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Microscopic picture of a Wood Wool Cement Board, TU/e BPS laboratory

Foreword

Wouter Reijnders

President 20th board of s.v.b.p.s. Mollier

Dear building physics and services enthusiast,

Proudly I may write to you the foreword of the first INSide Information of the academic year 2015-2016. For those of you who have not met me yet, I am Wouter Reijnders and I am the chairman of the 20th board of s.v.b.p.s. Mollier. With 2016 knocking on the door we are proud to present this magazine in which we look back on a successful year with activities, excursions and lectures.

The transition to graduate school has happened, while most of our members are operating in the old style of education. Courses have changed but the content should be about the same. If there are uncertainties or things remain unclear please do not hesitate to contact us. Sadly the long awaited relocation of the Mollier compartment will be/or is executed. For those who are looking for us, you can find us at the second floor of Vertigo, but we will remain the same.

This year we will organize a number of activities including the 4th lustrum, the exposition has ended and I hope that a lot of you have enjoyed. Other festivities have been announced by now and I hope to see you there. Besides the lustrum the usual activities like lunch lectures, the meet and greet and a study trip to Brazil will be organized.

On behalf of the 20th board, I want to thank the companies, the unit BPS, the students and others that collaborate with us to make the building physics and services into a lively and great study, and last but most certainly not least I want to thank the INSide Information committee for making this magazine.

I hope to see you around and wish you all a very good christmas holiday and hope you have a blast in the new year!

Yours sincerely,

Wouter Reijnders
Chairman 20th board s.v.b.p.s. Mollier

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This INSide


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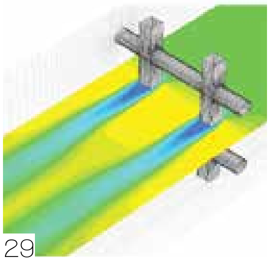
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The 20th board of Molllier

WOUTER REIJNDERS
CHAIRMAN

Hello, my name is Wouter Reijnders, 25 years old. I grew up in Heemskerk a town at the coast of Noord-Holland. According to my high school yearbook I set out to be an architect when I went to the University of Applied Sciences in Alkmaar to study the built environment. Pretty early during my study I lost my interest in architecture and went on to specialize in building technology and, that in its turn, changed to building physics. My internship was at het GeluidBuro an acoustic consultancy.

After graduating I could not find work that suited me, therefore I chose to do a master in Building Physics and Services. My main interest is acoustics. This originates from a deep interest in music, besides that I have affiliation with most of the other topics within the field.

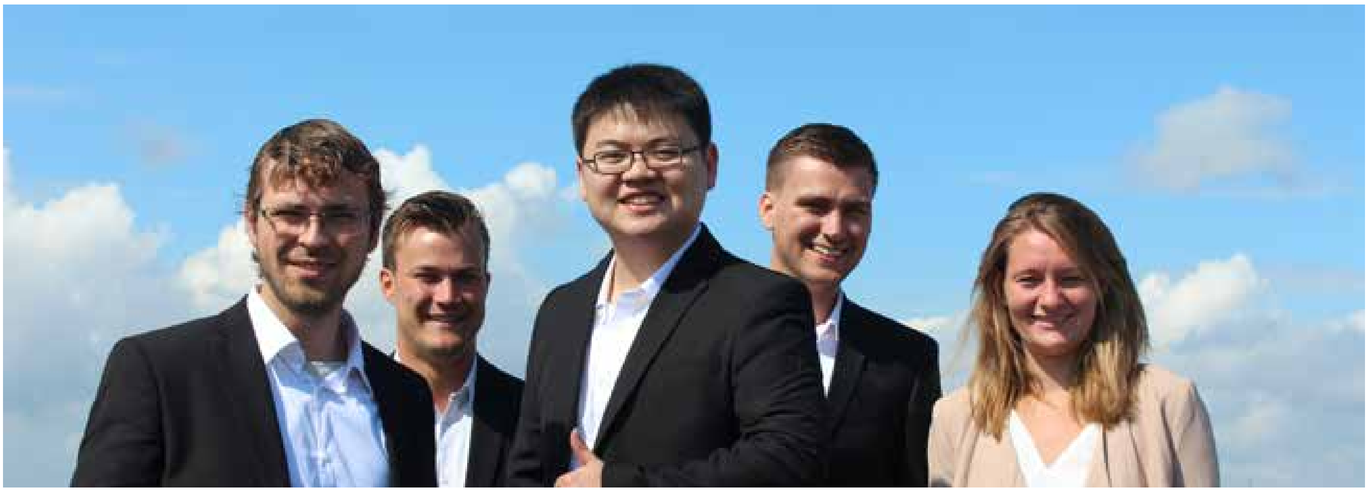
Besides the previously mentioned interest in music I like football, squash and an occasional game of chess. Next to events that are either intended for my physical or intellectual health I like the informal form of gathering with friends over a drink. For this year I hope that the association will continue to be awesome as it is, was and will be.

XIN XU
SECRETARY AND COMMISSIONER EDUCATION

My name is Xin Xu, which is pronounced like Sh-in Sh-yu. I am 24 years old and had lived with my parents in my birthplace Chongqing, China, which is a quite big city but not well known worldwide, until I started my study in the Netherlands in 2014. Like many other Chinese youngsters, I am the only without any brother or sister, such a pity isn't it?

I had my bachelor degree from a local university called Chongqing University, with major in civil engineering, and then came to TU/e for master. The reason why I learnt this subject was quite funny: actually my father expected me to be an electrical or communication engineer because of some family tradition, however I totally ignored his idea, but listened to a stranger on the train that building engineering is very cool, and of course, money-making. Fortunately it turned out that I love this subject.

In my spare time, I like to tweak computer and other electronic devices, and also play computer games. People call this group of people geeks. Besides, I like swimming, particularly 'baantjes zwemmen' in Dutch language. At last I would say working at Mollier is quite a new experience for me, and I wish I bring some international perspective to the association and have happy time with all of you. I am available at Mollier's office on Mondays, and I am always glad to meet you there, with a talk, tea, or anything else.



WIES WESTERHOUT
TREASURER AND VICE-CHAIRMAN

My name is Wies Westerhout, 23 years ago I was born in Delfzijl. I am in the middle of three children with an older brother and a younger sister. I grew up in Appingedam, till my 6th in a residential area of this small town and from then we moved to the countryside of this place. We still lived in the municipality Appingedam but near by a small village called Wirdum, where I went to the elementary school. From this 'middle of nowhere' I cycled every day 7,5 km to my VWO in Appingedam which I completed in 2010.

At first I wanted to become a mathematician or physicist but after an open day I knew I could not make friends and have fun with this type of people. After that I went to an open day of architecture and from then on I knew that I want to become something related to building engineering. So I started my bachelor which I finished in 3,5 year. Then I moved for half a year to Gambia where I was a project manager for the construction of a toilet building and a nursery school. After that I started my master BPS in September 2014.

In my spare time I play volleyball in Ladies 1 of Tamar in Eindhoven. I like to have dinner with friends and teammates, playing board games, going to festivals, traveling, going to city trips, winter sporting and a lot more. A few evenings a week I have to work in the restaurant/café of Natlab to finance all of my hobbies. Every Wednesday I am at the Mollier booth, so feel free to come around for questions, a talk, or a drink.

KOOP-PIETER ZIEL
COMMISIONER EXTERNAL RELATIONS

My name is Koop-Pieter Ziel, I'm 25 years old and have started with the 3rd year of my master BPS. I got my bachelor's degree for 'HBO-Bouwkunde' at Windesheim in Zwolle. I finished here in 2011. After successfully finishing my premaster within one year I started with my master. Now I have reached the final stage. Therefore I searched and found a company which offered me a graduation project and the possibility to work at their office in Eindhoven. With pleasure I spend most of my days during the week working at Deerns in the 'Klokgebouw' on Strijp S. My research project focusses on ATES, Aquifer Thermal Energy Storage, in particular on the performance, current obstacles and optimization on district scale. This is at the chair Building Services under the supervision of professor Zeiler.

About my personal life, I was born and raised in Oldeholtpade. What place? Yes, Oldeholtpade. A small place in the province Friesland, which is now familiar to most of my fellow students after spending one weekend at my family's dairy farm. As a young boy I spend most of my time outdoors, riding bikes, motorcycles, quads, cars, tractors. Basically everything with an engine and two or more wheels. The farm is still a place I love to come to relax and mess around. My other hobbies are football and skating on natural ice outdoors (if it ever comes again). I'm always in for a joke or a beer. Friday I'm often at university, join me in the afternoon at the Mollier booth and we will drink a beer and have fun.

JOSHUA VAN DEN HEUVEL
COMMISIONER ACTIVITIES

Hello, my name is Joshua van den Heuvel, 23 year's old. I grew up in Deurne (Noord-Brabant), not so far from Eindhoven, and lived there until I graduated at the Avans University of 's-Hertogenbosch in Building Engineering. I started the study Building Engineering with the main reason that I liked to draw and design. Soon after starting my study career I realized the diversion in building engineering and my interest started to grow for the building physical part, and the innovation that can be achieved within the building sector. After graduating Avans university, with a project about Passive House of course, I started the pre-master at the TU/e. The pre-master ended and I could not yet start with the master, so I went away for a year to work as an energy performance advisor. February 2015, I started the master Building Physics and Services.

Some people ask me. Why the board? There are multiple reasons for that. For a long time I was not an active member of Mollier. What I have wanted was to get to know other students from the master, where they are working on, and expand my network as well within as outside of Mollier.

Something about myself. At the age of 5, my dad send me to football. From that moment on I was hooked on football. My whole family remembers me as the boy who was always carrying a ball with him. Nowadays I still find myself on a Sunday morning giving it all to get the ball in the goal of the opponent. Besides football I like to go snowboarding in winter and rowing on a bright sunny day.

CONSTITUTION DRINK

On September the 30th the board of Mollier has officially changed. It started with a general meeting of members, where according to protocol the inauguration took place. Knotting the Mollier tie was the ceremonial highlight. Although some should had practiced a little bit more in advance. The afternoon and beginning of the evening continued in the Skybar. We were glad to see so many members of our association. Surprising was the high number of former board members and in particular the presence of the very first board of Mollier. They took us back in time by among other bringing the first sketches of our logo, the first official registration at the Kamer van Koophandel, and even their first Mollier clothing.

Characteristic as closure for the constitution, we all went out for dinner in the city centre of Eindhoven. Restaurant 'Ons' was packed with Mollier. The buffet tasted great and the party downstairs at the bar/dancing area continued until two in the night. Next day some may have had their regrets, but it was a great evening/night out. We hoped everybody enjoyed it as much as we did. We are proud to be the 20th board of Mollier as this year will be colored by our 4th Lustrum by among other activities, exposition and festivity. Let's celebrate! ■

Green walls and their acoustic potential

Author
M. E. (Maud) Dohmen BSc
Supervisor
Dr. Ir. M. C. J. (Maarten) Hornikx

INTRODUCTION

Green facades and green roofs are becoming more common in the built environment. This comes as no surprise since many researches have proven the positive effects of the outdoor application of green on buildings [1,2,3]. A few positive effects are reduction of urban heat islands and noise pollution. However, little research has been done on the indoor application of green walls. What is the acoustic potential of green walls in an indoor environment? Can they conventional sound absorbing materials?

RESEARCH

In the little research that has been done about the indoor application of green walls three sound attenuating factors have been identified; sound absorption by the soil, reflection and scattering of sound by leaves and branches, and absorption of sound by the leaves [4]. Whereas the soil has substantial absorption for all relevant frequencies, the leaves only absorb high frequencies.

To formulate an answer to the questions asked above using on site measurements different types of green walls from different suppliers will be analyzed, all with a different supporting structure for the soil and plants. The following systems are analyzed:

- Trays, hard plastic with a generic substrate layer (Bruinsma Hydrokultuur);
- Flexible bags, soft felt with a generic substrate layer (Bruinsma Hydrokultuur);
- Planter tiles with a generic substrate layer (Sempergreen);
- Planter tiles with a rockwool substrate layer (Van Ginkelgroep).

Figure 1. In situ green wall

To define the acoustic properties of a green wall two on site measurements are done; reverberation time (T20, following ISO 3382-02) and speech intelligibility index (STI following EN 60268-16). The measurements are done on the location where the green walls are installed. The STI was taken into account because the walls are all placed in work environments where communication is important. The absorption coefficient alpha of the green wall is calculated using the measured T20 with and without a green wall and a model for the T20 of the room.

RESULTS

The systems of Bruinsma Hydrokultuur have been measured and the results can be seen in Figure 2. In some way the graph is in line with previous research. The drop in T20 is higher in the 250 Hz and 4000 Hz bands than in the other mid-frequency bands. These drops could be assigned to the soil and the plants presence. However no solid conclusions can be made yet because only two structures have been analyzed and the absorption coefficients have not been calculated. The STI wasn't significantly influenced by the green walls.

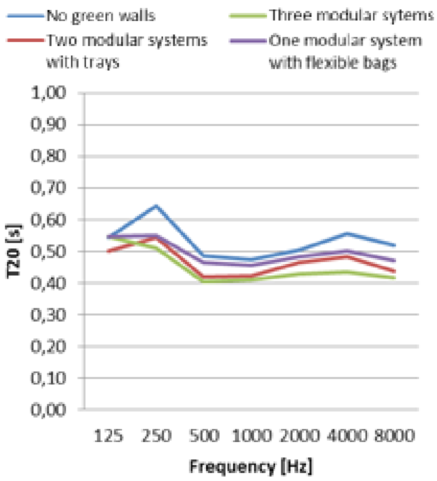


Figure 2. Reverberation time T20

THE NEXT STEPS

The next steps in the research are measuring more types of walls, comparing their absorption coefficients and analyzing the differences in results between the various systems. Finally the absorption coefficients of the walls are compared to the values for conventional materials, for example perforated plates. This will give an indication for the possibility of applying green walls instead of conventional sound absorbing materials. ■

[1] Ismail, M. R. (2013). Quiet environment: Acoustics of vertical green wall systems of the Islamic urban form. Frontiers of Architectural Research, 2(2), 162–177. doi:10.1016/j.foar.2013.02.002

[2] Manso, M., & Castro-Gomes, J. (2015). Green wall systems: A review of their characteristics. Renewable and Sustainable Energy Reviews, 41, 863–871. doi:10.1016/j.rser.2014.07.203

[3] Wong, N. H., Kwang Tan, A. Y., Tan, P. Y., Chiang, K., & Wong, N. C. (2010). Acoustics evaluation of vertical greenery systems for building walls. Building and Environment, 45(2), 411–420. doi:10.1016/j.buildenv.2009.06.017

[4] D'Alessandro, F., Asdrubali, F., & Mencarelli, N. (2015). Experimental evaluation and modelling of the sound absorption properties of plants for indoor acoustic applications. Building and Environment, 1–11. doi:10.1016/j.buildenv.2015.06.004

Concentration of CO_2 in the vicinity of sleeping infants at Dutch daycare centers

Author
T.W. (Thijs) Kruisselbrink

INTRODUCTION

Studies have shown that the indoor air quality (IAQ) in Dutch daycare centers often is inadequate. The goal of my master project was to investigate the CO_2 concentrations of bedrooms in Dutch daycare centers, with an emphasis on the performance of ventilation systems and the microenvironments inside the baby cots. It was expected that the CO_2 would be higher inside the cot because it may act as a confined space.

METHOD

CO_2 is used as an indicator for the IAQ, because CO_2 is able to indicate the pollutants coming from the human body, relatively easy to measure and often used in legislation. However, it is not able to indicate building related pollutants. Measurements are conducted in the bedrooms of two daycare centers located in Eindhoven. During this measurement CO_2 as well as the temperature and relative humidity are monitored. Two measuring points are applied in the microenvironment of the sleeping infant inside the baby cot, and one measuring point is applied to measure the general IAQ condition of the bedroom. In both daycare centers the measurements had a duration of one workweek.

RESULTS

Daycare center 1 was equipped with a CO_2 based demand-controlled ventilation (DCV) system and daycare center 2 with a natural ventilation system. The measurements showed that the DCV system provides a much better IAQ than an natural ventilation system. In daycare center 1 the CO_2 concentration fluctuated around 550 ppm during occupation, with some incidental outliers. In daycare center 2 the CO_2 concentration showed a continuous increase in CO_2 during occupation (Figure 1). So the CO_2 concentration in daycare center 1 is rather stable, where the CO_2 concentration in daycare center 2 covers a wide range (Figure 2).

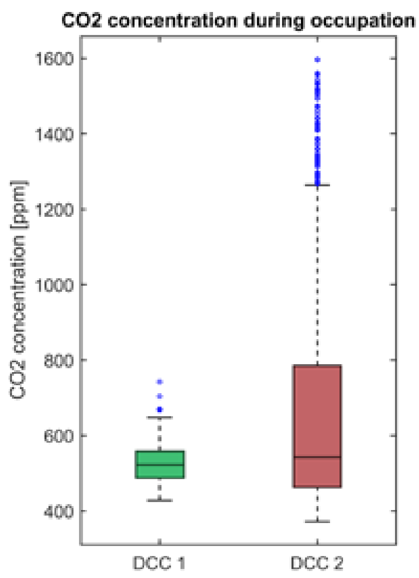


Figure 2. CO_2 concentration boxplot of general condition in both daycare centers while the beds are occupied

Daycare center 1, with a mean CO_2 concentration in the vicinity of the sleeping infants of approximately 550 ppm, was classified as 'Good' according to the Dutch Public Health Services. Daycare center 2, with a mean CO_2 concentration in the vicinity of the sleeping infants of approximately 900 ppm, was classified as 'Very Poor'.

CONCLUSION

Compared to previous researches done in the Netherlands, both daycare centers performed better than the average daycare center in the Netherlands. However, the IAQ of daycare center 2 is still inadequate. The high CO_2 concentrations inside the microenvironment of the baby cot are not caused by the confined space of the baby cot, but are caused by the ventilation rate of the entire bedroom. Therefore the performance of daycare center 1 is much better than daycare center 2 because the installed CO_2 based DCV system guarantees a sufficient ventilation rate while the natural ventilated ventilation system was uncontrollable. ■

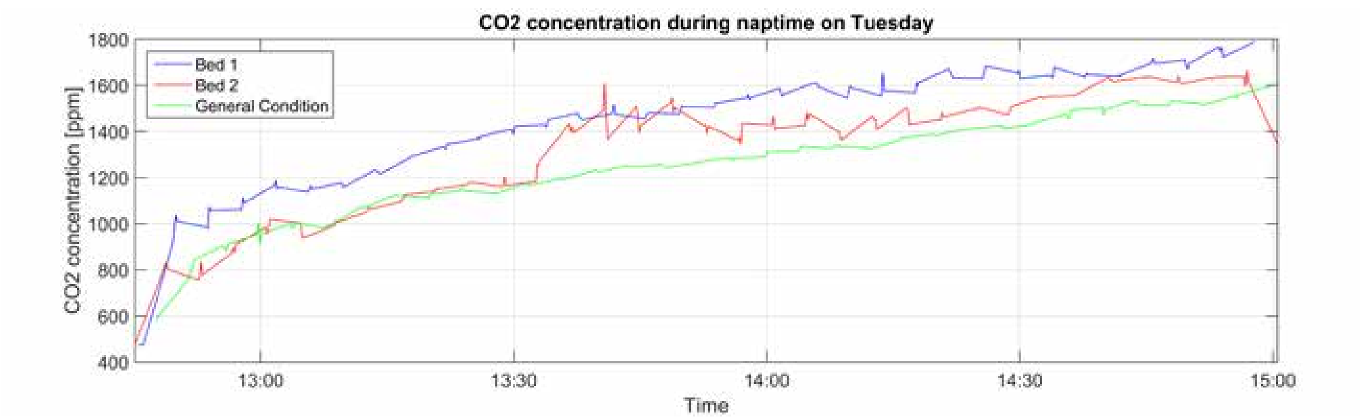


Figure 1. CO_2 concentration during naptime in daycare center 2 on Tuesday (09-06-2015)

Mollier Calendar
Past events

JUNE

LUNCH LECTURE #4

The fourth and last lunch lecture of the previous academic year took place in June. The guest speakers were Bastiaan Beerens from Deerns and Larren van Meeteren from Cofely. A special Lunch Lecture with not one but two main sponsors. An interesting combination with on the one hand the building physics side from Deerns and on the other hand the installation (services) side from Cofely.

END ACTIVITY

The yearly End Activity took place from 5 to 7 June. As usual the destination was kept top secret until departure, upon which all 34 participants were told to hitchhike to Bruges in Belgium. Saturday's activity was centered around a lake, where we had to build rafts as teambuilding and this teambuilding was continued later at night. The last day people had time to leisurely explore Bruges until the weekend came to an end later that day. We want to thank Foamglas for making this activity possible.

SEPTEMBER

SUSTAINABILITY BRAINSTORM WITH TECHNIPLAN

Under the guidance of sustainability consultants Techniplan invited Mollier – tomorrow's engineers – to give their vision towards energy-neutral building environment. During this event problems were analyzed and a common vision was formulated, thus inspiring both parties and evoke new practical insights.

CONSTITUTION OF THE 20TH BOARD OF MOLLIER

Wednesday 30 September the board of Mollier changed when the 20th board was constituted. After the general meeting of members the constitution drinks took place followed by a dinner with all Mollier members and former members.

OCTOBER

START ACTIVITY

The start activity of this academic year was held in the third weekend of October. A yearly activity where new and old members of Mollier go on a city trip to get to know each other better. At noon Friday the members gathered and where put as random groups in a car to Leuven, Belgium, which was the destination for the weekend to where the members went. That evening there was dinner and billiards in a pool center where different teams competed. The following day the city was explored, maybe more than preferred on the way to a bowling centre. Luckily, the local brewery and restaurant were easily found. The next day the weekend came to an end with a game of city golf.

NOVEMBER

LUNCH LECTURE #1

The first lunch lecture of the academic year was held by Valstar Simonis. In their presentation Ellen Boesten presented the company and some of their projects. She also told about her experience about work after graduation. Johan Groeneveld presented a large project consisting of BIM and installation design.

NOVEMBER

TVVL 'SMART CITIES EVENT'

In November TVVL sposored some members of Mollier to go to their 'Smart Cities Event'. There the members attended a lecture by Jeremy Rifkin and wrote their newly obtained perspectives for columns in the TVVL magazines.

BOWLING NIGHT

An interesting bowling night with other members of Mollier for relaxation and fun. Some members were even that enthusiastic that they went on for an extra hour!

OPENING LUSTRUM EXPOSITION

The fourth lustrum of Mollier is upon us! The study association Mollier was founded in 1996, thus turning 20 this year. "20 years Mollier" is therefore the title of the exposition about Mollier that marks the start of this celebratory year. The exposition was opened with a drink and could be seen on Plaza, Vertigo, from the 19th of November until the 6th of December. The exposition exhibited pictures and anecdotes of the many committees that contributed to Mollier these past years.

DECEMBER

LUNCH LECTURE #2

At the second lunch lecture hosted Stabiplan and KP&T presented their organizations. KP&T presented their views on connecting students to companies and gave some helpful tips about soliciting for jobs, internships or graduation projects. Stabiplan is a developer of innovative design software for the installation industry and talked about their view on design software and BIM.

ARCADIS IN-HOUSE DAY

An interactive and interesting day where members of Mollier visited the workplace of Arcadis to meet employees and students from other schools and universities. This day was filled with presentations, a site visit and a case study.

Upcoming events

FEBRUARY

MEET & GREET

An afternoon with elevator pitches of all individual sponsors followed by the Meet & Greet where students and sponsors have the opportunity to get to know each other and discuss possible projects, internships or (part time) jobs.

COCKTAIL PARTY

The third edition of the cocktail party will be held in February after the great success of the first two editions. Interested in what kind of creations the committee will serve? Find out in February!

LUSTRUM GALA

Study association Mollier turned 20 this year. To celebrate this lustrum members and alumni of Mollier are invited to the 4th Lustrum Gala including dinner and drinks. The dress code for the evening is 'purple tie' and we hope to see you all on the 20th of February for an unforgettable night!

MARCH

HEIJMANS MASTERCLASS

From 16 till 18 March Heijmans organizes a masterclass where you can meet Heijmans during several activities and case studies. This year the masterclass has the theme 'Robots in de bouw'. Interested? Register before Januari 15th!

MAY

STUDYTRIP 2016

Some of the Mollier members could not get enough of carnival, therefore, the destination of the study trip 2016 is Brazil. Twenty members of Mollier will visit companies, projects and culture in Rio de Janeiro and Sao Paulo.

TBA

LUNCH LECTURES / END ACTIVITY / EXCURSIONS

Ice Breaker

Marissa Vos

Hi, my name is Marissa Vos. I live in Eindhoven for almost 3,5 years, but grew up in Grijpskerke. Where? Just a little place near Middelburg in Zeeland. I am 21 and have one older brother, who is 5 years older than me. My mom and brother still live in Zeeland, but moved to Veere. My dad lives in Ameide, a little town close to Utrecht. My youth wasn't really special, as living in Zeeland can be a little bit boring, but I can't complain with living only a few kilometers from the beach. When I graduated from high school, I really didn't know what I wanted to study. My interests differed between medicines, civil engineering, innovation sciences and like ten other studies. So it took a while before I decided to study 'Architecture, Building and Planning' on the TU/e. When I started, I never wanted to become an Architect and liked the more technical side of building engineering. So eventually I chose the track for building physics and after 3 year of studying, I started my master Building Physics and Services this September.

When I was younger, I just walked around in cities and wonder how things were made and planned. But I always thought I liked the construction of buildings and bridges more than the other aspects of the build environment. Eventually, I found out that my interest are more in combining user aspects with high quality buildings and looking at the physical aspects of these buildings. It took some time before I found out, but eventually it has been the best choice.

Before I lived in Eindhoven, I played soccer for almost 6 years. When I came here, I started dancing, but eventually it took too much time and nowadays I only take group lessons at the sport center. Sometimes I try to go running in the morning, but most of the time, my bed is way too nice. Next to sports, I like to paint and be creative. Often, I just get some inspiration and start to make a painting or sculpture. This same inspiration can come for cooking. I really love to cook and try out new recipes or just create something new out of left over ingredients. I also like to bake, but unfortunately I just found out that I'm allergic for chocolate, so I can't make my delicious white chocolate cheesecake anymore.

I love to make pictures, but when I'm traveling you could only see me with two things, namely my Iphone and my analog camera. I often use my Iphone for quick pictures, but really like to take pictures with easy analog cameras, also known as Lomography. I really like to work with rolls of film, because of the surprising effect of the pictures. You can't see what is on the picture, until you develop them and the picture can be really different from what you expected it to be. This is also a thing I really like in buildings, as the outside of a building can be completely misleading for the inside interior of a building. I also love to travel and I often try to make some short city trips over the year. I just went to Istanbul in the weekend of the examination week and just at this moment I'm planning a trip to Marrakech with some friends during spring.

Next to these creative things, I just like to be busy. I do some committees at my student association and I do a lot of part-time jobs. I'm always in for a drink or some socializing, but I just have to get to know you better before I will spontaneously talk to you. So next time you see me, just feel free to say hi and maybe we could drink some coffee one day. ■

Guiding the cloud

Optimizing the Total Energy Consumption and CO_2 Emissions by Distributing IT Workload Among Worldwide Dispersed Data Centers

Author
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Ing. V. (Vojta) Zavrel, Ing. T.F.W. (Tom) Hundertmark

ABSTRACT

Major internet service providers have built and are currently building the world's largest data centres (DCs), which has already resulted in significant global energy consumption. Energy saving measures from chip to building level have been introduced gradually in recent decades. However, there is further potential for savings by assessing the performance of different DCs on a wider scale and evaluating information technology (IT) workload distribution strategies among these DCs. This paper proposes a methodology to optimize the electricity consumption and CO_2 emissions by distributing IT workload across multiple imaginary DCs. The DCs are modelled and controlled in a virtual test environment based on a building energy simulation (BES) tool (TRNSYS) and a controller tool (Matlab) is used to support testing and tuning of the optimization algorithm. A case study, consisting of the distribution of IT workload across four different types of DCs in multiple locations with different climate conditions, is presented. The case study will illustrate the efficiency of the approach proposed in this paper.

INTRODUCITON

In 2013, the electricity demand by IT systems approached 10% of world electricity generation (Mills, 2013). The demand for IT workloads, e.g. storage, network, and computation, is increasing rapidly (Rao et al., 2012). As these IT workloads become larger, DCs' electricity consumption shows a corresponding increase. The DCs' electricity consumption and the energy sources used to generate this electricity greatly influence the carbon footprint of a datacentre (Oró et al., 2015). A decrease in the electricity consumption and carbon footprint could be obtained by equipping DCs with renewable energy sources (RES).

The main objective of this research is to identify the potential reduction in electricity consumption and CO_2 emissions by distributing the IT workload among geographically dispersed DCs around the world. This principle will be referred to as 'Guiding the Cloud'. In order to obtain an answer to this objective, a literature review is performed. The next step is to define an evaluation method to assess the performance of 'Guiding the Cloud'. Simulation based assessments can support the testing of early stage DC operation strategies, avoiding the safety and economic risks derived from real testing in physical DCs. Building Energy Simulation (BES) tools, based on a white-box modelling approach offer a suitable platform for the development of virtual test environments. Numerical models of different typologies of DCs (i.e. different geographical locations, cooling systems and on-site RES)are developed to achieve a sufficiently heterogeneous case study for the testing and tuning of the first prototype of the 'Guiding the Cloud' algorithm. Thus the potential of an optimal IT workload distribution at the wide world (cloud) level can be assessed. Figure 1 presents an impression of the concept 'Guiding the Cloud'.

GUIDING THE CLOUD

The original principle of 'Guiding the Cloud' is based on a collaboration between the building, power, and IT management systems to establish an optimum IT load distribution in an appropriate time (Deerns, 2012). A numerical model of a DC can be obtained by combining the measured performance data and weather data. Using the weather forecast and predicted IT workload as an input, the performance of this DC can be modelled. Based on this information, IT workload can be scheduled via the IT management system in such a manner that minimal energy consumption is needed. If the goal would be to optimize other performance indicators than electricity consumption, additional information from other sources could be used. For example, including the electricity contract enables to minimize the electricity costs. Or, by predicting the availability of different systems, the maintenance and IT workload schedule can be configured to maximize the reliability of the DC. Besides the collaboration between management

Figure 1. Impression of the concept of 'Guiding the Cloud'

Systems, as described above, another important element of 'Guiding the Cloud' is the focus on multiple DCs at the same time. To be more specific, DCs are increasingly operating worldwide with activities dispersed globally. To support these worldwide activities, often multiple IT resources are geographically scattered. The use of these IT resources would be more beneficial, if worldwide IT resources were globally integrated by virtualization techniques, whereby the surplus of the IT resources could be used by another location (Stanoevska-Slabeva et al., 2010). Considering multiple DCs, as such, would enable a global optimization of the DCs' performance.

ASSESSMENT METHOD

A virtual environment is developed to assess 'Guiding the Cloud' control algorithm. The method presented in this paper consists of a simulation and prediction model.

The simulation model represents a virtual test environment of DCs that generates the performance indicators needed for an early stage assessment of the 'Guiding the Cloud' control algorithm. It is a physics-based (white box) model developed by a BES tool (TRNSYS), and it is used firstly for an identification of prediction model and then for the final evaluation of the GtC control concept.

As part of the prediction model, the controller requires fast response in order to evaluate a large number of alternatives for the optimization of the chosen objectives. Based on this requirement, simplified data-driven (black-box) models were selected. Figure 2 shows the different models involved in the process as well as their function.

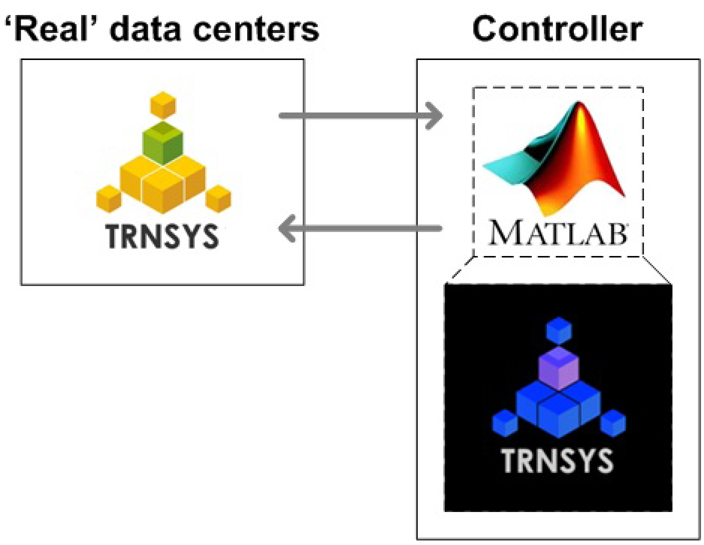

Figure 2. Schematic representation of the test environment consisting of the 'real' DC models (TRNSYS) and the controller (Matlab) during simulation run-time. The reference models resides inside the controller; communication inside the controller is based on Matlab scripts

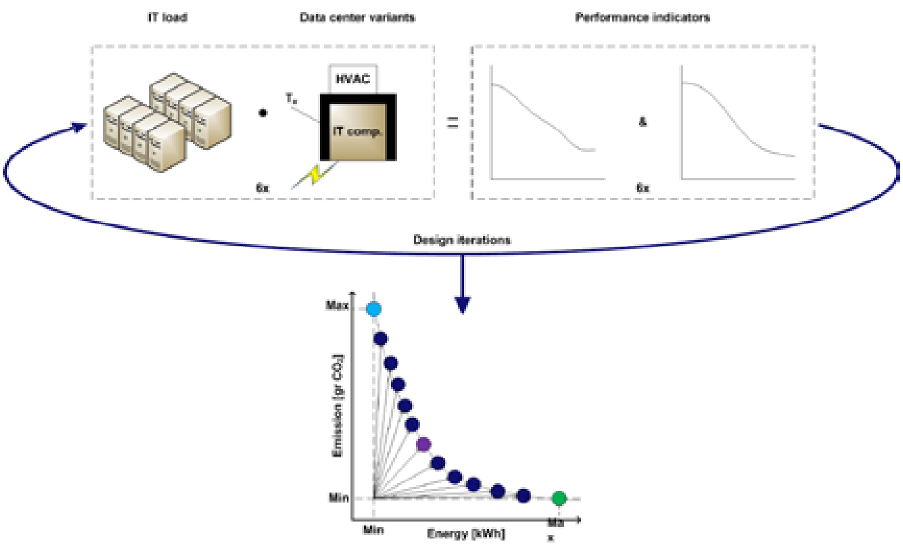

Figure 3. Schematic overview of the performance assessment methodology for 'Guiding the Cloud'

MODEL PREDICTIVE CONTROL

The algorithm developed in Matlab is based on model predictive control (MPC), that searches for the best control strategy using a data-driven model of the DC and its systems. The MPC algorithm follows the next steps:

1. Search for control strategies with respect to predetermined boundary conditions and predict the performance of 'Guiding the Cloud' using the control strategy.
2. Select an optimized control strategy.
3. Shift a control sequence forward and update the boundary conditions
4. Start again with step 1 until the total number of control sequence variants have been executed.

The quality of the black-box model influences the quality of the MPC's control sequences.

Schematic overview

Figure 3 presents the method of 'Guiding the Cloud' to optimize the performance indicators by varying the IT workload's distribution sequence over different DCs. The optimization process considers multiple solutions by altering the control strategy of the IT workload. When the Pareto Front is found, the decision maker selects the control strategy.

Multi-objective optimization

In this research, the multi-objective optimization is performed over two objectives, electricity consumption and CO_2 emissions. At first, these objectives appear complementary rather than conflicting, because a decrease in electricity consumption should result in a lower exhaust of CO_2 emissions. However, when IT workload is distributed to another DC due to a higher energy efficiency, it is possible that the CO_2 emissions increases when the other DC uses relatively more CO_2 in generating the net electricity.

Decision maker

The algorithm optimizes the objective values by varying possible distribution strategies. The results of the algorithm leads to a Pareto front with optimal distribution sequences. The selection of the final distribution sequence depends on the preference that is given to the objectives (i.e. CO_2 emissions and electricity consumption). In this assessment, the minimum solution of the first objective, the minimum solution of the second objective and a trade-off solution are selected to examine the savings potential of 'Guiding the Cloud'. Figure 3 illustrates the selected solutions in the Pareto Front.

Figure 4. The case study implemented in the simulation and prediction model

VIRTUAL TEST ENVIRONMENT

The virtual test environment for 'Guiding the Cloud' is created in TRNSYS and is used to simulate the energy consumption and CO_2 emissions of different typologies of DCs described in the case study and IT workload.

Case study

A case study is created to examine the potential of 'Guiding the Cloud'. It includes six imaginary DCs located around the world with different climate and time zones, HVAC and renewable energy systems, and electricity net conversion factors to emissions (Table 1).

The servers in these DCs are interconnected by an internal and external dedicated network. These IT components (e.g. hops) consume electricity while processing and distributing data. The data's distribution time to travel from one DC to another is ignored, to analyse the potential of 'Guiding the Cloud'. Figure 4 illustrates the case study that is developed in the simulation and prediction model to examine the potential of 'Guiding the Cloud'.

IT WORKLOAD

The IT workload processed by the DCs is characterized by three input parameters, namely (1) input data, (2) CPU processing time, and (3) output data. The CPU processing time and output data are assumed to be dependent on the input data.

The IT workload data consists of a combination of fixed and variable IT workload. The fixed IT workload represents the IT requests that should be done locally, while the variable IT workload can be distributed among the other DCs. When IT workload is distributed from one DC to another DC, the amount of input data changes, which results in a change of the CPU processing time and output data.

A predefined daily profile of the IT workload will be used and will be shifted in correspondence with the time zones.

Table 1. HVAC systems and RES assigned for each location

Locations	HVAV systems	RES
Sacramento	Chillers and dry coolers	PV Panels
New York	Indirect evporation cooling unit	-
Madrid	Indirect evporation cooling unit	PV Panels Gas turbine
Bergen	Sea water absorption cooling	Wind turbines
New Dehli	Chillers	Wind turbines PV Panels Bio gas turbine
Sydney	Chillers	PV panels Bio gas turbine

PERFORMANCE COMPARISON

The data simulated by TRNSYS is used to train the surrogate black-box models in Matlab and then the overall model-based controller is embedded into the TRNSYS environment so the influence of 'Guiding the Cloud' concept can be evaluated by comparing with a baseline scenario.

Simulation steps

The performance comparison consists of the following four simulation steps:

1. Gain results from the 'real' DCs in TRNSYS using the predefined daily IT workload profile.
2. Characterize state space models based on the results in the previous step.
3. Integrate the state space models in the MPC, search for optimized distribution sequences and select a distribution sequence.
4. Gain results from the 'real' DCs using the selected distribution sequences.

The results from step 1 and 4 are compared using three different decision makers by presenting the savings of the electricity consumption and CO_2 emissions.

RESULTS

As presented in Figure 5, using the decision maker (coloured as yellow) for selecting the distribution strategies results in savings of the electricity consumption and CO_2 emissions with 3.0% and 15.5% respectively. Selecting the minimum values for the electricity consumption from the Pareto solutions (coloured as blue), results in a decrease of 0.6% for the total electricity consumption and a decrease of 0.7% for the total CO_2 emissions. Selecting, on the other hand, the minimum values for the CO_2 emissions from the Pareto solutions (coloured as green), results in a decrease of 17.0% in CO_2 emissions. The electricity consumption has been decreased with 2.5%. When the best results are converted from a percentage, a maximum reduction of 5,108 kWh and 13.2 ton CO_2 is achievable.

Observable is that applying the electricity consumption's minimum values do not result in a maximum reduction in electricity consumption. This can be explained by selecting a distribution sequence will influence the future distribution sequences. In this case, the influence of the decision-making resulted in a negative way. Overall, the results show that by applying 'Guiding the Cloud' it is possible to reduce the energy consumption and CO_2 emissions of the case study. The case study that is used in this research indicates a maximum reduction of 2.5% in total electricity consumption and 17.0% in total CO_2 emissions.

CONCLUSION AND FUTURE RESEARCH

In this research, the potential of distributing IT workload among geographically dispersed DCs is investigated. The main objective is to examine its (possible) effect on reducing the total energy consumption and CO_2 emissions. The preliminary results indicate that a reduction in total energy consumption and CO_2 emissions is achievable. Savings of the total electricity consumption and CO_2 emissions can be up to 3% and 17.0% respectively.

In future research, the concept presented in this research could be extended with a time delay when IT workload is distributed from one DC to another. Besides the time delay, other relevant aspects can also be included, such as maximizing or setting boundaries for the reliability or minimizing the energy costs using spot pricing markets of the DCs. Another interesting concept is to combine a local and a global optimization. The local optimization will internally schedule the IT workload while the global optimization distributes the IT workload among the geographically dispersed DCs. ■

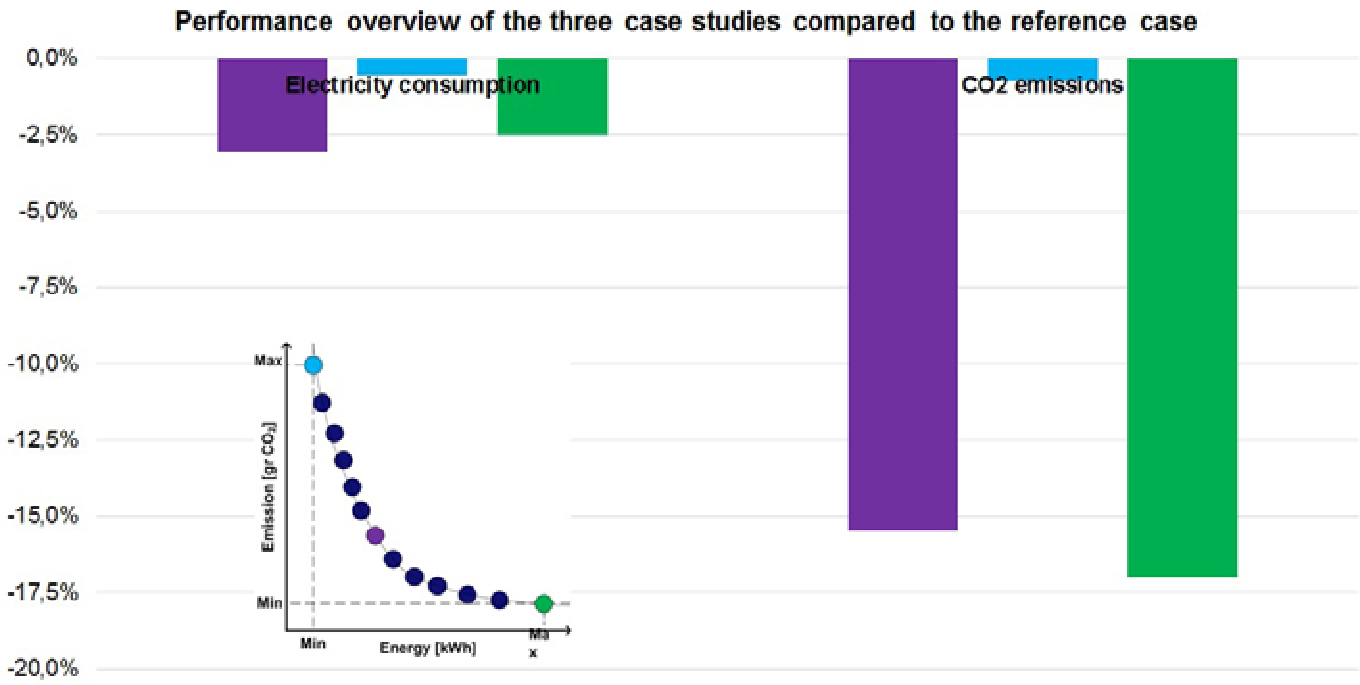

Figure 5. Performance overview of the results of the total electricity consumption and CO_2 emissions for 1 day

[1] Deerns 2012. Deerns Sets the Standard for Chasing Energy Reduction in Cloud DCs. Inside Networks. February, 2012.

[2] Mills, M.P. 2013. The Cloud Begins With Coal, Big Data, Big Networks, Big Infrastructure, and Big Power.

[3] Oró, E., Depoorter, V., Garcia, A., Salom, J. 2015. Energy efficiency and renewable energy integration in data centres. Strategies and modelling review, Renewable and Sustainable Energy Reviews, Vol. 42, pp. 429-445.

[4] Rao, L., Liu, X., Ilic, M. D., & Liu, J. 2012. Distributed Coordination of Internet DCs Under Multiregional Electricity Markets. Proceedings of the IEEE, Vol. 100(1), pp. 269-282.

Kuijpers

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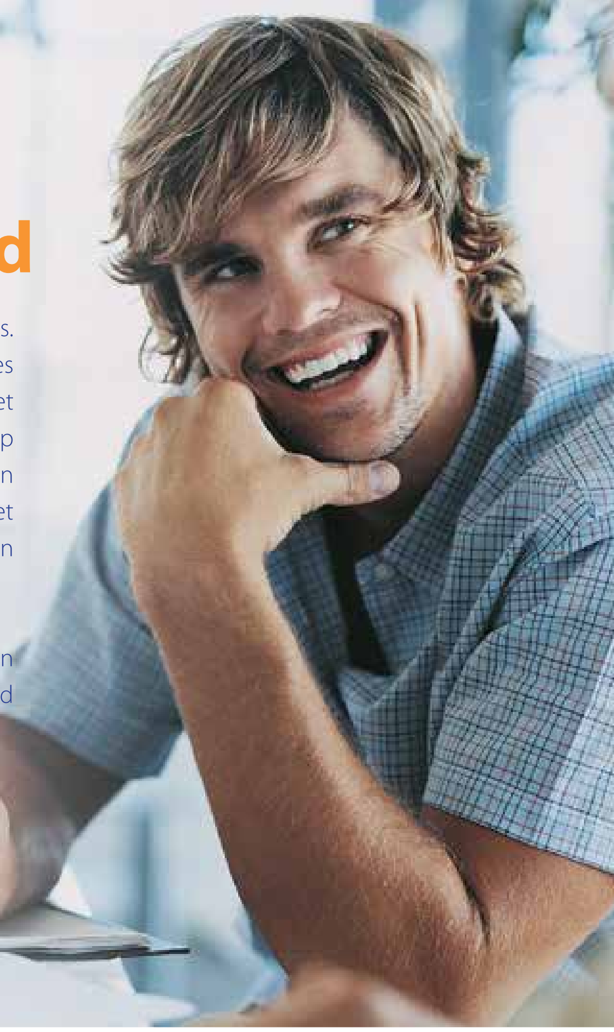

Kuijpers is een professionele technisch dienstverlener met ruim 800 medewerkers. We verzorgen het ontwerp, de bouw en het onderhoud van technische installaties in gebouwen en industrie. De wensen en mogelijkheden van onze klanten zijn het uitgangspunt voor onze technische oplossingen. We richten ons daarbij met name op functionaliteit en prestaties. Met een compleet concept en verschillende specialismen in huis, kunnen we onze klanten goed bedienen. Vanaf het begin van het proces tot het einde. En ook daarna nog. Kuijpers is een familiebedrijf, waar echte mensen werken aan echte oplossingen.

Een persoonlijke band met onze medewerkers en relaties staat daarbij voorop. Samen ontwikkelen we ons. Om zo het beste in elkaar naar boven te halen. In een betrokkenheid die leidt tot resultaat.

Kuijpers biedt mogelijkheden voor traineeships, afstudeeropdrachten en stageplaatsen. We hebben bovendien vele uitdagende functies beschikbaar. Nieuwsgierig? Kijk op:

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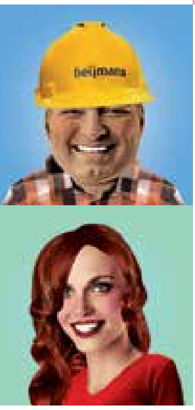

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Study abroad

Anne van Heijst in Göteborg

Hej!

After four years of studying at the Eindhoven University of Technology I thought it was time for something else. Going abroad seemed like a really nice variety for my study and a good chance to get to know another country and university. That's why I am taking this time during my master and had a look at the possibilities. The TU/e has a wide range of universities for an exchange period and I started by filtering this list looking for universities that have English spoken masters and courses that matched my interests. This way, I soon found Chalmers University in Göteborg, Sweden, because of their good technical education and made the decision to study there for the autumn semester.

At the end of August the time finally came to move to Göteborg. The first week we had a really nice introduction week where I met a lot of different international students from all over the world by doing different activities to explore the city and the Swedish culture. However, after this week it was time to get serious and start at Chalmers University. Immediately it was obvious how well everything is organized and courses were introduced extensively. Unfortunately this also meant days from 8:00 to 17:00 five days a week, so sleeping in is not an option here. Fortunately during these first weeks also a lot of fun activities were organized like international dinners and a traditional sauna trip.

Now, after more than two months I am settled in and used to all strange Swedish habits, like queuing everywhere, microwave walls for warming your homemade lunch and waking up early. In addition I also gathered a nice group of international friends with whom I explore the city and surroundings with activities ranging from barbecuing at the Delsjon lake to a hiking trip to Norway. Although the days now start to be really short and the weather get worse I am still not bored and will enjoy the next coming months. ■

Satisfying dimming speed in an open-plan office

Author
C.S. (Charlotte) Rosenkotter
Supervisors
Prof. Dr.-Ing. A. Rosemann (TU/e)
S. Chraibi MSc (Philips)

INTRODUCTION

Nowadays a better indoor environment in office building becomes more important. Different parameters, such as co-workers' mood, wellbeing, task performance and work engagement are linked to indoor lighting conditions. [1]

In open-plan offices, workers have to share the possibilities of having control over the physical aspects, however people might prefer a different comfort level than their neighbours. Currently available intelligent lighting systems have integrated occupancy and daylight sensors, offering the ability to have granular dimming in the office space. Each luminaire is capable to detect and respond independently to people's presence at their workplace.

LITERATURE

The focus in this research is to find the most optimal fading time of a granular lighting system in relation to the wellbeing of the co-worker in an open office, triggered by a change in occupancy level; i.e. someone enters or leaves the office. However this is a validation study, were earlier obtained results will be validated with participants between 30-50 years. By making use of an older age group, we get closer to the average age of the working by closing population (25 to 67) in the Netherlands. Furthermore, the lens of the eye of older people will change due to the aging process. Therefore, the influence of light sensitivity will be higher, which can lead to difficulties to observe different light changes. Moreover if a person gets older the amount light intensity of lux for the same task will increase.

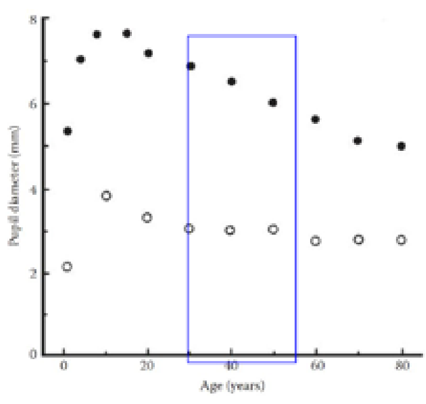

Figure 1. Maximum (black dots) and minimum (white dots) pupil diameters as a function of age [2]

Figure 2. Overview office laboratory, experience lab of Philips at the High Tech Campus in Eindhoven

METHOD

The Experience Lab of Philips at the High Tech Campus in Eindhoven is used for the experiment, see figure 2. Daylight is excluded in the study the blinds. The experiment took place only in the morning. The participants (N=17) were employees of Philips and were asked to perform an office based task. Moreover 8 actors have also participated in the experiment; they are students from the Eindhoven University of Technology.

During the task occupancy changes were simulated at one of the workstations by the actor entering and leaving the office at specific moments, the lighting requirements are changed at the same moment.

Participants were asked to press a red button on their screen when they noticed any changes; i.e. temperature, ventilation, sound, light, odour, occupancy or other. For each indicated change the participants had to rate how acceptable the change was to them.

ANALYSIS

For data analysis, software IBM SPSS Statistics Release 22.0.0.0 has been used (significance level is 0.05). To accept the hypotheses, the Wilcoxon signed ranks test is used. This test is a nonparametric test to evaluate the difference between two conditions where the samples are correlated.

RESULTS

Figure 3 shows a minimum of 70% acceptance level for all lighting conditions; this level is the result of the rate acceptance divided in 'acceptable' together with 'very acceptance' and the rate 'not noticed'.

The most optimal fading time in an open office for people between 30-50 years is found to be 2 seconds for as well dimming up as for dimming down lighting conditions. This was expected in relation to the younger age group of previous study. ■

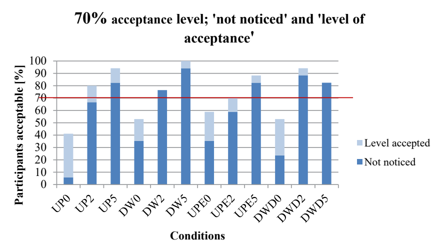

Figure 3. 70% acceptance level split up into 'level accepted' and 'not noticed' for all lighting conditions for dimming up and downs

[1] Borisuit, a., Linhart, F., Scartezzini, J.-L., & Münch, M. (2014). Effects of realistic office daylighting and electric lighting conditions on visual comfort, alertness and mood. Lighting Research and Technology.

[2] Weale, R.A., A Biograhy of the eye: Development, Growth, age, H.K. Lewis, London, U.K., 1982

The most economical swimmingpool in the Netherlands

Author
Deerns

Just opened: the most sustainable and energy-efficient swimming pool in the Netherlands. Right down to the smallest details, the new 'Noorderparkbad' swimming complex reflects the sustainability ambitions of our client, the City of Amsterdam, Northern District.

Its energy and water consumption is more than 80% lower than in the former 'Floraparkbad', partly thanks to the sophisticated MEP design by Deerns, in which solar energy and the reuse of water and heat are central. "In the new pool we are saving a couple of hundred thousand euros a year on energy and water charges," notes Building Manager Sjaak Huijsman of Projectmanagementbureau Amsterdam, which has overseen the project from beginning to end.

Over four years Sjaak Huijsman has sat down with architects, advisors, builders and maintenance specialists to ensure the design and realisation process was on the right track. The commission he was given by the district was challenging, to put it mildly. The new swimming pool had to attract far more visitors (300,000 to 350,000 a year) than the old one (200,000 to 250,000 a year), and it also had to fulfil extremely high demands in terms of sustainability and energy-efficiency, without detracting from user comfort. The sustainability also had to be visible and tangible in the architecture and materials, both inside and outside.

MAJOR SUPPORT FOR SUBSTANTIAL INVESTMENT

The ultramodern Noorderparkbad swimming complex, marks the entrance to the Noorderpark, right next to the former Floraparkbad which is awaiting demolition. Faded glory is making way for the future. Huijsman believes the transition comes not a day too soon. The antiquated, shabby and energy-guzzling Floraparkbad was in serious need of replacement. After an extensive location search, in which many options were considered, the outdoor pool area of the old swimming complex was ultimately decided on as the most suitable location for the new build.
"Because there was a really major need for a new swimming pool, there was also major support for investing substantially in it," explains the Building Manager. "The Noorderparkbad is certainly not a cheap swimming pool (it cost some 16 million euros to build). The district management had to make some tough choices at the time. After all, the extra money for the swimming pool could not be spent on other things. The clear choice the politicians dared to make here really deserves a serious compliment." The building management then made these lofty ambitions SMART by translating them into a concrete Statement of Requirements for the parties tasked with realising the project. Certainly the sustainability and energy-efficiency requirements didn't pull any punches: compared to the old swimming pool, an energy and water consumption reduction of 75% had to be realised.

NOT A DEGREE OF HEAT WASTED

With the LTEC (Long Term Energy Calculator) simulator it has developed itself, Deerns first tested the various architectural and technical possibilities for their contributions to the sustainability ambitions. The calculations were then translated into an actual design, in which an entire range of measures determine the sustainability and energy-efficiency. Among other things these include the thick insulation, triple-glazing in the outer walls, photovoltaic panels and solar heating domes on the roof, high-yield air handling in the swimming pool areas, the building's compactness, the south-facing orientation of the swimming pool areas, and the smart layout, where the warm swimming pool areas are surrounded on three sides by on three sides by other areas which act as extra insulation.

Not a degree of heat is wasted in the pool. Thus the hot air in the pool areas (at least 27°C), via a high-yield (82%) air handling installation especially developed for swimming pools with an integrated heat pump and a high-efficiency heat exchanger, and after dehumidification, is returned to the areas and the swimming pool installation. The heat from the waste water from the showers is also collected and reused. All the areas are illuminated with dimmable LED lighting.

"JUST DO IT"

The building design and systems yield an overall energy saving of more than 80%, even higher than requested. Water savings arising from rainwater collection and reuse are also more than 80%, or many tens of thousands of litres a year. This means the city district is saving a couple of hundred thousand euros a year on energy and water costs. The extra costs incurred in the sustainable building design will be recovered in 20 years. Huijsman: "The measures we have taken here certainly cost a heap of money, but ultimately much less than they will return. It's actually a no-brainer: you just need to do it."

TOTAL MEP DESIGN AND SPECIFICATIONS

Deerns was responsible for the entire MEP design and specifications, the monitoring protocol for the use phase, and the maintenance specifications for the system. Deerns Project Manager Erik Stegers explains: "The guiding thread running through our MEP design was three-faceted: using the large roof surface area as much as possible for solar collectors, photovoltaic panels and solar heating domes, the greatest possible reuse of water and heat in the building, and installing LED lighting in all the areas. Taken together with the building design, these measures delivered the intended savings."

A significant saving factor is the compactness of the building. After all, the smaller the building, the lower its energy consumption. With the help of BIM (Building Information Modelling), the architect, the structural engineer and Deerns were able to make the best possible use of all functions and areas, and attune them to each other. The added value of this 3D design method was significant, according to Stegers. "Thanks to BIM we were able to design much better and more accurately, so that we could use all the spaces to the fullest and not a centimetre remained unused. Because you work visually with BIM, you get more to the heart of things with the architect and structural engineer than with flat working drawings. It simply works better and more effectively if you can see together just what the possibilities and results are."

CONSUMPTION IS CONSTANTLY MONITORED

The intended savings in the design are based on calculations and assumptions. Practice should show whether these are justified. To establish this, the energy and water consumption is constantly monitored – the first two years by Deerns and thereafter by the maintenance contractor. Meters have been installed for this in almost all the areas, all of them connected to the building management system.

Much will depend on the conduct of the pool staff and visitors. Huijsman: "Ultimately pool staff need to be aware of their responsibility for the energy and water consumption. How do they deal with the water? Could they not clean more often with the scrubbing machine rather than the hose? Are the doors perhaps open too long? Are the lights on too long? The visitors also bear their own responsibility. Perhaps they also need to adapt their behaviour, for example taking shorter showers than previously. We want to be absolutely sure that the design works, and that the savings we have agreed are actually achieved. If that's not the case, then we have to sit down together to consider why, and how we can fix it."

INTEGRALITY THE MOST IMPORTANT SUCCESS FACTOR

Despite the impressive savings, the complex has not been stuffed full of high-tech innovations. A conscious decision, notes Huijsman. "I didn't want any experiments. That's why only technologies have been used which have proved themselves in practice. Much more important for the result is what you do in the preliminary trajectory: the choice of the parties who must realise the project, the compact building design with as many windows as possible on the south side, pools surrounded by heated areas, a smart changing room system where we could save a third of our changing room area. There's no one single factor which plays first fiddle. It was the integrality with which the entire team worked on the project from the start, which has made this project a success."

Several weeks after the opening, Sjaak Huijsman and Erik Stegers were able to reflect on this unusual project with great satisfaction. "What I particularly appreciate was the integrality with which Deerns approached the project," notes Huijsman. "Naturally one looked emphatically behind the scenes at other parties, so that everything could be properly coordinated. That was not a simple task." Erik Stegers praises the enormous involvement of Huijsman in the progress of the project: "Sjaak was constantly on top of things, which ultimately benefited the quality, including for the user. Because ultimately it's all about a good building which functions well, which people want to come to and where they like to be. I think that together, we have succeeded well." ■

SUSTAINABLE AND ENERGY-SAVING MEASURES

- An energy roof with rainwater collection
- 750m² solar panels for energy generation (8.5% of the total energy consumption)
- LED lighting with daylight control
- Energy-efficient air treatment units with an integrated heat pump and high-efficiency heat exchanger (82% yield)
- Shower wastewater heat recovery
- Metal curtains as passive sun-blinds and visible rainwater collection
- Insulation: day Rc=6.9 (requirement: 3.5), outer walls: Rc=5 (requirement: 3.5), triple glazing: U=0.83, incl. frame (requirement: 2.2)
- Extensive energy-monitoring system.

Alumni at work

Author
Werner Willems

It is now 15 years since I graduated at TU/e. I was the 5th in the Netherlands with a Master's degree in Building Services. Something to be proud of. After a couple of weeks holiday I was able to work as a technician at an engineering firm. I was happy that I finally could go to work. I had studied long enough.

From technician I promoted via assistant projectleader to projectmanager. Starting from consultation with the customer to delivery I lead projects. Nice was also that the firm allowed me to do the acquisition process as well, at that age already.

More than 3 years later I asked my dad if I could come and work at his company. He had a technical consultancy and we found both it was time to switch jobs . My brother had already made the switch a few years before my arrival. At dad's office I learned a lot. Our agency was known for his elaborate designs. And if you are in such a nest, you will learn to design better by itself.

For several years me and my brother also had management tasks. We then made clear agreements who is responsible for what and what the role of dad would be. My brother and I retrieved the shares of dad's company at the end of 2009. We have clearly chosen the gradual, as in our business it's all about trust.

The name of our company is 'Willems technisch adviesbureau'. We help clients from all over Netherlands realize their wishes into a comfortable, secure and easytouse (work) environment.

The designs in the phase preliminary design is for me the most beautiful thing to do. In this phase we give structure for the requirements of the client to achieve in the final design. Nice to see is that upon completion of a project about 80% of which was designed in the preliminary design is really implemented. ■

Stichting
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De Stichting PIT zet zich in voor promotie en innovatie binnen de installatiebranche. Wij financieren projecten die in technisch, economisch of wetenschappelijk opzicht vernieuwend zijn. Dat doen we voor organisaties die zich zonder winstdoelstelling bezighouden met onderwijs en kennisontwikkeling in de branche. Denk bijvoorbeeld aan universiteiten en onderzoeksinstituten.

Zo draagt Stichting PIT bij aan het genereren van nieuwe kennis en innovatieve ontwikkelingen waarvan de gehele installatiebranche kan profiteren. Daarbij moet altijd sprake zijn van substantiële cofinanciering. Zo waarborgen we dat er binnen de branche draagvlak bestaat voor onderzoeken en projecten die door de Stichting financieel worden ondersteund.



CFD analysis of (TU/e) wind tunnel screens

Author
Rob Vervoort

Wind tunnels are currently applied in a broad field of research and can provide crucial information regarding the effectiveness of for example building, aircraft and car designs.

However, for the results of wind tunnel measurements to be reliable, it is required that the mean wind flow across the width of the test section is uniform and that the angularity is low. The turbulence is desired to be as low as possible. Several components are included in the wind tunnel circuit to address this aspect.

Because of the fact that costs of a wind tunnel are high, it is valuable to optimize the circuit, using Computational Fluid Dynamics (CFD), before realization. In this report, the effect of screens, which are positioned in the settling chamber upstream of the test section, is investigated by making a comparison of the turbulence intensity behind the screen between experimental data and simulations. Various approaches with different meshing techniques have been applied using the RANS method in combination with the Reynolds Stress Model (RSM) and enhanced wall treatment. In this case, eventually no reasonably good fit was found between the CFD simulations and experimental data.

Steady-state analysis is not able to predict the turbulence generation mechanisms, that are essential for the turbulence reduction of screens (e.g. vortex shedding of wires), in a good way. It is advisable to do further research with unsteady (transient) simulations because then these mechanisms can be modelled. Probably most effective is to perform the transient simulations using large eddy simulation (LES). In this case large eddies are resolved, the computational costs however can become enormous. ■

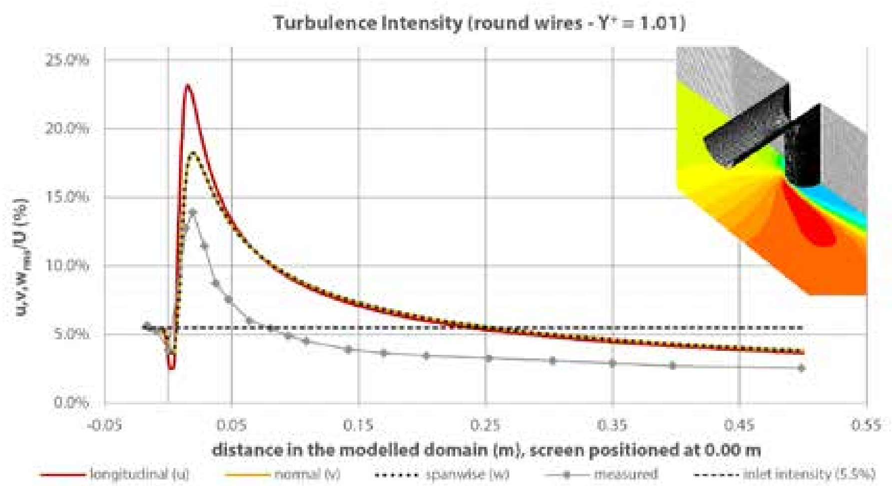

Figure 1. Turbulence intensity obtained from the screen with round wires in both directions (screen wire diameter = 1.0 mm - mesh length = 5.2 mm) using the RSM model in combination with enhanced wall treatment: Maximum at 3 x mesh length (Grid 895.447 cells)

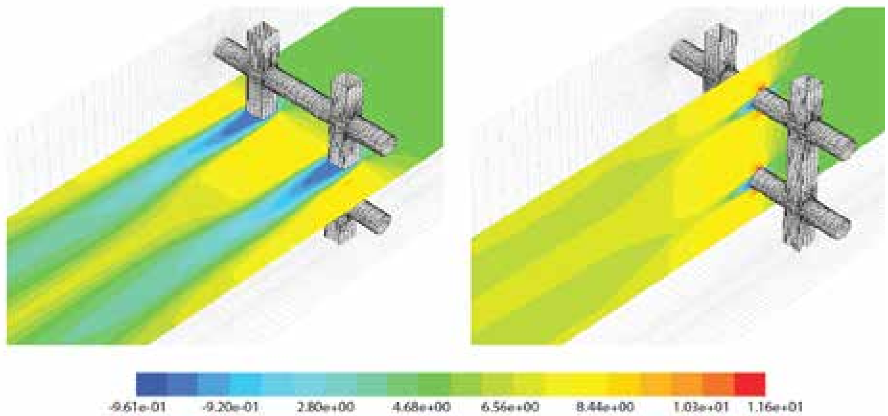

Figure 2. Contour plot of the velocity in the longitudinal direction downstream of rectangular (a) and horizontal wires (b) (screen wire diameter = 1.0 mm - mesh length = 5.2 mm)

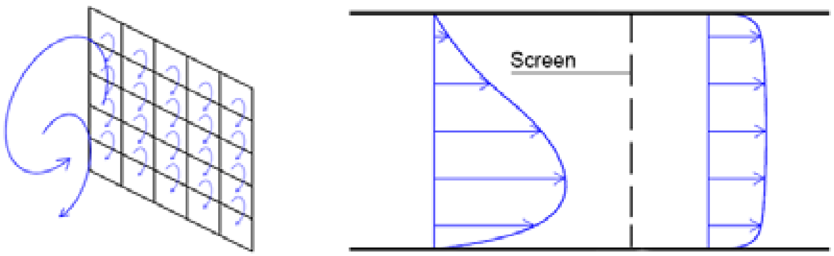

Figure 3. Principle of homogenizing the flow through a screen (a) and increased amount of uniformity of the wind flow due to application of screen (b)

Museums' indoor climate conditioning

preserving art, but at what cost?

Author
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The end of the year approaches at a fast pace. A period with deadlines and eventually concluded with a well-deserved holiday. During your leave, maybe, you'll visit one of the beautiful museums of the Netherlands, some of which are housed in state-of-the-art buildings, and some in appealing historical buildings. Nevertheless, after reading this article, you'll probably see the museum from alternative angles as you're used to: the museum indoor climate, intended to preserve artifacts and to provide comfort for visitors, appears to be very complex including many aspects, e.g. lighting (visual light and heat radiation!), air contaminants (extreme level of air filtration in many museums), temperature and humidity levels, and temperature and humidity fluctuations.

The competence group Building Physics of Monuments, leaded by dr.ir. Henk Schellen, focusses on research within the field of historical buildings and museums. Although this seems to be specific, it turns out to be a rather broad research area. Several PhD-studies are on-going of which some are focusing on object level, e.g. modeling of mechanical responses of materials and objects, some are focusing on the indoor climate and micro-indoor climate, and others focus on HVAC systems.

The project C4 (Clever Climate Control for Culture) focusses on energy conservation in museums while preserving, or even improving, collection conservation, building conservation (in the case of historical buildings) and thermal comfort, see figure 1.

As mentioned earlier, temperature and humidity levels and fluctuations are important aspects of a museum indoor climate. Indoor climate guidelines present several museum climate classes, e.g. ASHRAE presents class AA (very stringent), A (stringent), B (appropriate for most historical buildings), C and D, of which the latter two are not applicable for most museums. These guidelines, however, have been misused in the recent decades in the sense that the presented permissible fluctuations and levels were interpreted as prescriptive, instead of using the complete embedded knowledge as guideline. As a result, museums often chose the most strict indoor climate class assuming do the best thing possible, leading to excessive energy consumption, HVAC wear and condensation problems during the winter season. Some museums even act beyond the guidelines assuming that no fluctuation at all would be the best: 21°C / 50% RH all year round.

One of these museums was the Hermitage Amsterdam, housed in the building Amstelhof (1789 AD). The building was transformed from a nursery home to state-of-the-art museum in 2009 including powerful HVAC systems and aquifer thermal energy storage. However, after a few years of operation, the energy cost appeared to be tremendous, mainly due to the stringent indoor climate demands.

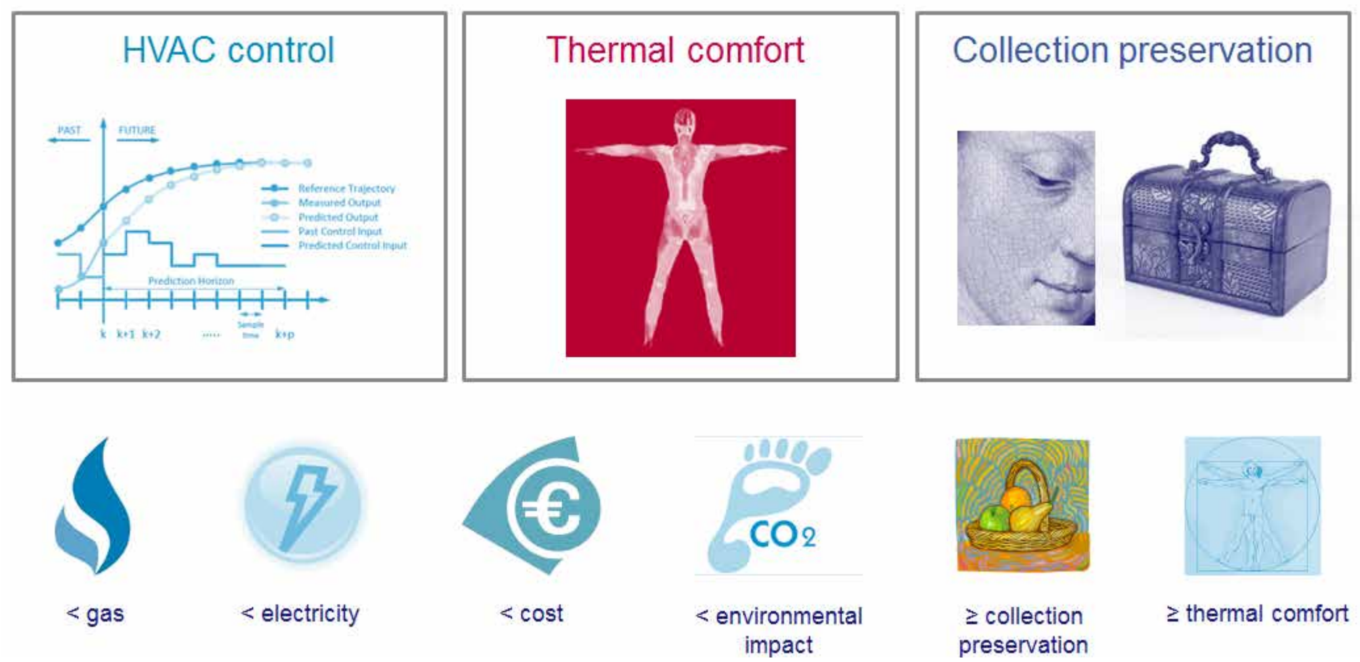

Figure 1. Project C4's main aspects and goals

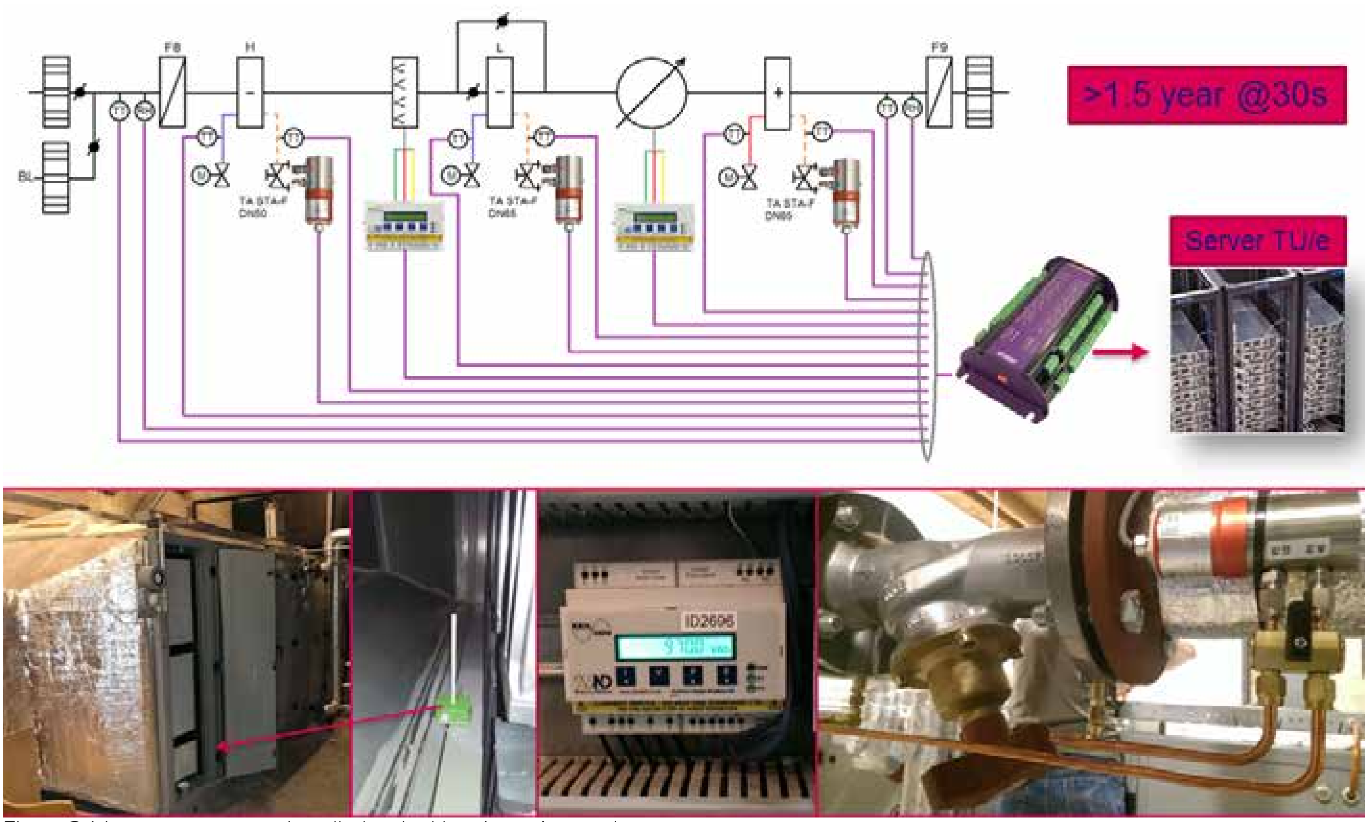

Figure 2. Measurement setup installed at the Hermitage Amsterdam museum

The Hermitage Amsterdam participates as a case study in the PhD-project C4. It is the first museum that allowed testing of different museum climate classes under full operating conditions, enabling us to study the energy consumption of the museum under different climate demands. To gain this insight, two measurement campaigns have been installed at the air handling units that condition the main exhibition spaces, see figure 2. The variables include air conditions (T and RH), water conditions of the heating and cooling coils (T and mass flow) and power consumption of the steam humidifiers and fans.

To exclude the effect of changing outdoor weather as much as possible, and other variable disturbances, the setpoints for T and RH were changed every week according to the following sequence: current situation (21°C / 50% RH), ASHRAE class AA (45-55% RH), ASHRAE class A (40-60% RH). Temperatures for classes AA and A were changed during the year. The measurements of the air handling units reveal significant energy savings for class AA compared to the reference situation (30-35%). Class A saves more energy than class AA compared to the reference situation (40-45%), but not twice as much, confirming the notion that relaxation of the indoor climate conditions follows the law of diminishing returns.

Besides the issues of excessive energy consumption and HVAC wear, the stringent indoor climate demand is also undesirable with respect to thermal comfort. Museum visitors often complain in museums that keep temperature at 21°C all year round: during winter it is slightly too warm, but during summer it is much too cold.

A survey study on thermal comfort has been conducted at the Hermitage Amsterdam museum for a period of one year. Each week, on one afternoon, 30 surveys have been collected, resulting in a total of 1250 surveys. For this study the indoor temperature was varied and the perception of the visitors was assessed. This enabled us to find the preferred indoor temperature (neutral) as function of the outdoor temperature, see figure 3. The work is still in progress. The temperature range between the lower and upper limit represents the 90% acceptance class. The lower limit is analogue to a PMV of -0.5 or 'slightly cool'. The upper limit is analogue to a PMV of +0.5 or slightly warm. Every point in the graph is the result of one day of surveys, i.e. the mean result of 30+ surveys. Until now, sufficient data is available to construct the neural line and lower limit, but data for the upper limit is still insufficient. Therefore, the upper limit is constructed, for now, by applying the same distance as the lower limit to neutral.

The range (neutral +/-1°C), is more stringent than previously expected: museum visitors often told us during the surveys that they were much more concerned about the conservation of the art and didn't expect to be very comfortable; thermal comfort experts often predicted that the temperature range could be large, because museum visitors do not have high expectations of the thermal comfort. However, the data refute these opinions. Actually, visitors did complain when the temperature was outside the presented range. If these temperature lines are completely validated, they can be implemented in the control algorithm for setpoint calculation.

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Importantly, these comfort limits are more stringent than the collection requirements for temperature. However, the comfort limits apply only during opening hours from 10 to 17h. In other words, during a period of 7 hours temperature setpoints are determined by the comfort limits, and for a period of 17 hours per day the collection requirements determine the setpoints for temperature. The setpoints for RH are always determined by the collection requirements.

In conclusion – The cost of stringent climate conditioning is fourfold: (i) excessive energy consumption; (ii) inadequate thermal comfort; (iii) risk of moisture damage to many buildings, especially historical buildings; (iv) shorter HVAC life span. The development and implementation of algorithms for museums to calculate setpoints for T and RH, that include sound knowledge of collection requirements, comfort requirements, and building requirements, results in significant energy savings, significant comfort improvement and protection of our built cultural heritage. Collection conservation may well be ensured because the comfort limits coincide even with the most stringent ASHRAE museum climate class AA.

The recently started PhD-project of Karin Kompatscher involves validating and testing the insights from the case study Hermitage Amsterdam via six other museums. Also, her project has a strong focus on the implications of the setpoint strategies for the micro climate, i.e. the indoor climate at a small scale near objects. Interesting master projects and graduation projects will follow. ■

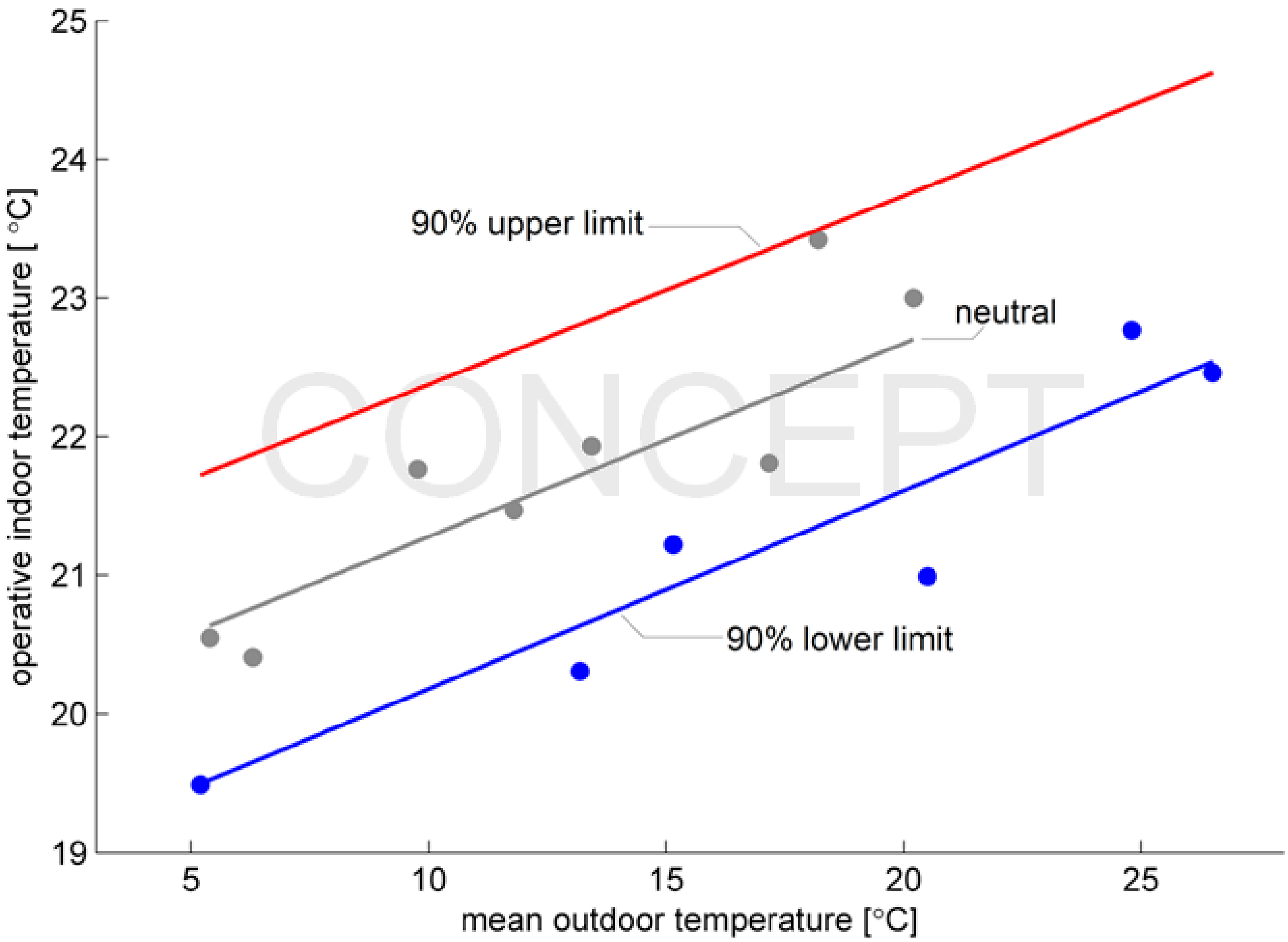

Figure 3. Resulting temperature limits of survey study

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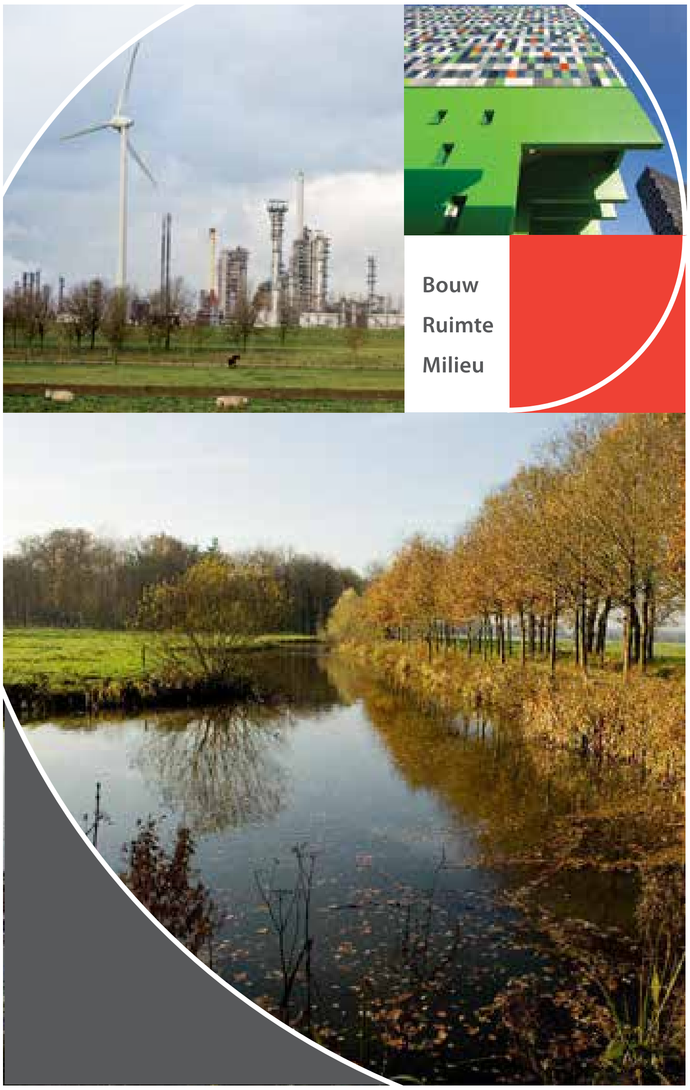

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Modelling and optimizing the sound absorption of Wood Wool Cement Boards (WWCB)

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INTRODUCTION

A wood-wool cement board is a building material known since 1920, consisting of wood-wool mineralized by Portland Cement (PC). It is mainly known for its application as a ceiling material in parking lots and for balconies. The boards are relatively cheap, possess high thermal insulation, fire resistance, sound absorption properties, have a high durability and low maintenance, hence are still popular in design nowadays.

A PhD-study is in progress by Guillaume Doudart de la Grée about these WWCBs in order to characterize the boards and to investigate if they can be produced in a more sustainable way. As a part of his study, the sound absorbing properties are investigated by the author of this article. The main questions in this research are how the WWCB is able to absorb sound and if it is possible to predict the sound absorption by making use of a simulation model. Lastly an investigation will be undertaken to assess in what way the sound absorption can be optimized.

SOUND ABSORPTION

The sound absorption of a material can be expressed by the sound absorption coefficient which is a dimensionless value between zero and one and is both frequency and angle of incidence dependent. Due the boards

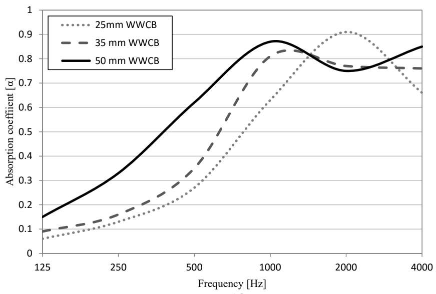


Figure 1. Absorption coefficients for the WWCB with 25, 35 and 50 mm thickness with a 1.5 mm fiber size (according to ISO 354:2003) [1]

high porosity (+/- 80%) with a high pore contact area, a WWCB is able to absorb sound. This sound absorption is relatively good between the 1000 and 4000 Hz frequency bands, which is illustrated in Figure 1. This figure shows the results of measurements in the reverberation rooms of Peutz.

The sound absorption for the lower frequencies is significantly lower compared to that of the higher frequencies, which supports the need to investigate the possibility to improve this sound absorption by changing the board characteristics. It will be tested if it is possible to optimize the sound absorption for these frequencies without reducing the sound absorption for the higher frequencies whilst not affecting the other material properties e.g. mechanical strength, fire resistance and thermal insulation.

To start with the optimization it is important to fundamentally understand the sound absorption performance of the WWCB and characterize the board by studying its production process.

PRODUCTION PROCESS

Different types of forest trees with a diameter between 16-25 cm are harvested 30-50 cm above ground level [2]. The first 2 m of these trees are used for the production of WWCB. After cutting, the wood logs are transported to the WWCB factory and stored on site for 3-6 months depending on the season. During this period the tree sap, mainly consisting of sugars is then leached out.

From that moment on the production process is as presented in Figure 2. First the wood logs are cut into blocks of about 50 cm so that they can be screened for metal parts. After that they are cut into 25 cm pieces and shredded to wood-wool. The final dimensions of the wood-wool are maximum 25 cm in length, 1-3 mm in width and 0.1-0.5 mm in thickness. In this research the 1.0, 1.5 and 2.0 mm fiber width will be evaluated.

The wood-wool is dipped in a solution to accelerate the compatibility with the wood-wool cement paste interface where it is afterwards pressed to decrease the water content. The wet wood-wool with 50-65% moisture content, together with cement powder,

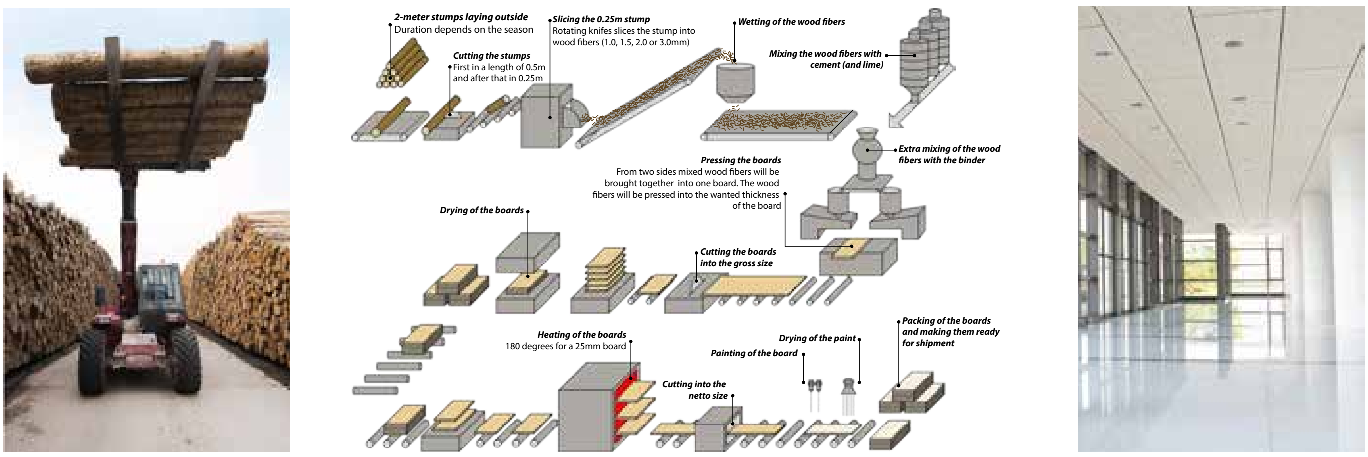


Figure 2. Production process of the WWCB and its application in practice

is fed into a continuous mixer. The irregular flow of wet wood-wool is continuously controlled by an electronic device for a continuous flow of cement. This process is called the mineralization of the wood-wool and takes approximately 2 minutes. During a factory visit it was noticed the mixing procedure is not perfect, resulting in parts that are very wet and contain a lot of cement in parts that are relatively dry and contain less binder.

The mixture is then transported to the double distribution machine. This machine spreads two different layers of a continuous mat of wood-wool cement into the molds.

After having passed a hydraulic pre-press roll (with a small force, enough to press the plate together), the molds are separated by a circular saw and moved to the hydraulic stacking press. This machine stacks the molds with fresh material under pressure (the mold height is used as a reference for the pressure). As soon as the stack is full, the stack is moved out and stored under pressure (e.g. by a concrete block of 1500 kilo for 24 hours). After the setting of cement, the boards are taken from the molds for further curing, while the molds can be cleaned and oiled for re-use.

After a storage period of 10 days, the boards are put into an oven at 140-160°C for 30 minutes to remove the extra water. Finally, the plates are painted, stacked and packed.

SOUND ABSORPTION MEASUREMENTS

There are two ways to measure the sound absorption of the WWCB: in a reverberation chamber and in a standing wave tube. The first one measures the sound absorption coefficient of random incidence sound waves on a big surface (10-12 m^2). In the standing wave tube the sound absorption coefficient of vertical incidence sound waves on a small sample (diameter 40 mm) is measured.

The random incidences of sound waves are close to the practical conditions, therefore, this method is superior to other methods. However, the working space is much larger and the costs are much higher than the standing wave tube facility. The standing wave tube facility is better suited to the laboratory measurements because of the fast measuring time and less material is needed, making it beneficial for this project. A more detailed research can be performed in this way.

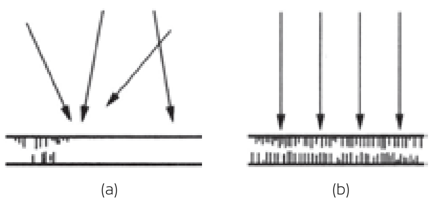


Figure 3. Different incidences of sound waves (a) diffuse (reverberation room) (b) standing waves (impedance tube)

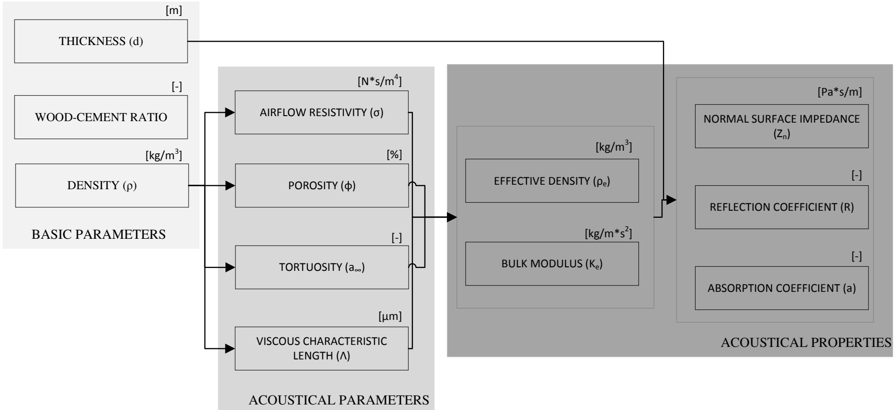


Figure 4. Simplified overview of determing the sound absorption by making use of the Johnson et al. [4] and Zwikker et al. [5] models

SIMULATION MODELS

The sound absorption of porous media can be predicted by rigid-frame models [3]. By simulating the sound absorption a lot of measuring time will be saved and it will quickly give insight in how the sound absorption of a material can be improved. Different models have been analyzed and their suitability for the WWCB has been evaluated.

Finally a suitable model was found, which requires four input parameters; the open porosity, flow resistivity, tortuosity and the viscous characteristic length. Based on these input parameters, the complex density and dynamic bulk modulus, can be determined. The first one describes the viscous effects and the second one the thermal effects. These values will be used to calculate the normal surface impedance and finally the sound absorption coefficient, as is simplified presented in Figure 4.

PRACTICAL MEASUREMENTS

For this study the open porosity and flow resistivity, were measured in practice as a function of the density. The porosity is measured with a helium pycnometer at the Eindhoven University of Technology and the flow resistivity at the University of Leuven. The results are presented in Figure 5.

Where it is quite difficult to measure the tortuosity and viscous characteristic length in practice they are determined by making use of the inverse calculation method. Where the normal incidence sound absorption can be measured with an impedance tube, the tortuosity and viscous characteristic length can be derived from this based on curve fitting. To see if the outcomes are reliable it is important to define a specific range where these values should be in. Just like the open porosity and flow resistivity, also the outcomes for the tortuosity and the viscous characteristic length are related to its density. By deriving the exponential equations from the relations only the density and thickness of a specific WWCB-sample are required to predict the sound absorption.

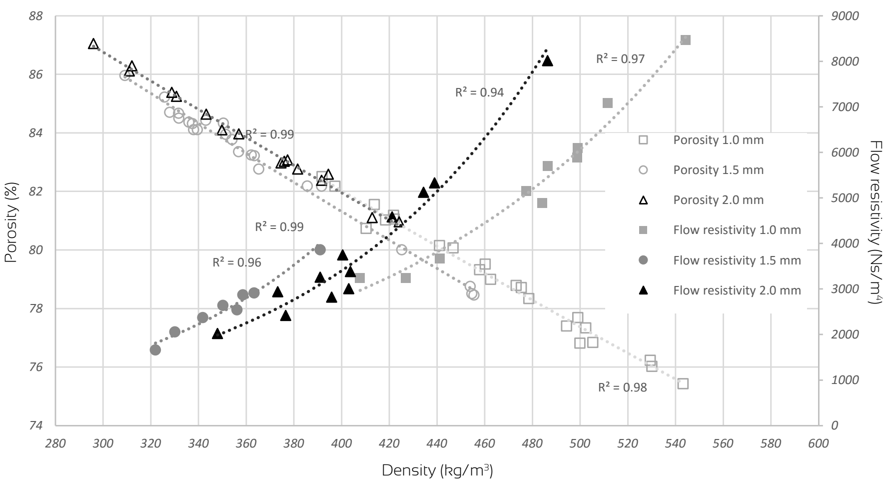


Figure 5. Measured open porosity and flow resistivity for the three fiber sizes (1.0, 1.5 and 2.0 mm) as a function of the density

IMPEDANCE TUBE

To measure the impedance and the sound absorption coefficient, the impedance tube in the ECHO-building at the Eindhoven University of Technology was used. A standing wave is set up within this tube and the impedance of the sample changes the reflected wave. In this way the impedance tube enables both the normal incidence sound absorption and surface impedance to be measured under well-defined and controlled conditions [6].

Figure 6. Impedance tube at the ECHO-building

Theoretically the impedance should reflect the standing wave completely in case no sample is placed within the tube. Due to resonances inside the tube and impedance of the microphones this is not the case. The reflection factor for this tube is given in Figure 7, where dashed gray lines define the error range of 5%. Because of this error peaks and dibs will be visible in the measured sound absorption, especially for the higher frequencies (> 2500 Hz).

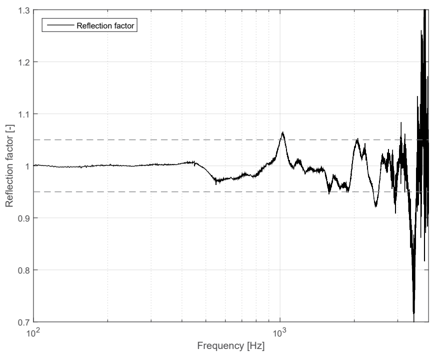
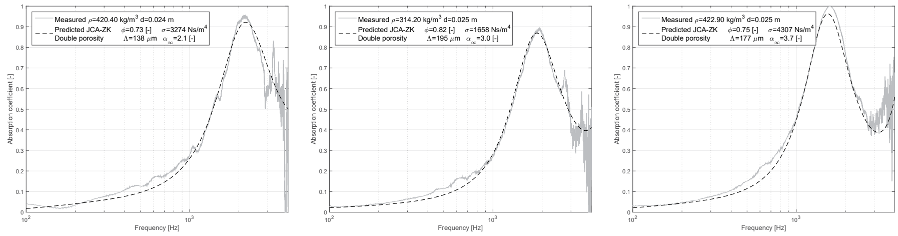


Figure 7. Reflection factor for the used impedance tube

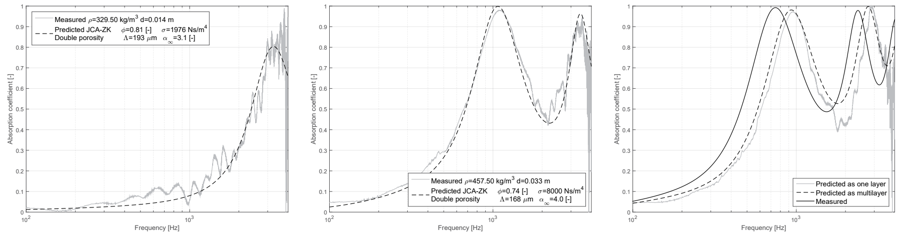
DOUBLE POROSITY

In a study about hemp concrete [7] it was proven that not all the porosity measured by the helium pycnometer takes part into the sound absorption. When a high contrast of permeability exist, which is the case for the WWCB, between the pores and micro pores, $size_{micropores}/size_{pores} \approx 10^{-3}$,the micro pores, like the pores in the wood fibers and the cement are not "seen" by a sound wave. Therefore, they should not be incorporated into the simulation model. By also making use of the inverse calculation method for the porosity, a lower porosity was found for the different densities resulting in an increased prediction accuracy of the model.



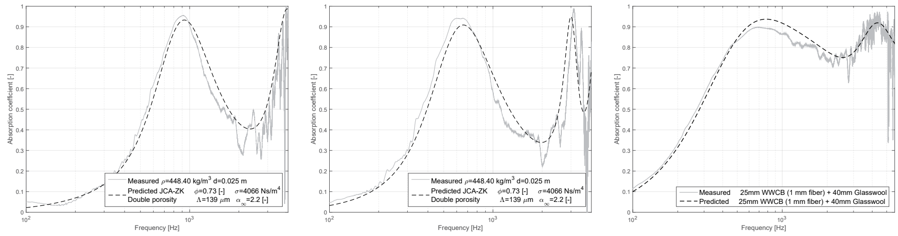
(a) (b) (c)

Figure 8. Validation of the simulation model for a 25 mm WWCB. Solid lines are the measured values, dashed lines are the predicted values; (a) 1 mm fiber (b) 1.5 mm fiber (c) 2.0 mm fiber



(a) (b) (c)

Figure 9. Validation of the simulation model for different thicknesses. Solid lines are the measured values, dashed lines are the predicted values; (a) 15 mm (b) 35 mm (c) 50 mm



(a) (b) (c)

Figure 10. Validation of the simulation model for a 25 mm WWCB with an air cavity behind it; (a) 25 mm air-cavity (b) 50 mm air-cavity and (c) 40 mm air-cavity filled up with glasswool

VALIDATION OF THE MODEL

The measured sound absorption from the impedance tube is compared with the predicted sound absorption by the model for a standing wave. The results are shown in Figures 8,9 and 10.

From these different graphs is it evident that the model is able to predict the sound absorption for the 25 mm WWCB boards, with different fiber sizes (Figure 8) and different densities (Figure 9). By changing the thickness in the model it is also possible to predict the 15 and 35 mm thick WWCB (Figure 10a and 10b). Due to the production process, this is not possible for the 50 mm board. The density is not equally divided over the thickness. Therefore the 50 mm boards were cut into different layers, the density was measured separately and the sound absorption was predicted by simulating the board as a multilayer. In this way it is also possible to predict the existing 50 mm thick WWCB (Figure 10c).

Figure 11. Microscope picture of a 2.0 mm fiber WWCB (Made by Veronica Caprai)

PARAMETER ANALYSIS

The tortuosity mainly effects the location of peaks, whereas the porosity and flow resistivity affect the height and width of the peaks. The tortuosity also determines the high frequency behavior of sound absorbing porous materials. By increasing the tortuosity and making the path more complex, it is also possible to make the material 'acoustically thicker', which is beneficial for the low frequency sound waves [3].

RESULTS SO FAR

The validated model is able to predict the influence on the sound absorption by making use of:

- Different fiber sizes (1.0, 1.5 and 2.0 mm);
- Different densities;
- Different thicknesses (15, 25 35 and 50 mm);
- Different cavities;
- Combining different layers of WWCB;
- Another porous material (e.g. glass wool) behind a WWCB.

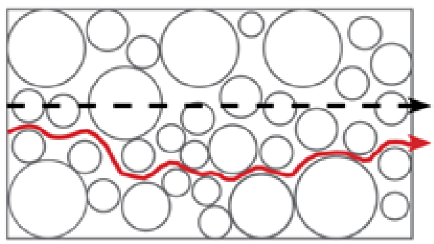


Figure 12. Tortuosity is the ratio between the travelling path of the sound wave and the thickness

In Figure 13, 14, 15 and 16 the influence of different material properties is shown. In these graphs the NRC-value, average sound absorption over the 250 till 2000 Hz octave bands, and the average sound absorption over the 125 till 4000 Hz octave bands are given.

The difference in sound absorption between the different fibers is due to a different recipe for the 1 mm fiber boards (more binder) and other relations between the density and the input parameters. A more refined grid is found for the 1 mm fiber size resulting in a more complex path, a higher tortuosity and flow resistivity for the 1.5 and 2.0 mm fiber size. And higher values for these parameters will result in a better sound absorption, as is visible in Figure 13.

More material in the same volume will lead to lower porosity, a higher flow resistivity and a more complex path (higher tortuosity). Therefore, a higher density results in a higher sound absorption (Figure 14).

In order to be absorbed, the sound waves need to be "seen" by the WWCB. A 25 mm thick board is able to absorb the high frequency waves since the thickness of the WWCB will come close to the wavelength, but the low frequency waves will pass through the material. Increasing the thickness of the WWCB, will therefore result in a sound absorption curve where the peak shifts to lower frequencies, which is visible in Figure 15.

Overall it can be concluded that increasing the amount of wood will lead to an increase of the sound absorption. More material will lead to higher costs, which is not preferable. Therefore the influence of the cavity is investigated as well, as presented in Figure 16.

Another way to increase the sound absorption is to fill up the cavity with a porous material (e.g. glass wool). An example of this is given in Figure 9c. A 40 mm glass wool layer is added behind a 25 mm WWCB. The glass wool layer is modelled with the Delany, Bazley and Miki model [8] and the predicted value is meeting the measured values. An improvement for the lower frequencies is visible and the dip is less for the higher frequencies.

DISCUSSION

The final phase of this study is to use the gained knowledge and the simulation model to define an optimum WWCB, based on the existing properties. As well as determining how the sound absorption can be improved by for example changing the production process, recipe or by combining different layers of WWCB.

STW-PROJECT

STW is a foundation which realizes transfer of knowledge between technical sciences and its users. They are doing this by funding several research projects and bringing together researchers and companies forming a user committee. The material science department has set up the WWCB research project and several companies were included. These companies provide materials for the project and knowledge. Every six months the user committee comes together and presenting my work for these companies, was a great experience with a lot of positive feedback. I especially enjoyed this practical point of view of my project.

The focus in my project is on the acoustics and therefore I spend a lot of time in the acoustical lab and on modelling the acoustical properties. But without the practical measurements and understanding the WWCB into detail it was not possible to explain certain phenomena. The production process for example is essential in analyzing and understanding a material like this. ■

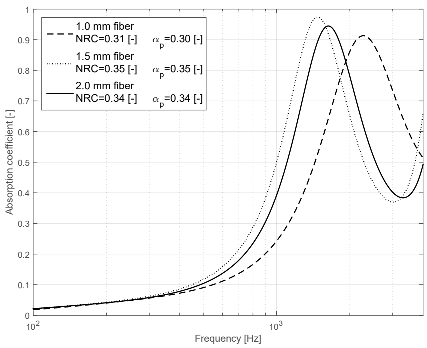


Figure 13. Comparison of the three fiber sizes (1.0, 1.5 and 2.0 mm) for the same density (400 kg/m³)

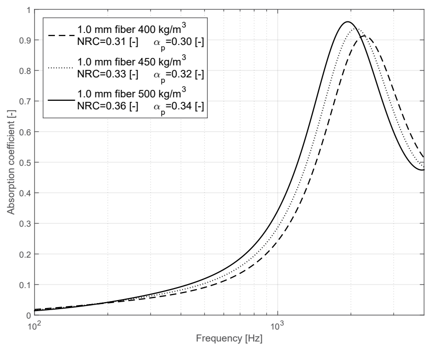


Figure 14. Comparison of a 1.0 mm fiber with different densities (400, 450 and 500 kg/m³)

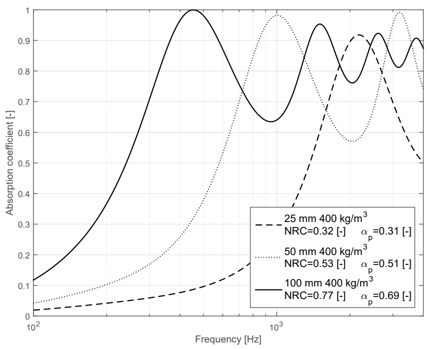


Figure 15. Comparison of different thicknesses (25, 50 and 100 mm) for a 1.0 mm fiber WWCB (400 kg/m³)

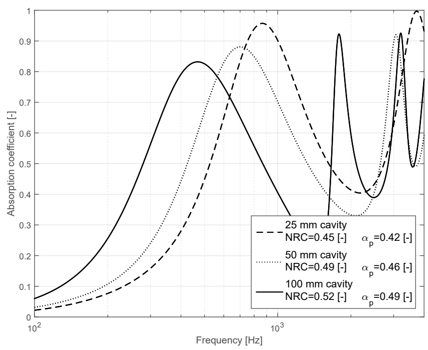


Figure 16. Comparison of different cavities (25 mm, 50 mm and 100 mm) for a 1.0 mm WWCB (400 kg/m³)

PARTNERS

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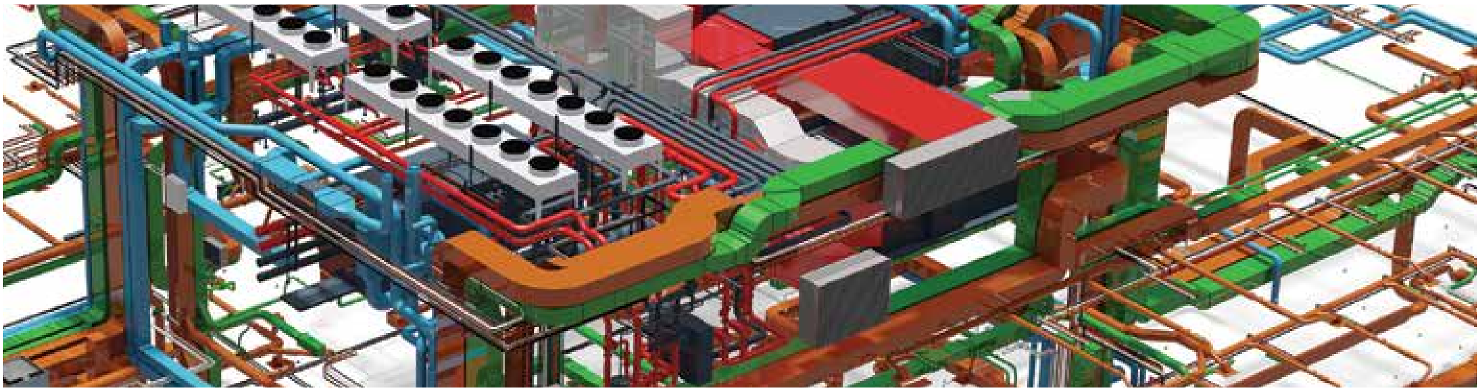

Deel je onze passie?

Wij hebben passie voor installatietechniek. Omdat klanten (zoals TBI, Cofely en Unica) met onze design software prachtige 3D-modellen maken. Het resultaat: spraakmakende gebouwen in binnen- en buitenland. Als product manager, software engineer of BIM-consultant ben je meer dan een klein radertje in het grote geheel – je doet ertoe vanaf de eerste dag.

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Leading in MEP design

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Structural lightweight aggregates concrete

Author
Daan Glas
Supervisors
Prof. dr. ir. H.J.H. Brouwers
Dr. ir. Q.Yu, Dr. ir. P. Spiesz

This study was my master project (M1) in the start of the master program Building Physics and Services at Eindhoven University of Technology. Within the master program there are several research groups, for this project I chose research group: Building materials. I investigated the development of a structural lightweight aggregates concrete (SLWAC), aiming at a good balance between a low thermal conductivity and high mechanical properties. During this study I was supervised by: Dr. ir. Q.Yu, Dr. ir. P. Spiesz and Prof. dr. ir. H.J.H. Brouwers. The mix design was performed by applying the modified Andreasen and Andersen model to secure a densely packed matrix, composed of a binder and lightweight aggregates. The water absorption of the applied lightweight aggregates, expanded clay, is studied and an effective water dosage is determined from the obtained results.

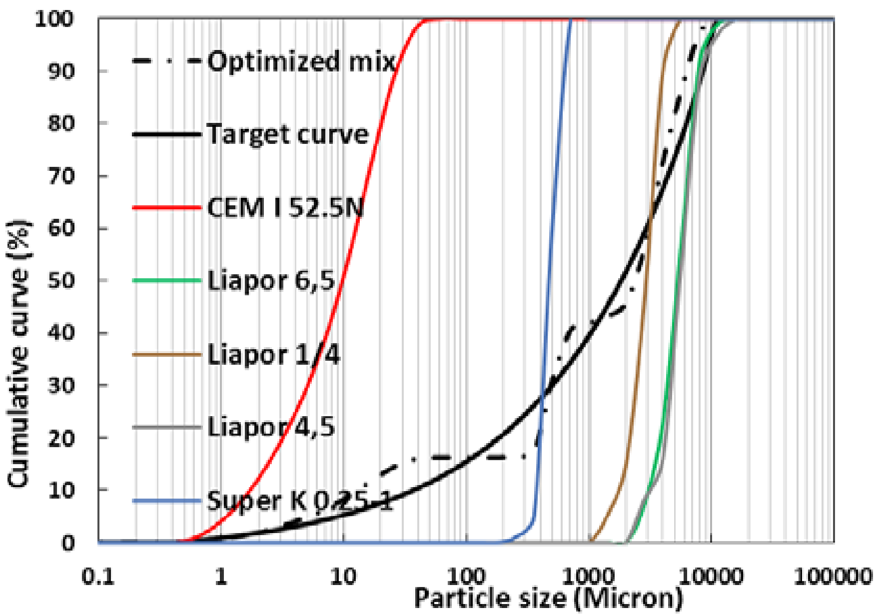

Figure 1. The optimized particle size distribution

METHOD

Two widely used LWAs are expanded glass and expanded clay. The major differences between these two are that expanded clay is mechanically stronger but at the same time has a higher thermal conductivity. Besides the density and the crushing resistance, the particle size distribution (PSD)

$$P(D) = \frac{D^q - D^q_{min}}{D^q_{max} - D^q_{min}}$$

Equation 1. Andreasen and Andersen model

is an important factor. The modified Andreasen and Andersen model is used for an optimized packing of the solid particles (equation 1). The performance of concrete is strongly linked to the porosity, i.e the void fraction. A minimum porosity gives a maximum strength and can be achieved by an optimal particle size distribution (PSD).

In this modified Andreasen and Andersen model the P(D) is the fraction of the total solids being smaller than size D, D is the particle size (μm) and q is the distribution modulus. To reach an optimal packing the modified Andreasen and Andersen model acts as a target function. The Mix grading close to this target curve is achieved with an algorithm based on the Least Squares Method (LSM). This algorithm minimizes of the deviation between the target curve and the composed mix curve.

RESULTS

The optimized mix, with the optimal cement content determined, is shown in Figure 1 The fresh behaviour tests (see picture) of the designed concrete show an acceptable workability under a water-cement dosage of 0.35. The developed SLWAC shows excellent thermal properties, with a low thermal conductivity of about 0.20 W/(m·K); and moderate mechanical properties, with a 28-day compressive strength of about 34 MPa (class of LC30-33 according to EN 206-1), with an apparent density of about 1250 kg/m3. The significantly low thermal conductivity of the developed concrete under this strength class can find a wide application potential, as both a structural purpose and thermal insulating purpose.

FUTURE

Currently I just started my final master project also on building materials. Here I want to work on this SLWAC and develop it further. There are several ways to further improve this SLWAC. For example: by improving the preparation of the lightweight aggregates and by improving the PSD by using different types of lightweight aggregates. ■

The next generation about building energy neutral

The vision of young engineers

Author
Techniplan

Techniplan advisors is sponsor of Mollier, the study association of students for the master track Building Physics and Services at the university of technology Eindhoven. A nice opportunity to ask the next generation about the theme: building energy neutral. How do the future constructors, developers and policymakers -completely uninhibited– encounter this? Striking: the solutions are mainly sought in process and organization, and not so much in technology.

The Vertigo building of the faculty for the built environment is the setting for a two hour lasting workshop on buildings that run completely on renewable energy sources. Sustainability expert Esther Gerritsen and specialist sustainability & innovation Remko van Gijzen of Techniplan Advisors accompanied the workshop. The introductory makes clear that we are dealing with a wide range of interests and master thesis subjects. This also applies to the vision of young engineers about energy neutrality in general. What do they feel is important? For example, that a building is not only designed 'right' in the preliminary stage, but that it actually performs well. Or the user needs more attention: there is still a lot to gain. Also stressed the scale of importance: at building level, we are not getting there, a global approach is needed. Not only does the new build must be considered, existing buildings are equally important. And this: it must be fun! Sustainability is interesting, but it should not dominate everything.

FREE ROUND

In the first round of the workshop everybody is free to brainstorm. As many ideas as possible are welcome by thinking out of the box, judgements will be postponed. When asked what the students define as an energy neutral building and ditto environment, provides a wide variety of answers. Frequently referred to are the users influences, but also topics like flexibility and "smart" design - such as making optimal use of solar heat. The clustering of parties that produce and consume energy are mentioned and by extension the necessity to upscale from building to area level. Also concepts such as the Trias Energetica and cradle to cradle are reviewed. Eventually three core themes are identified that lend themselves to further discussion: reducing energy consumption, the role of the end user, and the importance of different scales in approach.

LOW ENERGY CONSUMPTION

What is not consumed, does not need to be produced sustainable. This requires buildings and installations that are well designed. Flexibility is mentioned as an important quality measure, also in terms of time. Adaptability is a more suitable word: how to adapt a building to changing climatic conditions, can it "evolve"?

In addition the thorough use of materials is referred to. How are materials produced, used and recycled? Building quality is essential: not just by clogging with pur, but by the use of high-end materials. An important role here is reserved for the entire construction team: built consistently as it is designed and save yourself from improvising, however good the intentions are. Within the building all devices that are used must be examined carefully: basically they are all energy consumers and heat sources. To achieve a lower energy consumption it should be allowed to address the user in its behavior. Let them take a sweater on or off, and thereby respond to a building that cools down or warms up. Finally the importance of proper maintenance is stressed. Does a building maintains the same energy performance over the next fifty years or does poor maintenance inevitably leads to degradation and therefore a loss of sustainability?

THE ROLE OF THE USERS

When the influence of the end-user at the energy neutrality of a building is taken into account an interesting discussion unfolds. Should there be an intelligent designed building that takes all the important decisions itself, and takes the user by hand? Whether the user has a mindset of itself, which leads to certain behavior and thus should be influenced or guided actively? Some of the students prefer to tackle the user firmly: antisocial behavior must be tackled hard, since the welfare of future generations is at stake. Reward and penalize: it is both necessary. Social responsibility is no longer binding. Providing feedback is labeled as crucial: confront users with the consequences of their behavior. A difficult point that arises is the extent to which individual users must have 'controllability' of their workplace, housing or building. That control undeniably contributes to a feeling of comfort and luxury, but corresponds with an increasing energy consumption. Perhaps users will need to be educated in accepting a more 'Spartan' or collective environment. The students indicate that the real awareness at this point is still to come.

SCALE LEVELS

Upscaling emerged as one of the central concepts in this workshop. Buildings may or may not be energy neutral itself, the real profit lies in connections and the construction of smart grids. The students also explicit suggest to explore the possibilities of energy (in nature, but also outside this world). Peaks in the power consumption can be reduced through the intelligent application of peak shaving. There are also opportunities to link the suppliers and consumers of energy better with each other at a more district level. All should mean that there will be no more energy needed from Russia to heat buildings here: local energy is the future.

The workshop definitely fulfilled the expectations of Techniplan and provided interesting insights. Esther Gerritsen commented: "These inspiring ideas and visions come specifically from the students themselves. Perhaps they are not all immediately embraced by the market, but the discussion does show a clear view on the need for further change. In particular that the next generation is not shunned to step back in luxury." ■

PARTICIPANTSS OF THE WORKSHOP

- Bart Kok
- Randy van Eck
- Lisan Crommentuijn
- Franziska Roberz
- Wies Westerhout
- Wouter Reijnders
- Robin van de Sande
- Jelle Reinders
- David Al Juma
- Chris van Loenen
- Charlotte Rosenkötter

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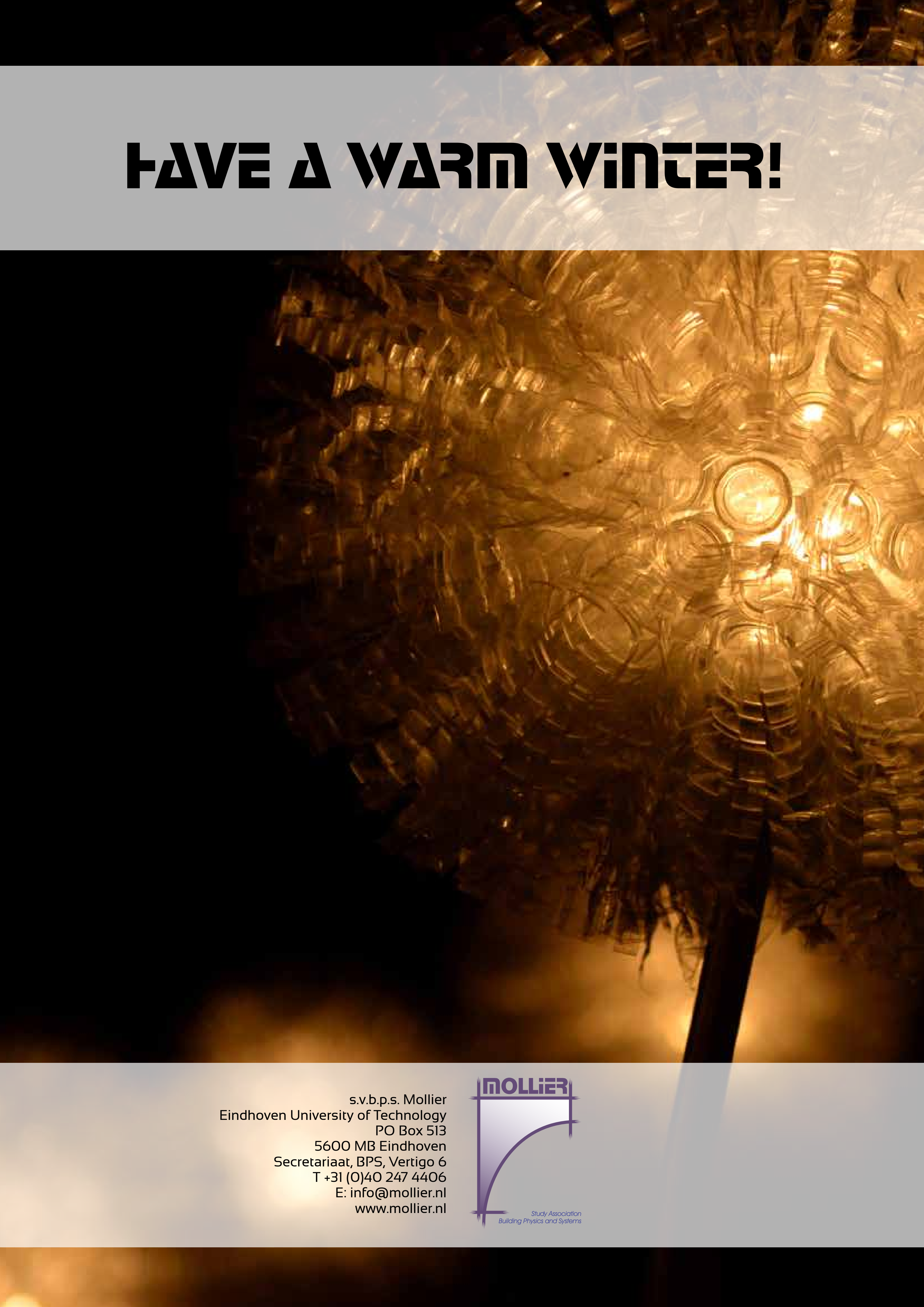

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