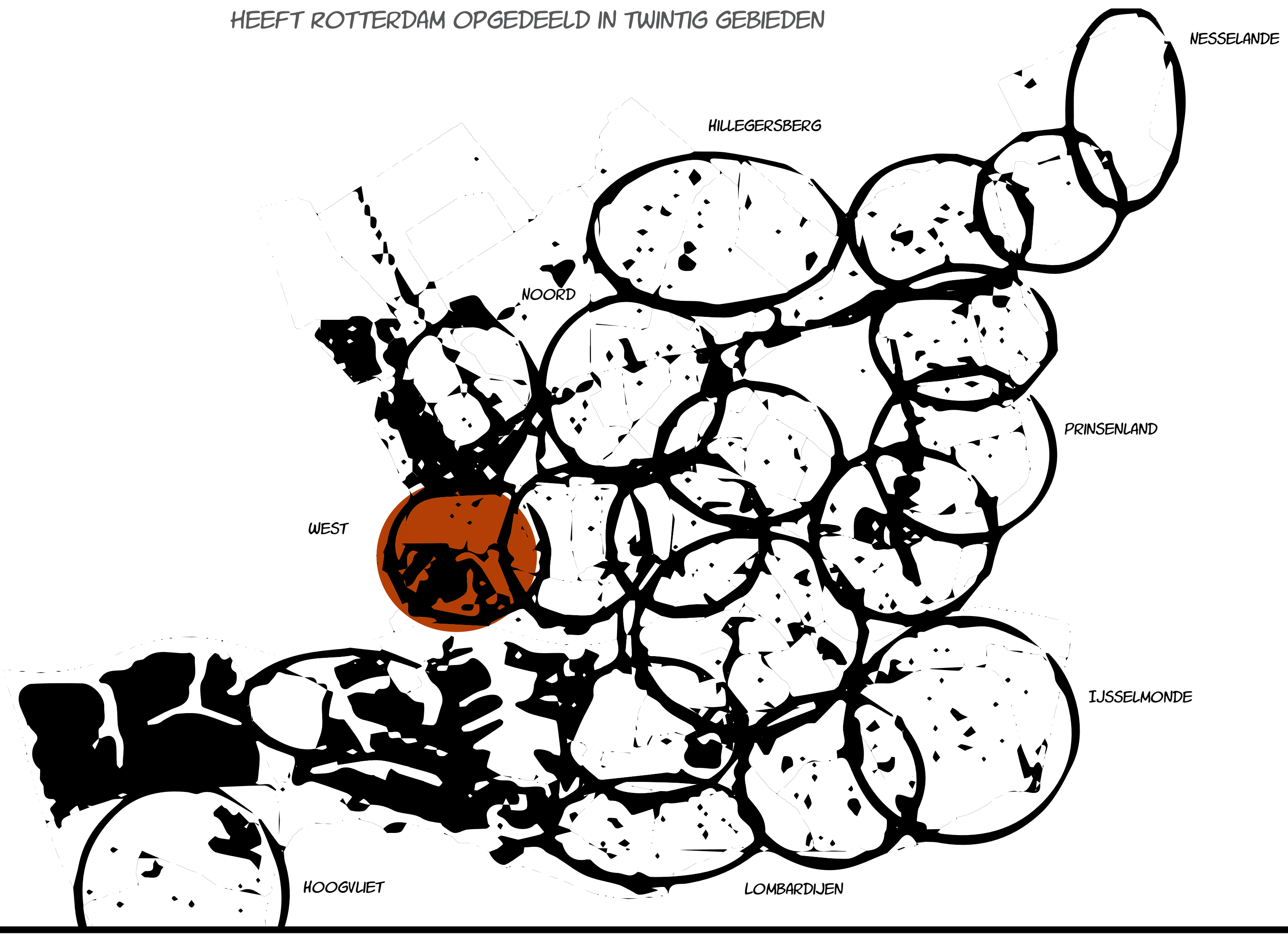
University of Twente
dr. **Timo Hartmann**, prof. dr. ir. **Arjen Adriaanse**

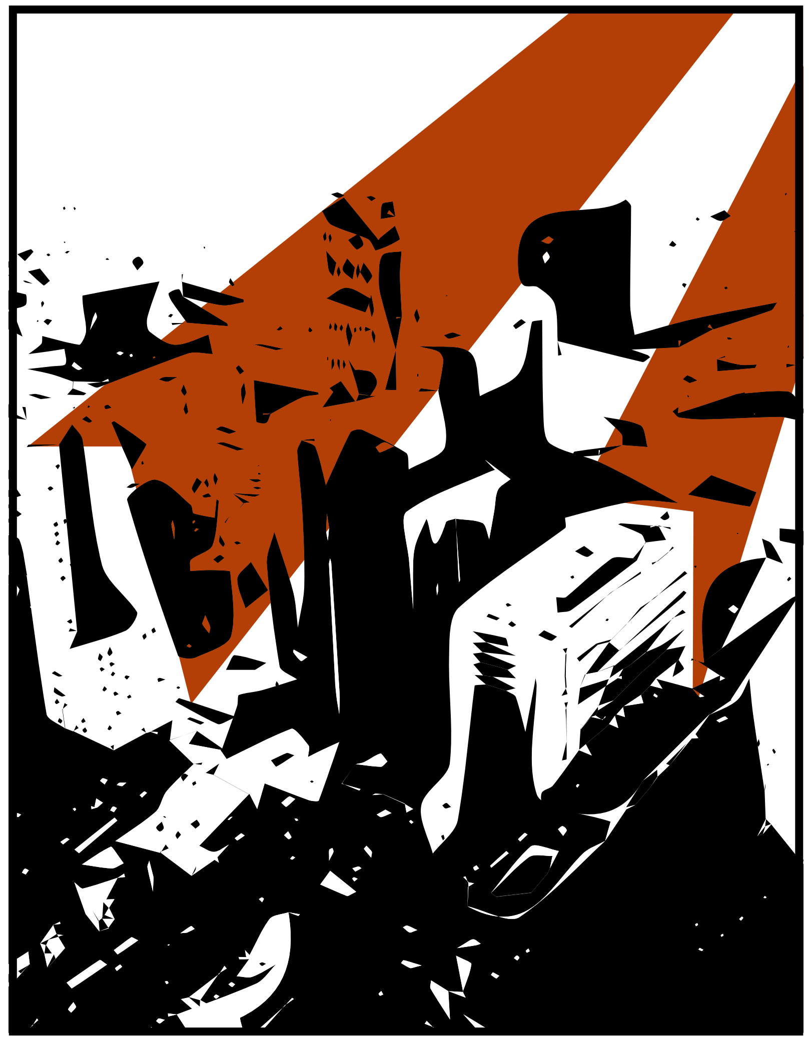
Eindhoven University of Technology
dr. Dipl.-Ing **Jakob Beetz**, ir. **Thomas Krijnen**

Delft University of Technology
dr. ir. **Alexander Koutamanis**

Balast Nedam, Microsoft Netherlands

SENSING HOTTERDAM (ONDERZOEK NAAR WARMTE IN DE STAD) HEEFT ROTTERDAM OPGEDEELD IN TWINTIG GEBIEDEN

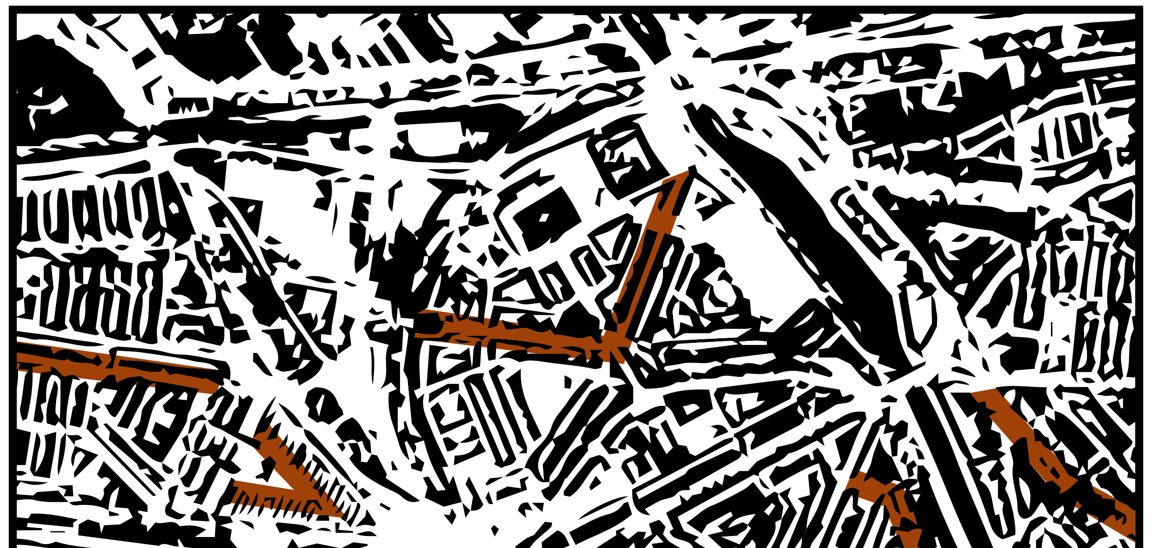




Delft University of Technology
dr. ir. **Frank van der Hoeven**, ir. **Alex Wandl**

Eindhoven University of Technology
prof. dr. ir. **Bert Blocken**

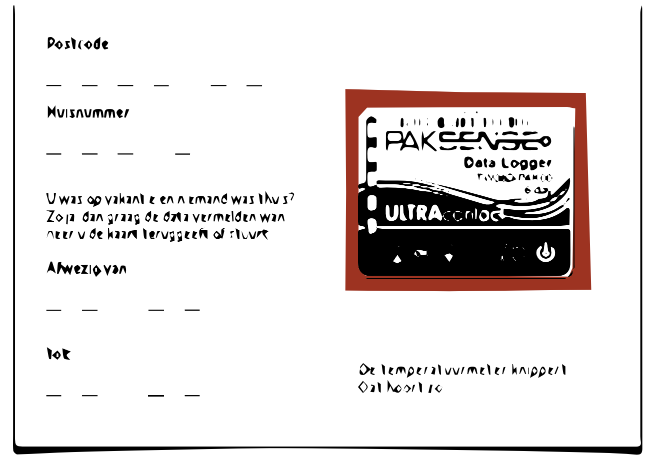
City of Rotterdam

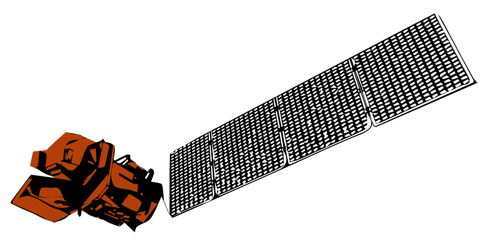


VIJF REPRESENTATIEVE STRATEN GESELECTEERD IN ELK GEBIED, MET ALS DOEL TIEN HUISHOUDENS TE VINDEN IN ELKE STRAAT.

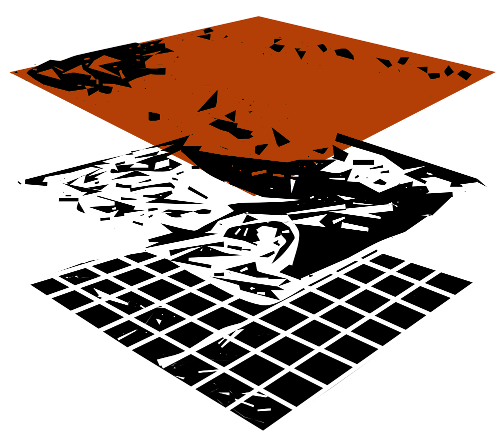
TWAALF STUDENTEN KREGEN EEN VAKANTIEJOB AANGEBODEN, MET ALS TAAK PER STRAAT DIE TIEN HUISHOUDENS TE VINDEN

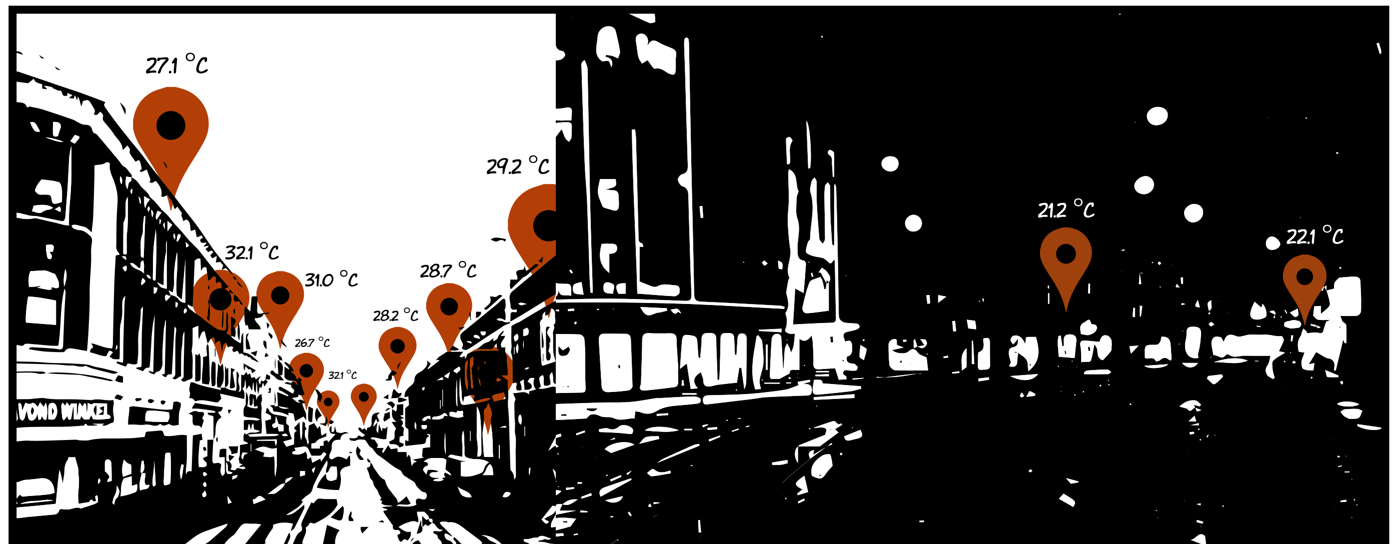
OM DAAR EEN KAART ACHTER TE LATEN MET EEN KORTE UITLEG EN MET AAN DE ACHTERKANT EEN



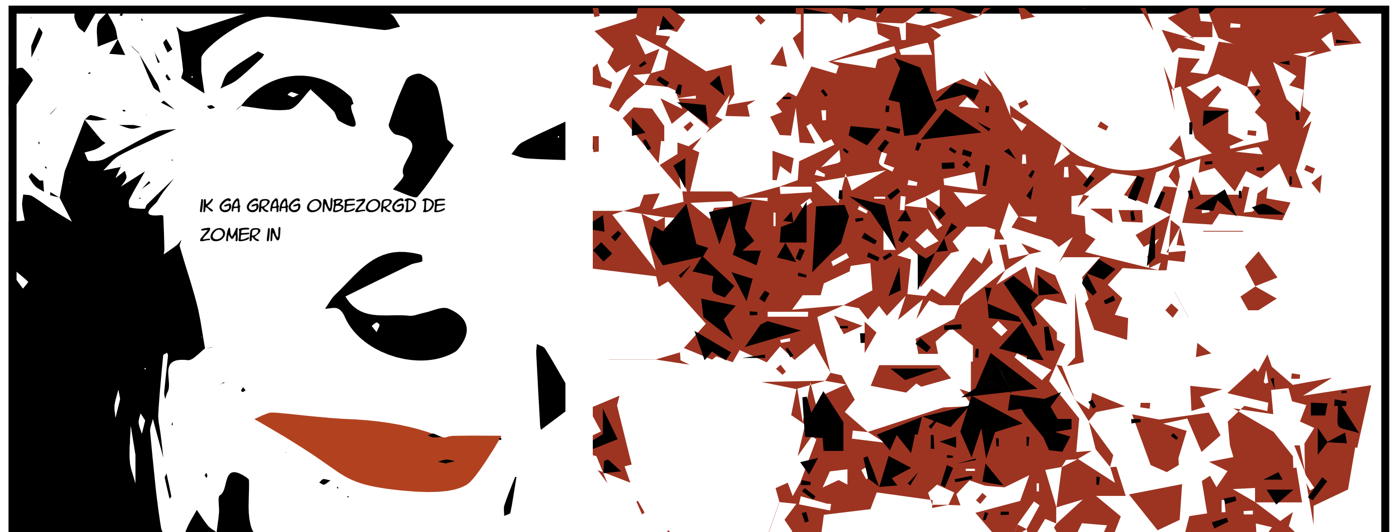


DIE METINGEN ZIJN DAARNA GECOMBINEERD MET ANDERE DATA VAN SATELLIETBEELDEN, GIS EN 3D-MODELLEN





ZO HEBBEN 800 SENSORS DE BINNENTEMPERATUUR GEMETEN EN 200 SENSORS DE NACHTELIJKE BUITENTEMPERATUUR.



MET ALS RESULTAAT TWEE WARMTEKAARTEN DIE VOORKOMEN KUNNEN DAT OUDEREN ONNODIG OVERLIJDEN BIJ HITTEGOLVEN.

THE LIGHTVAN

rijdend licht laboratorium

Een van de uitdagingen voor de gebouwde omgeving is dat er een sterke reductie van het energieverbruik nodig is. Daglicht heeft vele mogelijkheden om een goede energiebron te zijn wanneer sommige problemen, zoals verblinding en oververhitting, kunnen worden voorkomen. Naast een goede energiebron is daglicht ook nodig voor het biologische systeem van het menselijk lichaam, het hormoon systeem en het slaap-waakritme. Dat betekent bijvoorbeeld dat bij een goede daglichtomgeving kinderen beter kunnen presteren op school en senioren beter kunnen slapen en minder depressieve gevoelens zullen hebben.
Praktische daglichtonderzoeken worden meestal gedaan met proefpersonen die al op universiteiten en laboratoria aanwezig zijn, zoals de studenten en de medewerkers. Het is de vraag of conclusies getrokken uit dit type studies geschikt zijn om bijvoorbeeld goede basisscholen en senior woningen te kunnen ontwerpen en bouwen. Onderzoekers verwachten dat de ontwerpregels volledig kunnen verschillen voor deze specifieke gebouwen en hun gebruikers, omdat de zintuigen van mensen en de verwerking in de hersenen eerst op jonge leeftijd een ontwikkeling doormaken en later bij het ouder worden ook weer veranderen. Zo blijkt bijvoorbeeld dat senior ogen vier keer zoveel licht nodig hebben als die van jongeren en dat problemen met verblinding anders ervaren worden. Jonge kinderen en ouderen hebben vaak geen mogelijkheden om naar universiteiten te komen om proefpersoon te zijn bij laboratorium testen. Als we willen dat daglicht gebruikt wordt als een goede, gezonde en goedkope energiebron, dan moeten we gebouwen ontwerpen die visueel comfortabel zijn voor de gebruikers. Dat vraagt om meer specifiek onderzoek met ouderen en kinderen als proefpersonen.

LIGHTVAN

Recent is een multifunctioneel mobiel lichtlaboratorium gebouwd in een transport auto, de LIGHTVAN. Deze LIGHVAN heeft een tweeledig doel: Met dit rijdend lichtlaboratorium kunnen we naar de leefomgeving van specifieke groepen mensen gaan, de kinderen en de senioren, zodat zij proefpersoon kunnen zijn bij specifieke leeftijdsafhankelijke lichtonderzoeken. In dit rijdende laboratorium is daartoe meetapparatuur aanwezig en ook een tafel en stoelen voor de diverse proefpersonen. Testen over luminantie- en kleurcontrasten zijn mogelijk, evenals 'licht en schaduw' patronen. Zelfs kleine oogtesten kunnen worden uitgevoerd. Daarnaast is de achterzijde van de bestelauto aangepast zodat bij geopende deuren allerlei innovatieve gevels getest kunnen worden. De LIGHTVAN kan naar verschillende locaties worden gebracht en gericht op diverse zon richtingen. Diverse passe-partouts zijn aanwezig voor verschillende maten van gevels, zodat bouwfysische metingen gedaan kunnen worden en proefpersonen hun voorkeuren betreffende comfort en gezondheid voor gevels kunnen aangeven.

Als we willen dat daglicht gebruikt wordt als een goede, gezonde en goedkope energiebron, dan moeten we gebouwen ontwerpen die visueel comfortabel zijn voor de gebruikers.

Mobiel lichtlaboratorium

De bouwfysica groepen van de Technische Universiteiten van Delft en Eindhoven hebben in een eerder stadium van onderzoek al pilotstudies in scholen, seniorenwoningen en verzorgingshuizen uitgevoerd, met bouwfysische metingen en vragenlijsten voor de gebouwgebruikers. Met het mobiele lichtlaboratorium kunnen we ook laboratoriumproeven en observaties gaan uitvoeren in de leefomgeving van kinderen en senioren, dus met de juiste proefpersonen. Daarnaast kunnen we alle leeftijdscategorieën van proefpersonen bevragen over het comfort en hun voorkeuren bij nieuwe innovatieve gevels. Dat zal meer mogelijkheden en betere onderzoeksresultaten geven.

Met het 'LIGHTVAN' onderzoek beogen we het lichtontwerp voor gezonde scholen en moderne seniorenwoningen en verzorgingshuizen te optimaliseren met betrekking tot het gebruik van daglicht als een goedkope en belangrijke energiebron.

Delft University of Technology
assoc. prof. dr. **Truus Hordijk,** Dr.-Ing. **Marcel Bilow**

Eindhoven University of Technology
ir. **Marielle Aarts,** prof. Dr.-Ing. **Alexander Rosemann**