Academic year 2017 - 2018 #2 | June

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

A study trip to Chicago: the windy city

Optimizing lighting quality using a luminance distribution

ir. T.W. (Thijs) Kruisselbrink

Active Insulation: Computational performance assessment of a dynamic insulation system

ir. S.J.M. (Stefan) Koenders

MOLLIER GOES U.S.A.

Foreword

Diyako Shadmanfar

As the end of this academic year is nearing, this also marks the release of this year`s second INSide Information. On behalf of the INSide committee, I can state that we proudly present the newest edition to our dearest reader. It has been a year filled with numerous interesting educational activities and delightful fun activities. The 22nd board has ensured that the planning was packed with plenty of things to do. Traditionally, the study trip is central in the second edition of the INSide Information. This year`s study trip has led 20 Mollier students to Chicago, you can read all about their U.S. of A. experience in the travel report on page 15.

In this edition, we have a wide range of articles from Mollier students, the Unit BPS, and our sponsors. Recent BPS-graduate Stefan Koenders has written an interesting article about his investigation into the performance of a novel forced convective dynamic insulation system. Next to a master thesis article, this edition also features multiple master project articles. Subjects range from acoustical problems in our very own Vertigo to hydrophobic concrete to energy-efficient renovation of monumental buildings, you can find it all in this INSide Information.

From the Unit BPS Building Lighting PhD candidate Christel de Bakker has written an insightful article about her time abroad in the United States, spending her time at Lawrence Berkeley National Laboratory. Also from Building lighting, PhD candidate Thijs Kruisselbrink enlightens us on how to measure lighting quality, specifically using luminance distribution. In addition, three company articles are featured. This edition we have Deerns, Heijmans, and new main sponsor DPA|Cauberg-Huygens.

To conclude, the INSide committee always works hard to maintain the quality and evolve the magazine where we can. We have made some slight changes in the layout of the INSide, can you spot them? Also, if you are interested, we are always looking for new enthusiastic editors in the committee. Don`t hesitate to contact any of the committee members or the board of Mollier.

Enjoy reading!

Yours Sincerely,

Diyako Shadmanfar
Editor In-Chief

INSide Committee
Top: Gert-jan Braun, Don Bremmers, Meghana Kulhalli, Bram Dorsman
Bottom: Sonia Soares, Diyako Shadmanfar

COLOPHON

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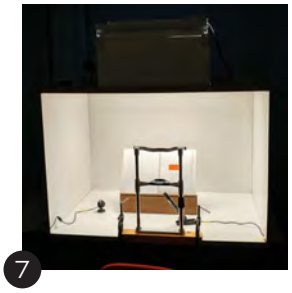
Visiting address
TU Eindhoven
Vertigo 2nd floor

Post address
Postbus 513
p/a Secretariaat BPS
5600 MB Eindhoven
Tel: (040) 247 4406

Email: inside@mollier.nl
Website : www.mollier.nl

This INSide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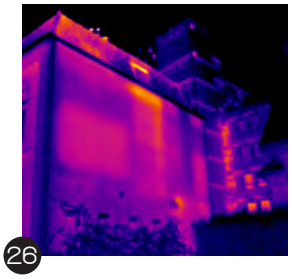
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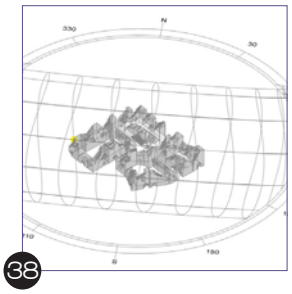
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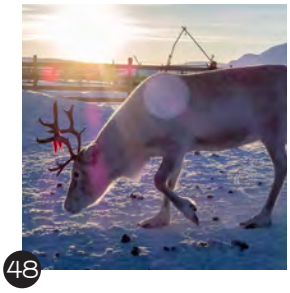
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MOLLIER & MEMBERS

BUILDING PHYSICS & SERVICES

COMPANIES

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Consultancy, Engineering & Management

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The influence of illuminance on reading medication labels

Author
C.L. (Casper) de Ruiter Bsc

Supervisors
Ir. M.P.J. (Mariëlle) Aarts

BACKGROUND

In this study, optimal lighting conditions in medication selecting rooms in hospital environments are studied. Errors made during medication dispensing can affect patient safety and therefore should be prevented by all means [1]. Optimal lighting conditions regarding the visual aspects have been established by G.H.W. Craenmehr [2]. The focus is now on creating a working method to research the non-visual aspects, in particular the acute effects of lighting. To investigate this, a potential method is set up and a pilot study is conducted to optimize the research method.

RESEARCH METHOD

The initial research method is presented here: Women in the age groups of 20-32 and 53-65 years with good visual acuity will participate in experiments on two days where on both days a different lighting condition is tested (500 lx versus 1200 lx on the eye). To see the influence over the day an experiment will be held both in the morning and late afternoon. The task consists of reading out loud fifty letter sequences per booklet, five booklets in total, as accurate and fast as possible. All books consist of the same fifty letter sequences. The outcome measure therefore becomes the speed at which the participants read and the amount of errors they make. The experiment is held with an experimental box which can be viewed in Figure 2.

Figure 2. Experimental box

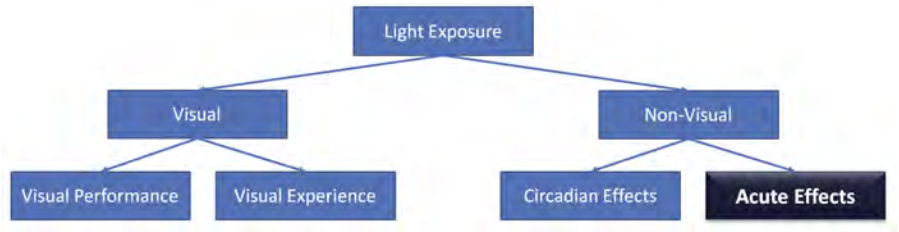

Figure 1. Pathways of light

PILOT STUDY

A pilot study with five participants was conducted to test the general functioning of the method, the duration of the experiment, and to see whether participants during the experiment start to perform worse over time. The latter would show that it is indeed an intensive task, which increases the chance of finding significant results during the real study.

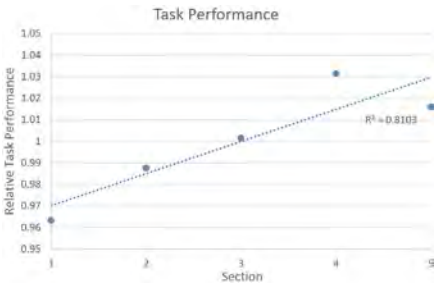

Figure 3. Results: Task performance over time; higher task performance number indicates longer time to read

RESULTS & DISCUSSION

The duration of the experiment should be equal to the task duration of medication dispensing in hospitals, which is roughly 45 minutes. However the experiment lasted about 30 minutes in the pilot test. Regarding the task performance, a positive trend can be seen in Figure 3.

One section equals the reading of one booklet and you can see that over the sections, the time to read increased. Between the reading sessions participants were asked if they had any visual inconveniences. The results in Figure 4 show that everyone had problems such as blurred vision, tired eyes etc.

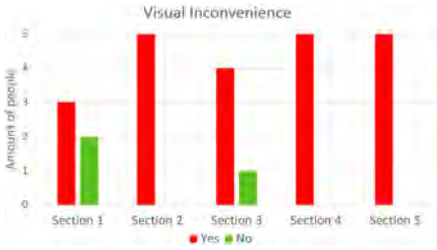

Figure 4. Visual inconvenience over time

CONCLUSION

From the results it can be concluded that the experiment duration has to be increased and steps have to be taken to prevent serious visual inconveniences. An aspect which could also negatively impact the validity of the research is the fact that all books consist of the same fifty letter sequences and participants might start remembering them. With this in mind and the fact that the experiment did not take long enough, it makes sense to increase the amount of letter sequences per booklet to make the experiment last longer. To prevent visual inconveniences participants will now be allowed to somewhat change the distance between the head rest and the reading task. With these changes, the research method is ready to be applied in a full study. ■

[1] A. M. Mayo and D. Duncan, "Nurse Perceptions of Medication Errors: What We Need to Know for Patient Safety," J. Nurs. Care Qual., vol. 19, no. 3, 2004

[2] G. H. W. Craenmehr, "The impact of light on the visual for selecting medication," University of Technology Eindhoven, 2017.

Ice Breaker
Daria Zendri

Hey there! I am Daria, I'm 23 years old and I come from Italy. I grew up in a small valley in the Alps, just a few kilometers from Lake Garda; it has been a great home, and I have lovely memories of my time there as an adolescent and teenager. As nice as it can be, it had very limited study choices. I've always had a particular interest in buildings and architecture in general. So, after high school, I decided to move to Mantova, a small city not far from Verona, where I completed my bachelor in Architecture offered by Politecnico di Milano.

During my 2nd year, I felt the need to get more from student life, so I applied for an Erasmus program. My first choice was Spain, mostly because I wanted to learn Spanish and partly because, well, I'd learnt that Erasmus in Spain means a lot of parties and not a lot of studying (true, not true). And as luck would have it, I was accepted by the University of Las Palmas de Gran Canaria. It was, absolutely, a life changing experience. It made me grow, opened my mind and somehow, made me realize that architecture was not my future. I decided anyway to finish the bachelor and search for a Master that would focus more on the technical aspects of the building. That was how I found the Eindhoven University of Technology and eventually decided that the Netherlands was a good country to go to.

Figure 2. My first time in Amsterdam

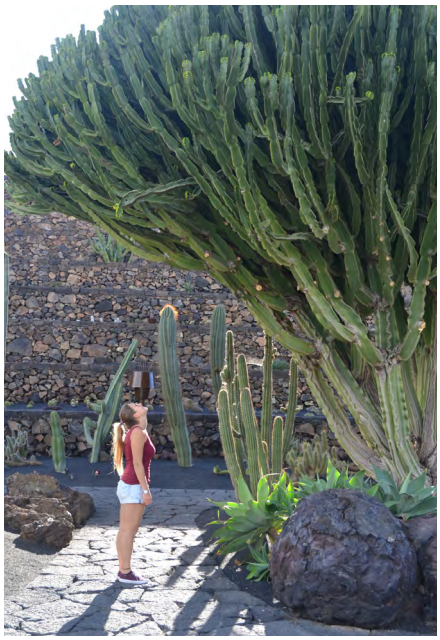

Figure 1. Me and a giant cactus

So, after a gap year that I spent back in the Canary Islands working, surfing and living in a crazy hostel, I moved to Eindhoven. I'm happy with the choices I made! I was lucky enough to find a nice student house with 21 roommates and, since 19 of them are Dutch, I was able to totally immerse myself in the local culture; 'fietsen' everywhere, Thursday-night borrel, stamppot, sinterklaasverhalen and much more. I'm still not used to eating dinner at 6, though.

In spite of the university system being different — it took me a while to get used to the teaching system — I'm impressed by the amount of opportunities that TU/e offers: study associations, student teams, lunch lectures, study trips, the endless activities in the sport center, and so on. There is a little something for everyone, which really makes a difference in the university environment, which tends to be stressful sometimes.

Ever since I moved to Eindhoven, I have had quite a busy schedule. I'm mostly at the library trying not to be behind on subjects. I'm part of the student team, VIRTUe, which is participating in the Solar Decathlon Middle East 2018 and also part of a committee organizing a trip with the goal of helping communities in developing countries. For the rest of the time that I have left, I try to squeeze in workouts at the gym at least 5 days a week, binge watch TV-shows, (maybe too many for it to be normal), cook healthy food and spend time with my roommates, usually drinking over some board games or watching movies, and keeping up the Italian spirit by often having dinner with my small Italian group of friends.

I'm still trying to figure out what I really like, what I want to be and do in my future, in order to make good choices and be happy with my successes. In the meantime, I am trying to make the best of all the experiences life has to offer. I like to think that the memories and the friends I made and will make here in Eindhoven will stay with me; even if I don't know where I'll end up living, this will be the home I can always come back to. ■

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Mollier Activity Calendar

LUNCH LECTURE #3 - KUIJPERS

On 11th January we had a lunch lecture with guest speakers from Kuijpers. Kuijpers is an installation company that does the design, development, maintenance and also the operation of a building. Wouter Flach, corporate recruiter, started the presentation with an introduction of the company; Kuijpers employs more than 1000 people situated in 12 locations across the Netherlands. After the introduction, Paul Molenaar from Kuijpers 'Specialistische Oplossingen BV' talked about his experience at Kuijpers. He also explained the current divisions Kuijpers has, and what kind of graduation projects are possible at each division.

BEER PONG BATTLE

On 20th February, Mollier battled KOers in a game of beer pong to decide which study association could call itself the righteous Beer Pong Master 2017 - 2018. Sometimes, Mollier won a battle due to ultimate beer pong skills, sometimes KOers had dumb luck and stole a victory from us. The final scores were a draw for the battle between the members and a major triumph for Mollier in the battle between the boards.

ESCAPE ROOM

On 18th January, four teams of 6 to 7 Mollier members battled each other to be the first one to get out of the escape room at Strijp-S. We all had one hour to escape from identical rooms by solving puzzles that had something to do with 70's culture. Although all groups did their best, only one group got out in time, maintaining the reputation of Mollier by becaming the #1 of the month January. Maak 'm koud!

EXCURSION PEUTZ

On 5th February, 16 Mollier members visited the laboratories of Peutz in Molenhoek. Casper Esmeijer, the director of Peutz, started the presentation by welcoming us and he explained a little bit about what Peutz does. Tim Weekenstroo continued the presentation and showed us some interesting projects they were working on. Manon Derks talked about her daily activities at Peutz. After the presentations, we went on a tour through the laboratories of Peutz. We saw the rooms for acoustical measurements, a storage room of enormous 1:10 scale models of some imposing theaters, the climate rooms and the wind tunnel. We would like to thank Peutz for making the company visit possible and showing us the interesting facilities they have.

BPS CAMPUS TOUR

On 20th February, Mollier organized a BPS Campus Tour. We started the tour at the Alcodome (Koepel). Karin Schollbach and Perry van der Wouw showed us a concrete pulverizer and tests for concrete with military purposes, to see how well it can withstand an impact.
The second stop was the new wind tunnel where Thijs van Druenen showed us around and explained us how the wind tunnel works.
The third stop was the acoustic laboratory ECHO where we had a tour and a presentation by Raúl Pegán Muñoz about all the current researches that are being conducted in the acoustics field
Next, we went to the roof of Vertigo on the third floor, where Roel van Loonen showed us SolarBEAT, the solar research facility where new innovative building integrated photovoltaic products are analyzed..
After that, Katarina Katik showed us the climate chamber, where simulations can be done on several environmental conditions.
After seeing the climate chamber, Karin Schollbach was eager to tell us more about the materials laboratory inside the Vertigo building, where most of the tests are being done and where most of the equipment is.
At last, we paid a visit to the daylight research facilities, where they have a diffuse sky simulator and direct sunlight simulator.

We would like to thank eveybody cooperating with the campus tour for their help.

LUNCH LECTURE #4 - ENGIE

On 7th February we had an interesting lunch lecture with a guest speaker from ENGIE, one of the biggest technical suppliers of the Netherlands, but it is also situated in many other countries. It has around 6,200 employees and a revenue of 1.1 billion in the Netherlands alone. Maurice Adriaans, project manager at ENGIE Services, told us about the diverse work they do. From consultancy, project management, engineering, producing, installing, fine-tuning to maintenance, operation and facility management. They make an integral design with a focus on the installations, with innovative concepts and integral sustainable solutions. As an example he showed us the installations of cleanrooms at ASML. Afterwards Elise Vreeman, campus recruiter at ENGIE, explained the possibilities for working at ENGIE.

MEET&GREET

On 28th February, our annual Meet and Greet took place. The Meet and Greet is very important to us, as Mollier tries to form a bridge between companies and students. We are therefore proud to say that 15 of our sponsors were present. This high amount of attending companies shows the good relationship between the companies and Mollier and that a lot of companies are interested in students from the Master 'Building Physics and Services'.
The event started with an introduction by Gert-Jan, followed by pitches of the attending companies. Our main sponsors started the pitch session, followed by our other sponsors. Each pitch provided a good and quick overview of what the company does and what they are looking for. In the beginning, around 25 students (both national and international) were present. The pitches took around one hour and afterwards there was time to network. In total around 33 students attended the Meet and Greet, which we think was a great attendance.

LUNCH LECTURE #5 - ROYAL HASKONINGDHV & BAM

On 14th March, Bas Peeters and Rik Maaijen from Royal HaskoningDHV and Dennis van Goch from BAM visited us to provide us with a lunch lecture.
The representatives of Royal HaskoningDHV were presenting the possibilities of working at their company. Also some distinctive projects where highlighted, such as the new Booking-campus Office building, where there were some acoustical challenges and discussions about the design of the building versus the thermal comfort.
The presentation of Dennis van Goch, the representative of BAM, was about smart energy management. A big project BAM has, is called 'REnnovates', which has a lot to do with smart energy. This project is an extension of 'De Stroomversnelling', a project where 111,000 residences are renovated in order to be classified as 'nul-op-de-meter'.

COCKTAIL PARTY: LUSTRUM EDITION

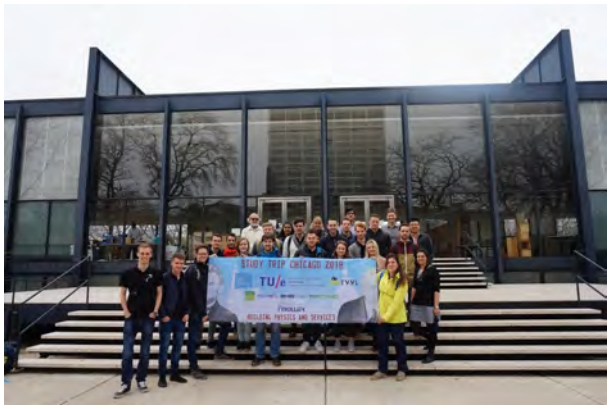
On 1st March, the fifth Mollier cocktail party was organised. This included 5 different cocktails, of which one was the (in)famous Mollier cocktail; 'Meister on mars'. All attendants had a great time and we will look forward for the next cocktail party next year!

LUNCH LECTURE #6 - NELISSEN

On 4th April, Jeroen Houben from Nelissen presented its company in a lunch lecture. In this lecture, he talked about different projects Nelissen works on. One of these projects was a school, of which the temperature regulation was done by water from the river Maas. We would like to thank Jeroen Houben and Nelissen for its time and interesting presentation!

BOWLING NIGHT

On 22nd March, Mollier organized a bowling night at Megabowling Woensel. Some new bowling records were set, while some people's scores hit an all-time low. It was a night full of laughter, frustration and a lot of 'gezelligheid'. After the bowling night, most of our members went to Stratum for a drink.



STUDY TRIP CHICAGO

From the 2nd to the 15th of May a group of 20 Mollier members went on a study trip to Chicago. More information about this trip can be found on pages 15 - 19.

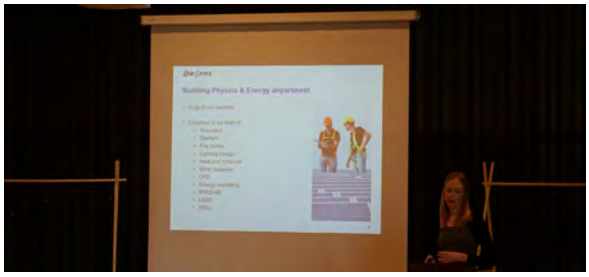
LUNCH LECTURE 7

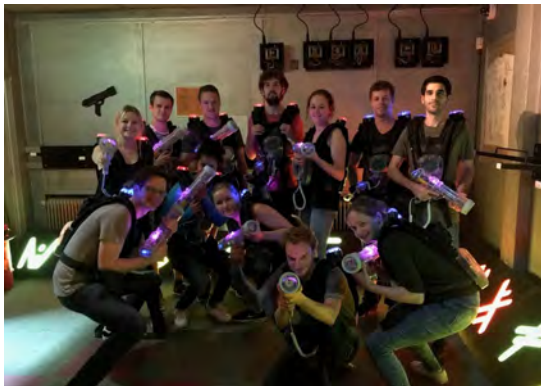
On 18th May, Ilse Dijkstra-Nugteren of Deerns and Marthe Doornbosch of Heijmans provided us with an interesting lunch lecture.

Ilse, from Deerns, spoke about the building physics of the ASML-plaza, the canteen of ASML where 1,500 people can have lunch. This project consisted of two parts: a renovation of an existing part with no daylight, and a construction of a part with a 12 meter high ceiling with a lot of day lighting. She did the lighting design and the acoustics of the project.

Marthe from Heijmans talked about BeSense, a startup where existing buildings can be made 'smart'. The idea is that every workplace and every room has a sensor, which can be used to show which parts have to be cleaned, where a free workplace is, if there are too little or too many workspaces and more ideas are coming.

We would like to thank the speakers for this lunch lecture!





LASERGAME

On the 24th of May, 23 Mollier members were divided in four teams and then battled eachother in lasergame. Large numbers of lasers were shot, many hits were reported and the frustrations of most participants were released through combat.

MORE ACTIVITIES

When this magazine is printed, many more Mollier activities have been carried out. For a recent, up-to-date overview of the past, and the future activities, please take a look at the Mollier-site: https://www.mollier.nl/

RETSCREEN TRAINING

On Friday, 18th May, VanHout adviseurs en installateurs came by and gave us an interesting course about RETScreen. RETScreen is an energy management software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis.

Jan van Hout, the director of the company, and Sander ter Mors, a Medior engineer, took us on a journey to discover the possibilities of RETScreen. Last year they also gave a crash course where they showed us how to make PV-panels feasible on a dwelling. This year they gave a small introduction to the software. We did a workshop on how to import and analyze data from the fuel consumption of a project. We made a prediction for the ongoing fuel consumption and compared this with the actual consumption. This way we could see how an improvement in the system reduces the fuel demand.

After that we did a similar analysis of the data of a PV-panel. By analyzing the data we could see that for a while more electricity was generated then there was expected and for another period less. This was caused by roof maintenance and a lighting strike. It is important that when someone places PV-panels on their roof they also make sure that it keeps working according to expectations.

It was a really interesting course and we would like to thank Jan and Sander for coming.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Mollier goes USA!

Author
W. (Wesley) van der Sommen
N.A.J. (Nick) Tenbült
Study Trip Committee & Participants 2018

DAY 1

Wednesday morning, around 6 AM, most of the group took the train to Schiphol from Eindhoven Station. We gathered at Schiphol at half past seven at our red-and-white meeting point. Once we were complete and took a customary group photo with the banner, the trip could start for real! Unfortunately, the flight had some delay before the takeoff due to the maintenance of the ventilation system. Under the observant eyes of all the passengers, the ventilation system was fixed by a mechanic with some duct tape, and we were ready for takeoff.

Figure 1. Ready bright and early, set to go!

Sleeping was very difficult due to, among other things, high sound levels in the plane (80 dB measured by a phone). All in all, we had a good flight and all of our luggage arrived as well. At the airport in Chicago, the travel cards were arranged and we could continue our travel to the hostel by subway. After settling in, we explored the neighborhood and played some games before sitting down for a group dinner. The evening was further spent relaxing.

DAY 2

Due to the jet lag, the day started early for most of us. Around 6 o'clock everyone was already awake, wandering around the hostel, trying to find a vacant toilet or a shower. Mission impossible, apparently. After breakfast that consisted of bagels, sugary cereals, milk and a lot of coffee, we were ready to go on our journey to the university.

Our first visit was to the Illinois Institute of Technology (IIT) and the first appointment of the day was with Brent Stephens, professor of Architectural Engineering, who presented their course, reasearch work and the PhD candidates he was working with- who also presented their projects. The next presentation was about their project Illinois Tech DOE. This project was designed in the north of the campus, and was very technologically ambitious. The day continued with a campus tour beginning in the architectural engineering department, where they showed us the different wind tunnels they have. Afterwards, we got the chance to get an insight into the history of the University, especially regarding the architect who most influenced its design: Mies van der Rohe. The tour was thorough and very fulfilling in our needs for information about the campus architecture. At the end of the day, we decided to go downtown and have a walk through the main avenues of the city of Chicago.

DAY 3

After another sleepless night with many thanks to the jetlag, almost everyone woke up early. We then set out for Baumann Consulting. The Baumann Office is located on the 16th floor. The Vertigo Elevators could learn something about efficiency and speed from those high-rise elevators. Kelly Adighije from Baumann welcomed us and offered us a second breakfast consisting of muffins and other sweetness. Thereon, the President of the company Oliver Baumann gave an introduction about the company and the history of how a German engineer ended up in Chicago. The webinars began, where Arjan and Remco presented their master projects. In total, about 100 people from all around the world tuned in for this. We were then presented with information regarding the WELL certification in preparation for a group article; for which they had prepared very "WELL".

At around 12 o'clock, the visit came to an end. The group then headed to spend some casual time. During the free time, the group divided themselves. One group went to the Google Office, another had an interview at Threshold Acoustics, and the rest headed to the Pier.

Figure 2. Campus tour stop at the wind tunnel at the Illinois Institute of Technology

Figure 3. Table talks over breakfast at Baumann Consulting

Figure 6. Tilting off the edge of the Hancock Tower for a 360 degree view over the city

Figure 7. Preparations underway for an upcoming play at the Writer's Theatre

Figure 4. Million-dollar downtown view at Baumann Consulting

Figure 8. Not your ordinary jelly bean! Chicago's famous Cloud Gate at the Millenium Park

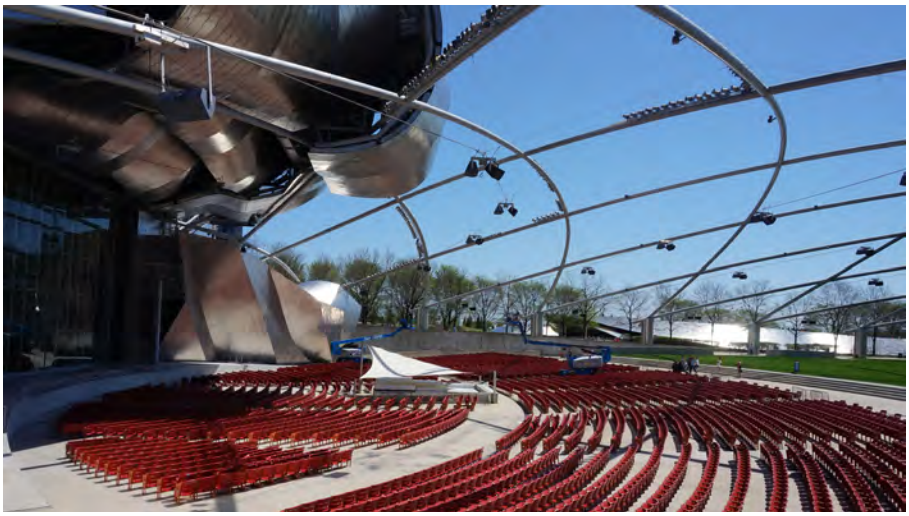

Figure 9. Score a free concert at the open air wonder in the middle of Millenium Park

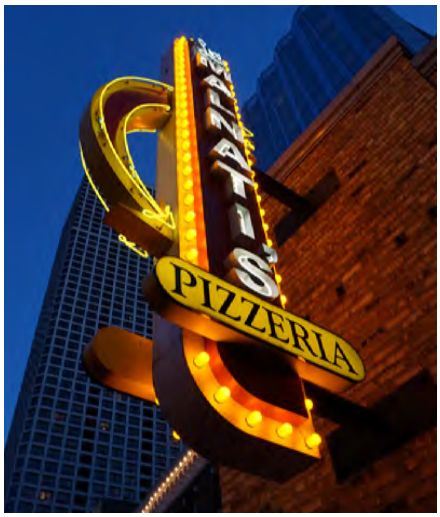

Figure 5. The very famous Lou Malnati's!

Figure 10. Serpentine Bridge through the Millenium Park, overlooking the city skyline

At 4 o'clock, the group gathered up at the John Hancock tower and headed to the 360° Observation Deck on the 96th floor. Marjolijn stayed at the ground floor to make sure the building did not tip over. In the evening, we went to the AMC Theatres to check out the latest Avengers movie, which was awesome. The good guys were fighting the bad guys, the Mollier members were fighting sleepiness. You know, the usual.

DAY 4

Today, the group started the day off with some nice cereal and bagels, much like every other day. After the breakfast, we all headed downtown towards Millennium Park to admire Cloud Gate for the first time. Cloud gate is a sculpture of 10 x 20 x 13 m with an exterior of polished stainless steel. After walking around in the park for a little while, the group split up. Some people went along the shoreline and headed to Navy Pier, whilst some went into the city centre to shop for a couple of hours.

At 3 o'clock, we all met at the Cloud Gate again to head towards a surprise activity! The surprise was a tour and tasting in Chicago's very own Goose Island brewhouse! The group was split into two, one group was had the tour at 4 and the others at 5PM. From the returning first group, it appeared that the samplers were very generous, especially the girls were seen having a bit too much fun.

After the tour, we headed towards Lou Manati's for some famous Chicago deep-dish pizza. Unfortunately, when we arrived it appeared our reservation was forgotten and we had to opt for take-away. The idea of eating our pizza at the beach with a view of fireworks at the pier sounded very good, but we soon found out why Chicago is known as the windy city. It felt as if the temperature dropped about 20 degrees and we all sat next to each other to keep warm.

Figure 11. A truly American experience with a victorious baseball game at the home field of the Chicago Cubs. Go Cubs, Go!

Also, the firework show was at 22.30 instead of 21.00. We headed back to the hostel before the show, since we were all freezing.

DAY 5

Another beautiful day started in Chicago for the study trip of Mollier. No company or university visit since it was a Sunday. We left for the Museum of Science and Industry. The most surprising thing for all the group was a 20m high tornado you could interact with. This was not the only unexpectedly exciting attraction there. A Tesla coil, real-size planes, a German U-boat, a crazy mirror maze and more kept us occupied all day. The museum closed at 16:00, a little earlier than expected for some of the groups, so each of them planned different things for later.

The group split up, so some went out to do some shopping, others continued to tour the city and enjoy the sun, while others went to the Buckingham Fountain to enjoy the scenery.

Figure 12. Awestruck at the Science Museum

Figure 13. Riverwalk along the expensive downtown business district

DAY 6

The sixth day started with a visit to Writer's Theatre. We met with Jon Farris, the managing director of the theatre. Jon explained all about the structure, building physics and architecture behind their building. The theatre started in an old library not too far from where the theatre is now. After outgrowing their previous buildings two times, they decided to have a fundraising and built the building we visited today. The theatre looks very modern and has two theatre halls. The catwalk around the auditorium has a very interesting wooden structure made out of small beams to hold it up. We visited the big theatre hall with 250 seats. It has an interesting panel system installed on the ceiling to make sure the sound on stage will always reach your ears. During construction of the theatre, they used almost 80% of the materials from the old building. This was clearly visible in this theatre hall as well in the surrounding stone walls. The small theatre hall could engage 100 people. Here, they used two types of panels on opposites sides in the walls (a reflective and absorbing panel) to get good acoustics. We then had a nice group dinner and went to a baseball game of the Chicago Cubs against the Miami Marlins at the Wrigley Field. We watched the game, participated in the dances, yells and even the wave. Our cheering helped, because the Cubs won!

DAY 7

Keeping up with the practice of getting a good night's sleep, Mollier was up and running at 8 am after a quick breakfast to head to Arcadis downtown. Starting off with some amazing and freshly baked muffins, we were introduced to Arcadis' company organization, the various disciplines and their future plans by Paul Darby, the associate VP and an avid water-skiing enthusiast. He guided us on a walking tour of their projects and sites: first through an art museum designed by Renzo Piano, then to the Shirley Ryan Ability Lab and then to the Gems World Academy, one of Chicago's most prestigious primary schools.

George, who is also from Arcadis, explained a lot about a metro station renovation project. The project was being undertaken while the transit lines were active. Every seven minutes, the work was stopped to allow the trains to pass.

After looking at some intimidating construction drawings, we had worked up an appetite to eat the largest pizza we had ever seen. Three huge 30" pizzas were delivered, and the Mollier pigs finished it all. Even the salad and soda were not spared. Some people got to peep into the vault of the bank that was in the same building.

Figure 14. Arcadis' renovated CTA Station

Figure 15. Very excited before the project tour

DAY 8

We woke up with stormy weather, but luckily the skies cleared when we headed out to the metro station to go visit the Light Fair International. The Lightfair is the world's largest annual architectural and commercial lighting trade show and conference. Being fairly early at the Lightfair gave us all plenty of time to explore the fair before each group attended their scheduled speaker

Figure 16. Mandatory group picture with safety hats at the Underwriter's Laboratories. Barely able to hide our excitement!

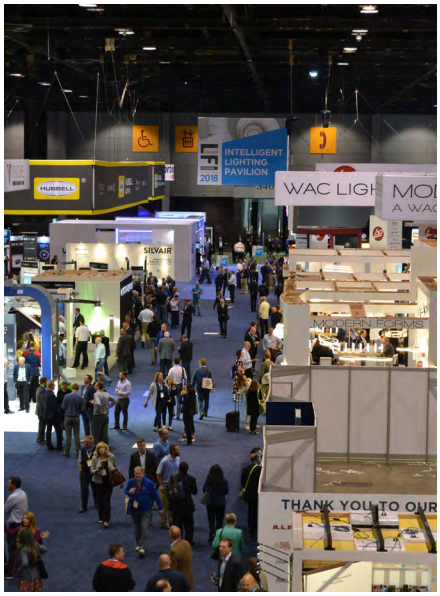

Figure 17. An enlightening experience at the Light Fair International 2018

sessions. Some subjects of the visited seminars were: Lighting metrics for well-being, spectral design of healthcare environments and Lighting the way to Net-Zero Buildings. Most of the seminars were very interesting, others a little less.

Later in the afternoon, about half of the group joined in for the "student and emerging professional networking event". Here we had the chance to talk to some of the professionals in the lighting industry. Five professionals rotated between different setups and different topics were discussed. At the end of the day, we all went home with a goodie bag and the free drinks offered at some of the stands were much appreciated after quite the intense day program.


Figure 18. Getting some fire safety lessons

Heading back to the hostel during rush-hour was quite the challenge since not everyone fit in the already crowed metro carriages. Return at the hostel, some of the group members ate the leftovers of the deep-dish pizzas, whereas the others went to have dinner in a nearby restaurant.

DAY 9

The day started off with a last breakfast at the hostel. After that we were picked up at the hostel by a luxurious bus that was arranged by Underwriters Laboratories (UL). This is a huge research facility that creates building standards, tests products and certifies them. At UL, we were welcomed by Sean DeCrane and Theresa Nemeth. After putting on some nice helmets and a pair of safety goggles, we left for the fire safety facilities of UL. Here we saw the new smoke alarm lab that opened earlier in the year, where they test smoke detectors and alarms for residential and commercial purposes. We then went to another lab where UL conducts commodity testing. They have a huge facility (30.5x30.5m) with a moveable ceiling to test whether sprinkler systems work according to design.

After the tour through the fire safety labs, we went back to the conference room for a Q&A session with Dwain Sloan. He told us about the challenges of UL for the next years; their biggest problem being technology outrunning the facility's ability to make safety codes. We then went to another building at the UL campus, were they conducted building fenestration tests.

Wayne Breighner first showed us how they test the failure of doors, which is done by simply opening and closing it 20,000 times. Luckily, he doesn't have to do it manually. We then entered the thermal chamber that is used to determine the U-values of constructions.

Figure 19. Shining sun, blue skies, bluer waters and bobbing yachts at the Navy Pier

We even got to take part in a heavy rainstorm simulation. They did this by spraying high pressure jets of water on a façade construction with high speed fans as we stood behind them.

At last, we even got to see a spectacular test of tornado resistant glass that was conducted by shooting a wooden beam onto the glass with a big cannon. The glazing however did not withstand the force of the wooden beam, which turned the test into some nice video material.

Figure 20. Our weekend wind-down dugout

The trip to Camp Sullivan took us through the not so hilly countryside of Cook County. When we arrived, we were handed the key to a large bunkhouse. Some people went searching for wood to make a campfire and use our newly acquired fire safety skills. After dinner, the group seated themselves around the campfire to start a game of Werewolves of Miller's Hollow.

DAY 10 AND 11

Some of us started the day off right with some healthy and relaxing yoga in the nature around us on Camp Sullivan. Today was a free day, so everyone was free to do whatever they wanted to do. One of the two groups went back to downtown Chicago to do some last-minute shopping, meeting with friends or find some souvenirs.

The other group went to a shopping mall not too far from the campsite. After taking the bus to the Chicago ridge mall, the group spent the day buying food, shoes and clothes. After dinner we had some quality time with each other playing card games before going to sleep.

Figure 21. The calm before the storm!

The next day, we started off the day even better with bacon and eggs during breakfast. Everyone was still a bit dull from the night before, and had some time to relax since there wasn't a busy schedule today. There was an (optional) hike on the agenda, so we gathered everyone that wanted to join, got some beverages and left the campsite.

After one hour of walking, we got stuck amidst some heavy rainfall. Of course, it happened right at the turnaround point of the hike, so we were as far away from the campsite as possible.The walk back was close to an hour and to add up to our luck; it did not stop raining at all. Everybody was soaking wet when we got back, in the end even damaging some of our electronic devices and luggage.

Figure 22. Channeling our inner yogis

In the evening, the study trip committee had planned a pajama party. The cabin was reorganized, balloons were blown and the fun began! During the party, we held a costume contest. After the nominations, some drinking games were played such as beer pong and stress pong.

DAY 12 AND 13

On this extended weekend, the majority of Mollier woke up in the wee hours of the almost afternoon. After a healthy breakfast (or brunch?) of bread, eggs and bacon, most of the group enjoyed some games in the sunny weather outdoors that only left a handful un-tanned.

In the true American spirit, we had pizza delivered and devoured it all at around 4pm, in preparation for an Italian dinner.... cooked by Italians! The lovely Italians took up the task of cooking pasta with meatballs for Mollier and we ended up eating minced meat pasta and veggies. The study trip committee chairman gave a thank you speech as it was our last night, which was then followed by another amazing speech by the Mollier chairman Ruben. In a surprise takeover, the participants surprised the study trip committee with gifts!

The struggle of packing the next morning was real. With a quick clean-up session, most of the bunkhouse was returned to its original state. Luggage was then loaded into the bus to make the hour-long drive to the airport a lot easier than hopping around with the public transport for 3 hours.

Arriving much earlier than planned at the state-of-the-art airport with no wi-fi, we were all checked-in, scanned and ready for departure! In due time, as we boarded our flight ready to leave, the city cried heavy tears of sorrow, sad to see us go. This delayed our take off by an hour but then finally, we were on our way! ■

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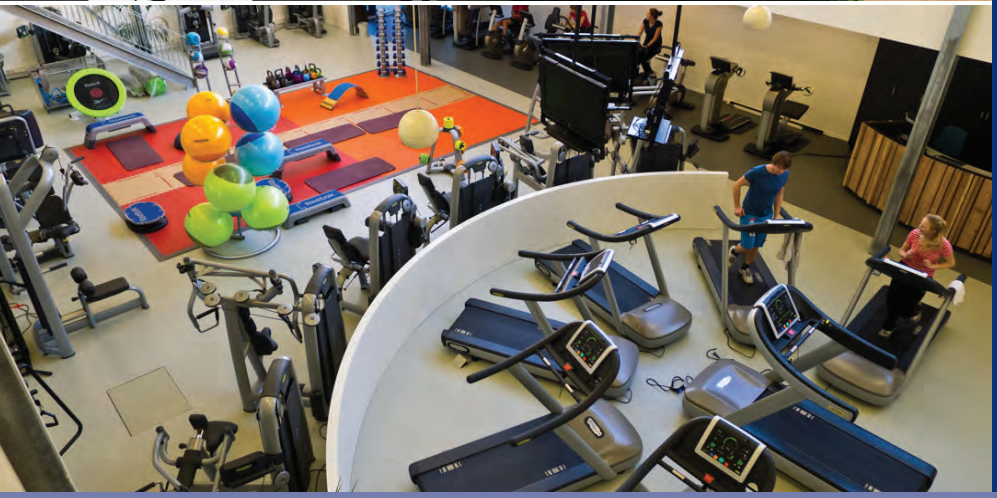

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Smart design of ventilation systems in relation to sleep quality

Author
ir. K.H.E. (Karin) Grooten

Supervisors
prof. dr. H.S.M. (Helianthe) Kort
dr. ir. M.G.L.C. (Marcel) Loomans

It has been estimated that people in developed countries spend around 90% of their time indoors; this means that we spent approximately 2.5 hours of the day outdoors [1]. Since we spend more time indoors than outdoors, the indoor climate is important. The indoor climate will be mostly influenced by humans who are present in the room. Opposed to the outdoor climate, we are able to influence the indoor climate via heating, cooling, ventilation, etc. via building systems.
Ventilation plays an important role in the quality of the indoor climate. The conclusions of a European research *Healthy Homes Barometer 2016* are:

> "Many residents in the Netherlands say they are having health problems due to a high relative humidity and a low ventilation rate in their houses. They feel tired, and suffer from nose and throat problems."

In the Netherlands, the relative humidity and insufficient ventilation are a problem. This is one of the reasons why 66% of the Dutch population does not have a good sleeping environment [2]. CO_2 is often used as a component in order to qualify the indoor air. Research shows that high CO_2 levels can have a negative effect on work efficiency. With higher indoor CO_2 levels, people tend to be less satisfied with indoor air quality, report more acute health symptoms, work slightly slower, and are more often absent from work or school. More recent studies show that CO_2 itself can be seen as a pollutant and it has an effect on the decision making process [3] [4].

Currently, there is interest in reducing ventilation rates to save energy and reduce energy costs. Yet large reductions in ventilation rates could lead to increased CO_2 concentrations that adversely affect decision-making performance, even when indoor air concentrations of other air pollutants are maintained low through implementation of pollutant source control measures or application of gas-phase air cleaning systems [4].

Next to higher indoor CO_2 levels, sleep quality also has an impact on next day performance. This means that, by improving indoor air quality in (bed) rooms, and therefore improving sleep quality, health and work efficiency can be improved. Previous research on this topic has only been performed on young people (age 30 and under). For this research the measurements will be performed with elderly, non-retired participants, in the age of 55 and older. Also an examination of the installed ventilation system is included.

The reason for this specific target group is the increasing population of the elderly in the Netherlands. The amount of people aged 65 and over will increase in the next decade. The employment rate for people aged 55 to 65 will increase in the next years due to the ageing of the population and the cut-back of the possibilities of early retirement. According to predictions made by CPB (Centraal Plan Bureau), the employment rate for persons aged 55 to 65 will increase to 60%. This group will therefore form an important group of the Dutch population.

For elderly people, no specific regulations for indoor environment apply. Previous research has established some alternative recommended regulations for light and acoustics, but no ventilation regulations can be found that specifically focus on the elderly.

The aim of this study is to optimize design and control of ventilation systems for improved sleep quality in bedrooms of healthy adults with a focus on elderly (age >55 and non-retired).

By measuring the CO_2 levels as an indicator of the quality of the indoor air and by measuring the sleep quality, a relation can be more objectively determined. The sleep quality of the participants will be objectified in terms of movements during sleep, length and depth of sleep, sleep stages and sleep efficiency. ■

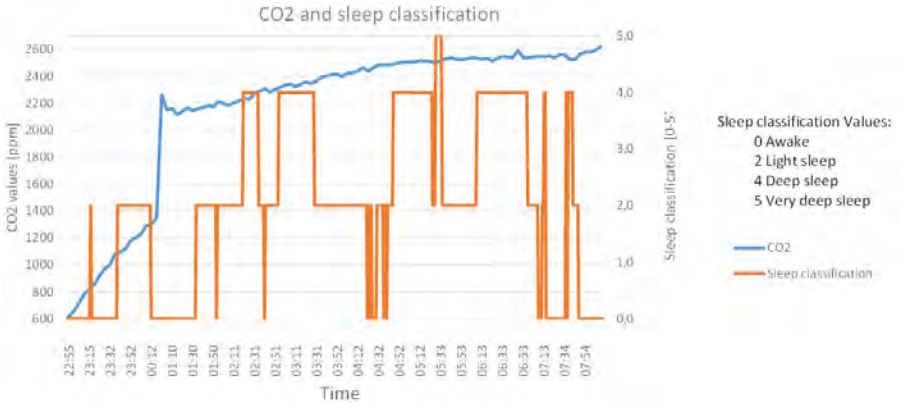

Figure 1. Different sleep stages and CO_2 values during one night

[1] Klepeis N., et al., The National Human Activity Pattern Survey (NHAPS) A Resource for Assessing Exposure to Environmental Pollutants
[2] http://www.velux.nl/wooninspiratie/healthy-homes-barometer-2016
[3] Satish, U., M. J. Mendell, K. Shekhar, T. Hotchi, D. Sullivan, S. Streufert and W. B. Fisk. 2012. Is CO2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance. Environ Health Perspect 2012, 20)
[4] Wyon, P. The effects of indoor air quality on performance and productivity (2004)

Management traineeship at Heijmans

Author
ir. Franziska Roberz

While writing my thesis I was not sure about what I wanted to do after graduating. There were too many job possibilities, too many choices. Right now, almost two years later, I am happy about my current position, even though it is not a position I would have imagined myself in.

A meet and greet organised by Mollier gave me the opportunity to talk with companies about Traineeships and I knew that this was something I wanted to do. What I figured during my graduation project was that I wanted to work closer to the construction phase of buildings rather than in the development and planning phase. The design phase would have been more obvious with my background in building physics and services.

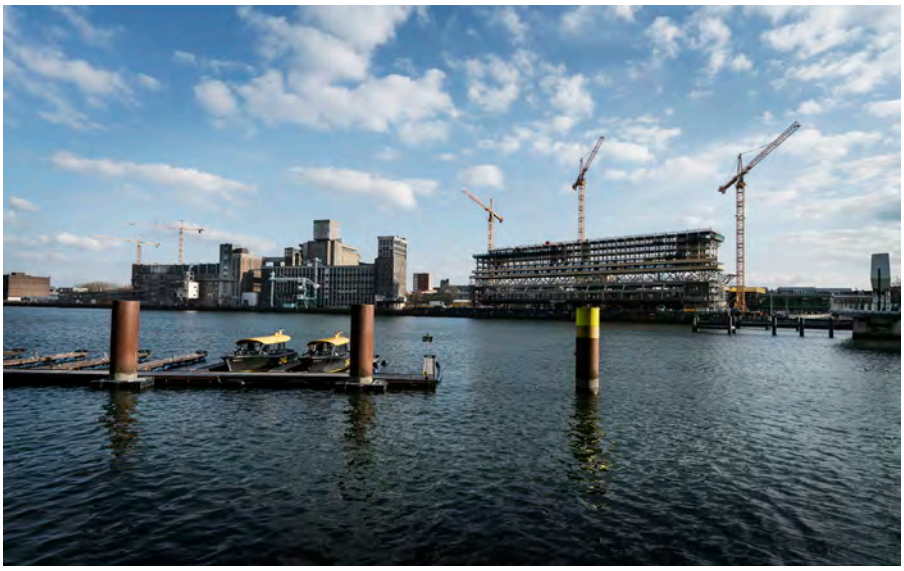

Figure 2. View from across the water of the Fenix construction site

Knowing that I wanted to work close to the realisation phase of projects I decided to apply at a construction company rather than a consultancy or engineering company. I like to get direct feedback and being close to the projects while it is being built.

I applied for a management traineeship at Heijmans and together with 10 other management trainees I started in September 2016. Over the course of one year I got the possibility to get to know the whole company with its activities in the different sectors of non-residential buildings, residential buildings and planning and project development. Civil engineering is the only department I haven't worked at. I worked for approximately three to four month at each departement.. At the beginning of each period there were courses and training about personal development, project management and/or soft skills, together with the 10 other management trainees.

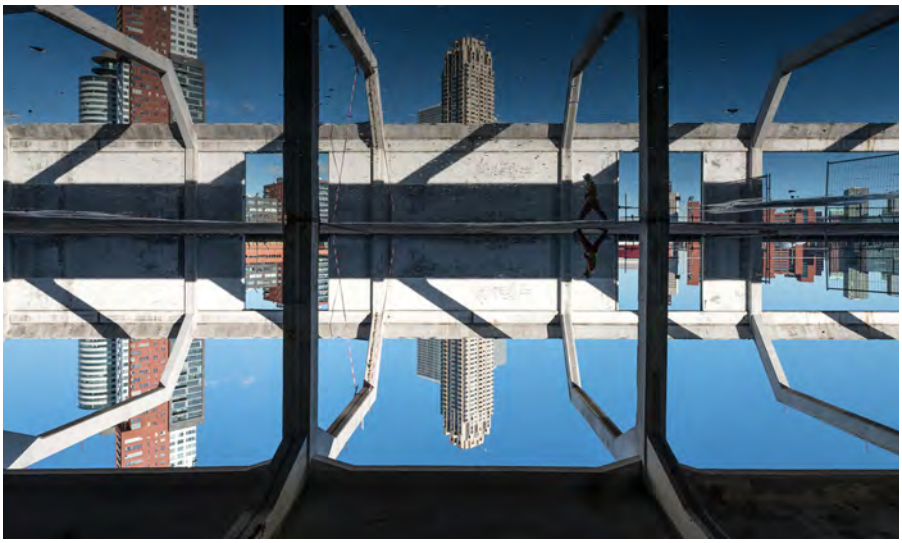

Figure 1. View from inside the Fenix construction site

The first period I worked at the non-residential building sector. I supported a tender team during a tender for a reconstruction of an office building and helped working on the idea of giving the building new life. I also worked on a general concept for reconstruction of office buildings, making them energy neutral and sustainable by adapting the building and reusing materials which will be released during reconstruction. During the first period of three months I discovered what it means to work in a big company and learned to find my way around the company.

During my second period I wanted to work closer to the construction of a building and so I had the opportunity to work on a prestigious project, the Fenix, in Rotterdam. I enjoyed working on the project from the first moment on, because I had the possibility to learn a lot about the building process and how to handle a big project with all parties involved in the process. It was impressive to see how the team cooperates and how the project was growing.

Figure 3. View from bridge to the Fenix construction site

While working at the Fenix I constantly wondered how the drawings and ideas of this project had come to life. This lead to a management traineeship at project development during the third period. I wanted to know what it takes to bring an idea to life and which steps have to be taken to get the drawings ready for construction. I noticed quite soon that planning and developing projects is too far from the actual building process for me.

After talking to colleagues and other trainees about which path to choose after the traineeship, I finally decided that I would like to work as a planner and I got the opportunity to start in September 2017 at a residential building project of 84 dwellings in Gorinchem.

Gorinchem is a project of around 1200 dwellings and apartments. Right now around 450 are realised, so there is still a lot to come. Everything is built in a construction consortium with the BAM. This even gave me a little insight into another company and how to handle differences between the two parties, Heijmans and BAM.

In the beginning it took some time to figure out how everything worked, but I had really helpful colleges. Having helpful colleagues, who appreciate someone being curious and eager to learn, gave me the possibility to learn a lot in a very short amount of time. It helped me to develop independence quickly, thus being able to support the team rather than slowing it down due to mistakes and ignorance. Working independently on the project and seeing progress in the project gives me a lot of motivation and satisfaction. This provides a good base for great commitment and ownership.

Especially during the first weeks I appreciated the support of my colleagues, which I got without asking for it. Just by showing great interest in their knowledge and experience I could absorb as much information as possible. They involved me in everything going on, in and around the project, explaining with great patience. Accepting that it takes time to build an extensive repertoire was one of the most difficult tasks for me. I wanted to do everything right from the start, which is almost impossible when you just started working.

My work right now consists of managing all incoming documents, distributing them between the subcontractors and adjusting them so they match during construction. I also have to check and make corrections on all incoming drawings and plans from our sub-contractors concerning all floor slabs, steelwork, installation and electricity plans. This resulted in having to immerse myself in many unknown topics and everything related to them. In December 2017 we started with the construction of the dwellings, so right now I have the possibility to get feedback on my work. I keep close contact with the contractor to learn from mistakes and things that went well. Right now I am working on the financial part of the project to I make sure we have enough budget for the work we are doing and that each sub-contractor gets the payment they are entitled to.

Also a part of the financial matters between the real estate department, customer, principal and contractor is part of my job. My supervisor and project manager gives me the freedom to work on every aspect of the project. This gives me the possibility to figure out what I like, where my strengths are and where I still want and need to develop myself.

When I started working at Heijmans I did not see myself fulfilling the position I have now. The management traineeship gave the possibility to discover what I like, to get to know my strengths and which position suits me best. I consider the position I have right now the best way for myself to develop in every aspect I want to and to do what I like. I see my current position as a good basis for further career steps. ■

Figure 4. The construction site in Gorinchem

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Groei verder. Ga voort

Research into ventilation systems in school buildings

Author
Y.C.M. (Youri) van de Ven

Supervisors
ir. G. (Gert) Boxem
prof. ir. W. (Wim) Zeiler

INTRODUCTION

The indoor climate within classrooms is an issue which reaches the newspaper often, almost always in negative light. An unhealthy indoor climate within classrooms has a negative effect on the learning, performance and the health of the children and employees. One of the major reasons for this deteriorated indoor climate is a shortcoming within the ventilation system.

The simplest way to solve this problem is to increase the air volume of the ventilation system in order to improve this shortcoming. Despite an increase in the capacity, the problem still persists. A higher capacity is related to a higher airspeed which results in a higher probability of discomfort due to uncomfortable air drafts within the room.

Therefore, a ventilation concept needs to be designed which focuses on health, learning performance, energy efficiency and comfort. In order to contribute to this social problem, this research analyses multiple ventilation concepts in order to form three different concepts, all with their own scopes and fields of application.

VENTILATION CONCEPT

When designing a ventilation concept, many choices between different parameters need to be made. In this research, the input parameters are delineated to five major parameters, namely:

- The strategy of the ventilation system;
- The controllability of the system;
- The outgoing airspeed which enters the room;
- The outgoing air temperature which enters the room;
- The outgoing relative humidity which enters the room.

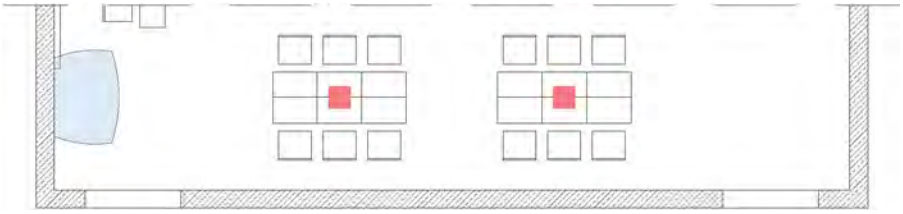

Figure 2. Displacement ventilation

CONCEPTS

As a result of the literature study, it can be concluded that existing ventilation concepts can be broadly divided into displacement ventilation and mixing ventilation. In order to contribute to the social problem described earlier, a concept is developed on both strategies. The third ventilation concept is focused on 'a relatively new' technology named micro-climatization. All concepts are 'tested' in a fictional case study. The resulting concepts are discussed in short below, for further explanation, I recommend referring to the report.

1. Mixing ventilation

In this concept, the inlet and outlet grids are mounted on the ceiling. An overflow strategy has been chosen where the outlets are located in the hallway. Swirl grids are chosen for the inlets and perforated grids for outlets in order to obtain the most comfortable airflow, while taking into account the throw and temperature of the incoming jets. Figure 1 shows the layout of the design.

.

2. Displacement ventilation

In this concept, Wall mounted diffusers have been chosen for its characteristics and the high internal heat gains. These wall mounted diffusers are adjusted to the maximal throw and temperature of the jet in order to maintain the internal comfort. For extracting, perforated grids are used. Figure 2 shows a map of the design.

3. Micro-climatization

This concept is designed based on a design decision making morphological charts. With this method, multiple solutions at different scopes are compared to each other to obtain the best-suited solution. The result is a personal ventilation system connected to a central grid system as shown in Figure 3. ■

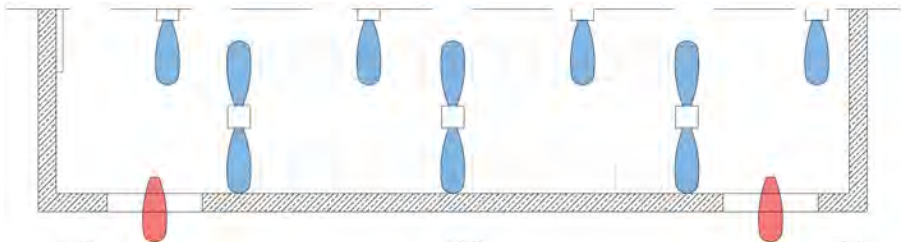

Figure 1. Mixing ventilation concept

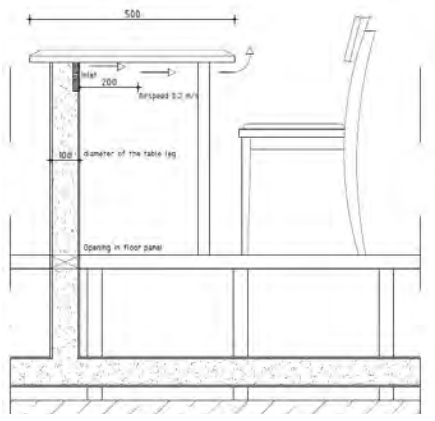

Figure 3. Personal ventilation system

[1] Scholen, H. C. (2012). Dramatisch gesteld met binnenklimaat in scholen doorheen Benelux. Antwerpen. Retrieved 02 23, 2017, from http://www.gezondescholen.com/pers-en-onderzoek/dramatisch-gesteld-metbinnenklimaat-in-scholen-doorheen-benelux/

Energy retrofit municipal monumental building

Author
ing. J.J. (Arjan) Kraakman

Supervisors
dr. ir. H.L. (Henk) Schellen
dr. ir. A.W.M. (Jos) van Schijndel

INTRODUCTION

Upgrading of municipal monumental buildings is one of the challenges to an energy neutral built environment in 2050. The monumental status protects the cultural and architectural values of the building, which, in turn, limit the common retrofit strategies greatly [1]. Furthermore, existing buildings continue to be upgraded at a very low rate. The unknown cost-effectiveness ratio is one of the problems that is pointed out. In general, it is not known which retrofit measure is cost effective. This unawareness can result in not considering retrofit measures. A suggested solution is a multi-criteria approach and employing a numerical energy model to simulate the energy performance effectiveness and economic feasibility of several retrofit actions [2]. To investigate optimal retrofit measures for municipal monumental buildings in a field study, a case study (Dommelstraat 6) was selected. This case study is one of the approximately 55,800 monumental buildings in the Netherlands. This study concentrates on optimal insulation measures that do not damage the cultural and architectural values of the building.

METHOD

Firstly, the existing building elements of the case study were identified. The identification was done by a historical and optical building research. Also, a building diagnostics by IR thermography was performed (see Figure 1). Findings were used to determine the building characteristics, which are used in the simulation model. Secondly, a base model of the current building was made. The base model has been modeled in the freely available and verified simulation model "Heat Air and Moisture model for Building and Systems Evaluation (HAMBASE)". HAMBASE is programmed in the MATLAB software environment.

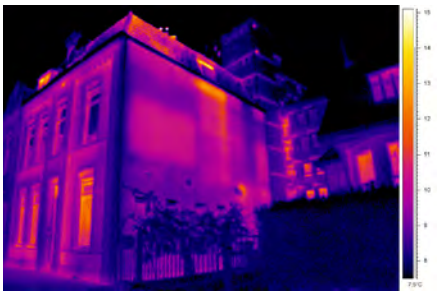

Figure 1. IR view of the front and side façade

Thirdly, the base model was validated. Due to the lack of historical data, it was not possible to perform a reliable validation of the base model. However, to make a 'less' reliable validation, the annual primary natural gas consumption has been compared with reference value of a non-insulated Dutch house without any energy efficient climate system. Finally, a retrofit study was conducted to find the best optimal insulation measures. An optimal measure was determined by considering the return on investment, which was the ratio of potential cost savings and material costs.

RESULTS

The validation shows that the annual primary natural gas consumption of the base model differs by 16 percent. Furthermore, table 1 shows that adding internal wall insulation will result in the highest gas reduction. The results, given in Figure 2, shows that adding of 10 cm insulation has the highest return on investment of 50 years. In addition, because of the internal wall insulation, a 1D Glaser calculation has been performed to examine the vapor transfer through the brick wall construction, especially on the risk of condensation. The calculation showed that there is risk of internal condensation. However, the low amount of vapor can easily evaporate in the summer period. Applying all measures of Table 1 results in a reduced gas consumption of ± 49%. To examine the effects of applied insulation measures (as described in Table 1), a comparison of the excess hours has been made. Adding insulation results in a large number of 'excess overheating' hours at the first and second floor. Adding exterior blinds will significantly reduce this number of excess hours.

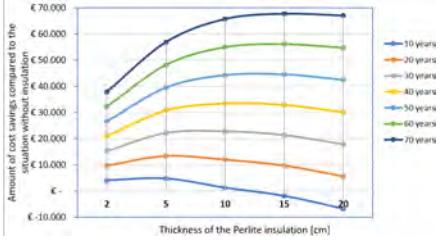

Figure 2. Cost reduction of different thickness indoor insulation

Table 1. Results simulation gas consumption per each practical insulation measure

Building element with applied measure	Reduction [%]
Base model	-
Single glass replaced	11
Attic floor insulated	11
Flat roof insulated	4
Slanted roof insulated	15
Inside wall insulation	23
Kitchen floor insulation	2

CONCLUSION

This study has shown that optimal insulation measures can be determined for municipal monumental buildings without loss of cultural and architectural values. However, due to insufficient validation, only the effects of the insulation measures could be investigated in this study. Furthermore, the return on investment has only been calculated by the material costs. To gain a realistic result, the building costs and inflation must be included. ■

[1] O. Irulegi, A. Ruiz-Pardo, A. Serra, J. M. Salmerón, and R. Vega, "Retrofit strategies towards Net Zero Energy Educational Buildings: A case study at the University of the Basque Country," Energy Build., vol. 144, pp. 387–400, 2017.

[2] F. Ascione, F. De Rossi, and G. P. Vanoli, "Energy retrofit of historical buildings: Theoretical and experimental investigations for the modelling of reliable performance scenarios," Energy Build., vol. 43, no. 8, pp. 1925–1936, 2011.

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the box

Noise environment satisfaction Vertigo 6th Floor

Supervisors
C.C.J.M. Hak
P.E. Braat-Eggen

Author
F.H. (Femke) Spitteler

Noise is one of the key sources that leads to dissatisfaction in open-offices. The ease of making a conversation with a colleague leads to audible and intelligible speech which is irrelevant and considered most disturbing to other colleagues [1]. Ventilation noise and other background noise which keep the same characteristics contribute less to the dissatisfaction [2]. Useful and constant sound is easier to get used to and is thereby less disturbing [3]. At the sixth floor of the Vertigo building there is great annoyance to the occupants due to noise. This research was about finding the cause of the noise annoyance.

ACOUSTIC PARAMETERS

According to literature, speech intelligibility is stated most disturbing for open office spaces. Good speech intelligibility lowers the privacy of an area. For sufficient speech intelligibility and sufficient privacy the Sound Transmisison Index (STI) should be around 0.5, the sound level of the zones should stay below 48 dB(A) [4].

METHODOLOGY

The occupants of floor 6 were asked to fill in a questionnaire [3], the floor was observed at the same time. Measurements during daytime would give knowledge about the sound levels of conversations (during morning, lunchbreak and afternoon) and measurements during evening would give knowledge about the background noise and the reverberation time. For the questionnaire as well for the measurements four different areas of open offices were taken into account (Figure 1), and also the sound sensitivity was taken into account for the questionnaire.

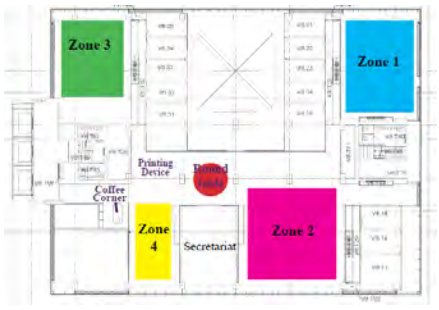

Figure 1: Floor 6 divided in four zones

RESULTS

During the observation of the floor it was noticed that most of the sound sources are located close to zone 4. It was therefore expected that the results would show differences between the zones.

Questionnaire

The results indicate that the attendees are mostly dissatisfied with the possibility of having private conversations, managing noise, controlling the temperature and not being seen by others. The attendees were satisfied about the lighting quality, the cleanliness of the work area and the equipment. 23% of the attendees often hears people talking and are able to understand the conversation but are also bothered by this (Figure 2). The questionnaire results did not show any differences between zones.

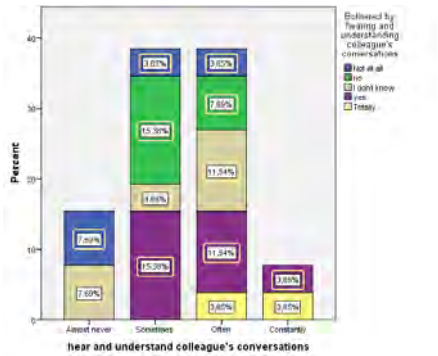

Figure 2: Hearing and understanding conversations

Measurements

The reverberation time showed a little difference between zone 2 to zone 1 and 4 (Figure 3). The sound levels during daytime are exceeding the requirements in zone 4 for 10 percent of the time. During breaks this was even higher.

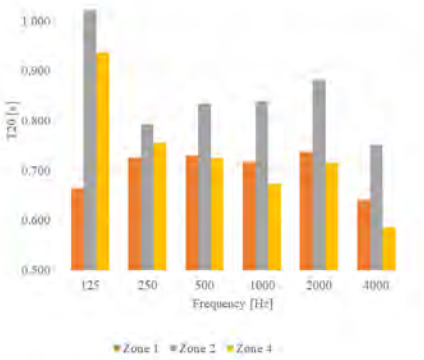

Figure 3: Reverberation Time T20 - Zone 1, Zone 2 and Zone 4

CONCLUSION

The questionnaire results confirm the statement that audible but irrelevant speech is most disturbing in an open office area. The annoyance is almost the same in each zone and the attendees are dissatisfied about the personal adaptability of the workplace climate. The results of the acoustic measurements show a difference in the zones, due to, as expected, the location of the sources. Zone 4 shows higher sound levels during daytime. A solution should create more privacy in the area and more adaptability.■

[1] J. Kim and R. de Dear, 'Workspace satisfaction: The privacy-communication trade-off inopen-plan offices', J. Environ. Psychol., vol. 36, pp. 18–26, Dec. 2013.

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[3] M. Pierrette, E. Parizet, P. Chevret, and J. Chatillon, 'Noise effect on comfort in open-space offices: development of an assessment questionnaire', Ergonomics, vol. 58, no. 1, pp. 96–106, Jan. 2015.

[4] N. J. V. Vlaun, 'Optimizing the acoustic properties of open plan workspaces using parametric models I', 2015.

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Optimizing lighting quality using the luminance distribution

Supervisors
Dr. R. (Rajendra) Dangol
prof. Dr.-Ing. A.L.P. (Alexander) Rosemann

Author
ir. T.W. (Thijs) Kruisselbrink

INTRODUCTION

Lighting is one of the key aspects for a high quality office environment. Lighting influences the visual performance, visual comfort, health, sleep quality, and well-being. Nevertheless, the lighting design strategy is generally to limit the energy costs driven by energy codes and standards, discomfort. Therefore, this strategy can be counter-effective as the wages represent the absolute majority of the costs in office environments. Ultimately, it is more cost-effective to provide high-quality lighting while potentially consuming a little more energy.

High-quality lighting can be defined as "lighting that allows you to see what you need to see quickly and easily and does not cause visual discomfort but raises the human spirit" [1]. However, lighting quality is not easily quantified as it is highly dependent on time, task and user preference. What we do know, is that the lighting designed with only the requirement of 500 lux on the desktop does generally not provide high quality lighting. The illuminance (in lux) is not the most relevant lighting indicator from a human perspective, however, it is often used because it can be measured easily. Additionally, lighting quality consists of more aspects than the quantity of light on the desktop that is indicated by the illuminance.

This research is part of the OptiLight project that aims to develop an automatic lighting control algorithm for human centric lighting. Currently, these kind of control algorithms are lacking or limited to the visual performance. Additionally, scalability, meaning an easy deployment in different environments without excessive tuning, is an important sub-objective of this research. The focus of this research lies on the practical measurement of lighting quality that will serve as input for the control algorithm. Furthermore, first steps are taken in to develop a quantitative model for lighting quality related to the visual aspects of light. The research is roughly divided in three parts. First, we explore of what lighting aspects make lighting quality based on a literature review. Second, we develop a measurement methodology for practical measurements of lighting quality. Third, based on measurements according to the developed methodology first steps are taken to develop a quantified model for lighting quality.

LIGHT QUALITY

To date, lighting quality does not have a rigorous definition, however, many unsuccessful attempts have been made. Those definitions do not provide any leads which measurable lighting aspects are relevant to the overall lighting quality. Based on a literature review

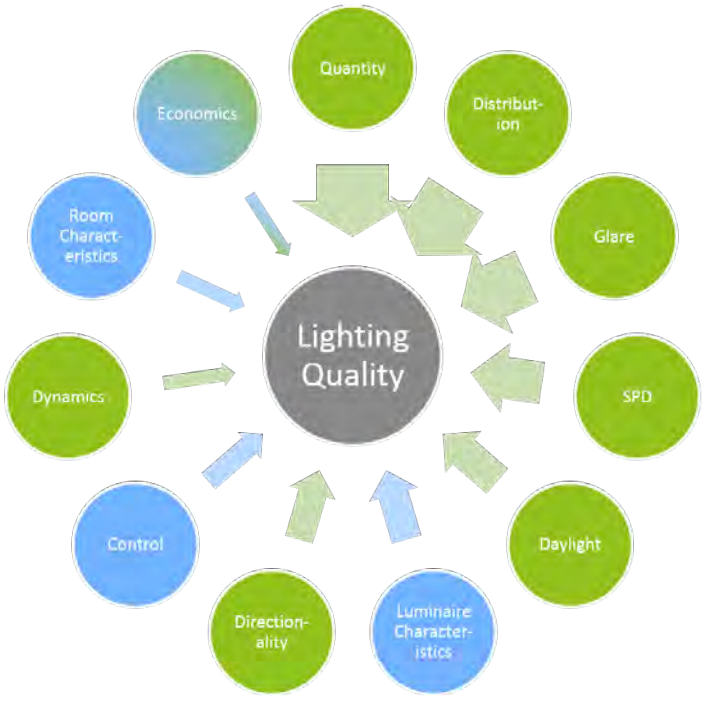

Figure 1. Lighting quality aspects found in literature. The green aspect are variable aspects changing over time, the blue aspects are fixed aspects. The arrows indicate the occurrence in literature.

using forward and backward citation, the different aspects of lighting quality are listed below. The different lighting quality aspects found in literature are indicated in Figure 1.

- The **quantity** of light is an important factor for the acceptability of the lighting for the visual task. Generally, more light, until a certain limit, means a higher satisfaction and improved performance.
- The **distribution** of light is related to the visual comfort. The human eye cannot simultaneously adapt to large difference of light, resulting in discomfort due to continuous movements between contrasting surfaces. However, a completely uniform light distribution is considered dull.
- **Glare**, a subjective sensation of annoyance, discomfort or loss in visibility caused by luminances in the visual field that are significantly higher than the adaption luminance. Discomfort glare is the most relevant glare type in the built environment. Numerous indicators have been developed to quantify this subjective sensation.
- The **spectral power distribution** of light is a complicated aspect. It relates to the color appearance of the light influencing the visual comfort and the light color quality influencing the visual comfort and visual performance. Moreover, the spectral power distribution is of high importance for the non-image forming effects related to health, wellbeing and sleep quality.
- Naturally, **daylight** is a very important lighting quality aspect. Generally, it improves the satisfaction but it is also more desirable for visual comfort. Daylight can also be described by the other lighting quality aspects.
- The **directionality** of light is not often considered, but it helps to distinguish task details, surface textures and faces. Additionally, it relates to the appearance and appreciation of an environment.
- Finally, the **dynamics** of light is a relatively new aspect that can improve the visual performance, but more importantly it is considered more stimulating and pleasant.

The fixed lighting quality aspects are also important; however, they cannot be optimized by a control algorithm. Therefore, these aspects are not considered in this research.

MEASURING LIGHTING QUALITY

Generally, the lighting quality aspects are measured independently of each other using very specific, often very expensive, devices. For a few measurements this can be acceptable; however, for continuous measurements related to a control algorithm, this is not desired. Measurement devices capable of measuring multiple lighting quality aspects at once are desired such that lighting quality can be measured quickly and cheaply. The luminance distribution is a parameter that contains a large amount of data that can be used to indicate multiple lighting quality aspects. With a device that measures the luminance distribution we can measure or indicate, as displayed in Figure 2, the quantity, distribution, glare, SPD, directionality and dynamics all at once. Subsequently, daylight can be indicated by these measurable aspects. Only the SPD cannot be measured using such a device. Concluding, a luminance distribution measurement device can be very useful to measure lighting quality. Nevertheless, not all light quality aspects are easily extracted from the luminance distribution, for instance, the directionality and the dynamics, because they are barely used in current practice.

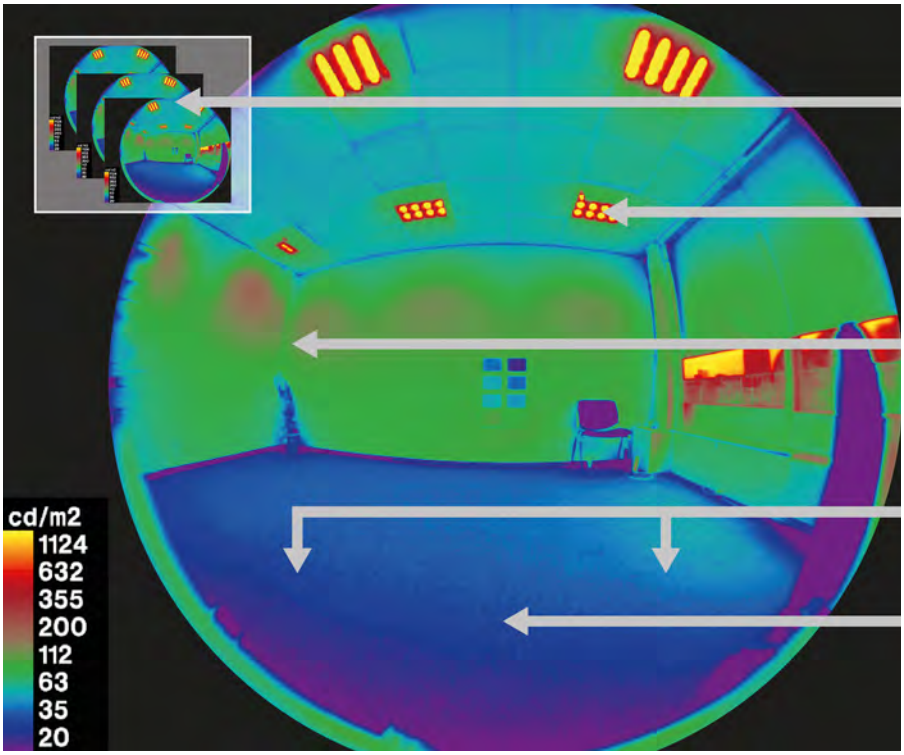

Figure 2. A luminance distribution with indications of location of information

MEASUREMENT DEVICE

As a result, the Bee-Eye, a luminance distribution measurement device, was developed [2]. The Bee-Eye uses a low cost single-board computer, camera and fisheye lens to autonomously measure the luminance distribution. The High Dynamic Range (HDR) technology is essential for the measurement of the luminance distribution because HDR images allow to capture the luminance range occurring in the real world, while standard 8-bit images have a very low dynamic range; typically from 0 to 255 [3]. The HDR images are made using a sequential exposure change technique, in which seven 8-bit images are captured by sequentially varying the shutter speed.

Figure 3. The Bee-Eye

Subsequently, the exposures are merged into one single HDR image. Within this process, the essential camera response curve is approximated using radiometric self-calibration. The response curve is a camera-specific function, which relates the pixel values directly to the scene radiances while also accounting for corrections administered in the proprietary imaging pipeline.

Based on the floating point RGB values of the HDR images, the luminance is calculated. Therefore, the RGB color space is translated to the XYZ color space because the color matching function $\bar{y}$ is equal to the sensitivity of the human eye for photopic vision. Consequently, the luminance is calculated by extracting the Y tristimulus according to equation 1, including a calibration factor to improve the accuracy.

$$L = k \cdot (0.2125 \cdot R + 0.7125 \cdot G + 0.0721 \cdot B)$$

Equation 1. Equation for Luminance

Finally, the vignetting effect is accounted for being a non-linear effect of light fall-off at the periphery of the lens due to internal scattering, which can be approximated by a polynomial function. Especially, fisheye lenses can exhibit significant light fall off, up to 73%, at the periphery of the lens.

Ultimately, the calculation of the luminance based on the HDR images results in a luminance value for each individual pixel as displayed in Figure 2 with a practical accuracy. To indicate the accuracy 10 samples, varying from dark gray to white, were repeatedly measured with the Bee-Eye and a Konica Minolta LS-100 luminance meter. The results of this measurement are displayed in Figure 4. An average relative difference of 3.6% with a standard deviation of 2.2% was found between the Bee-Eye and the luminance meter. It should be noted that the relative difference is expected to be slightly higher for colored samples.

The measurement steps are all automated on the single-board computer such that the luminance distribution is measured autonomously at a predefined measurement interval. Moreover, the Bee-Eye is remotely controlled using Wi-Fi. Additionally, the measurement results are send to a server such that the results can be sequenced from distance.

MEASUREMENT PROTOCOL

Conducting relevant measurements using the Bee-Eye is not straightforward. Preferably, the luminance distribution is measured from the eye position of the user. Especially in field studies this is not feasible, so the Bee-Eye needs to be installed at the ceiling and/or a suboptimal position in the vicinity of the user. Recommendations or best practice examples are not widely available yet. Moreover, the measurement interval is of importance when including daylight. Maintaining a very high interval might result in a sheer amount of data, while a lower interval might miss relevant data. Finally, using the Bee-Eye in field studies might arise privacy issues because the device uses images captured at relative short interval. We aim to give recommendations on how to extract the individual lighting quality aspects from the luminance distribution, suitable measurement positions, and suitable measurement intervals based on a combination on measurements and simulations in the form of a measurement protocol that can be widely applied.

QUANTIFIED MODELS

To develop quantified models the Bee-Eye and the measurement protocol are applied in field studies. During these field studies, spanning a few weeks, the luminance distribution will be measured using the Bee-Eye and the participants lighting quality ratings will be gathered using experience sampling. Experience sampling is a research methodology were participants are frequently, typically using 1 hour intervals, asked to report their, in this case, lighting quality rating. Using methodologies originating from data science, the luminous conditions are related to the participants lighting quality ratings. Based on this, the relation of the individual lighting quality aspects and their interactions to the subjective lighting quality are explored to improve the understanding of lighting quality and provide the control algorithm with quantified models.

SUMMARY

Current lighting strategies in offices do not necessarily provide high quality lighting. To provide high quality lighting aspect, such as the quantity, distribution, glare, SPD, daylight, directionality, and dynamics of light should be considered. Most of these aspects can be measured using the luminance distribution. Therefore, we developed the Bee-Eye, a practical and autonomous luminance distribution measurement device. With the Bee-Eye we are able to measure the individual aspect of lighting quality continuously such that it can serve as input for a control algorithm. Additionally, we can improve the understanding of lighting quality by relating the measured luminance distributions to the subjective responses of lighting quality. ■

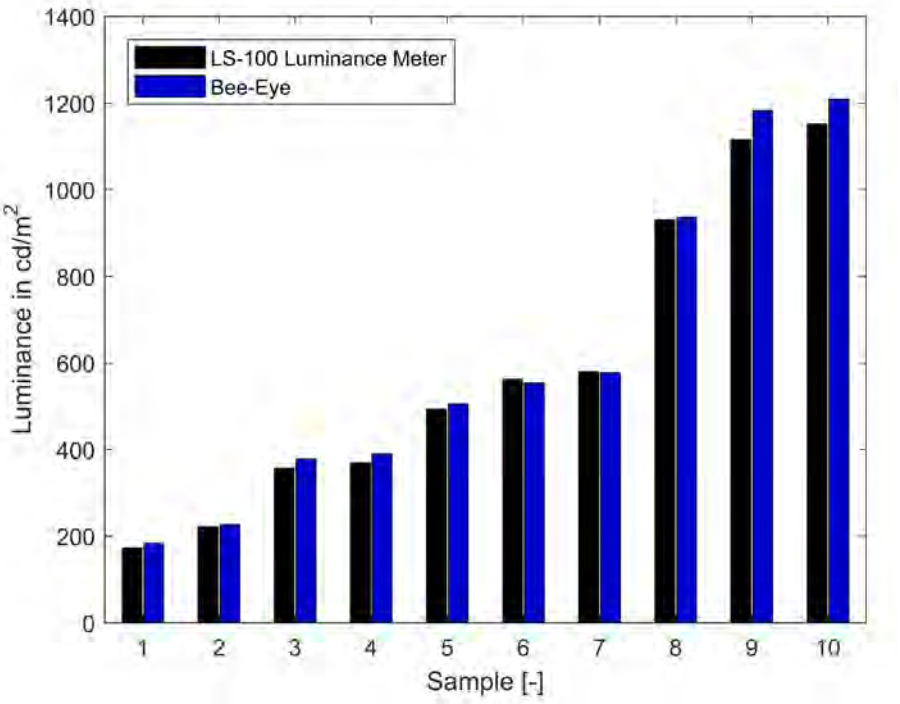

Figure 4. The average measurement results of the Bee-Eye compared to the Konica Minolta LS-100 luminance meter

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[2] Kruisselbrink T, Aries M, Rosemann A. A practical device for measuring the luminance distribution. Int J Sustain Light 2017;36:75–90.

[3] Reinhard E, Heidrich W, Debevec P, Pattanaik S, Ward G, Myszkowski K. High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting. San Fransisco: Morgan Kaufmann; 2010.

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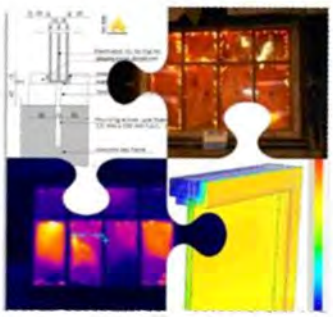

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Hydrophobic lightweight concrete using treated GGBS

Supervisors
Z. (Zhengyao) Qu , M.Sc
dr. Q.L. (Qingliang) Yu
prof. dr. ir. H.J.H. (Jos) Brouwers

Author
M. Z. (Mohamed) Tantawi

INTRODUCTION

Ground granulated blast furnace slag (GGBS) has been widely applied as a supplementary cementitious material and ingredient for concrete production. In this study, a simple preparation process was applied to produce a low-cost super hydrophobic powder from GGBS as water-resisting additive for designing a hydrophobic lightweight concrete (HLC). A particle grading model was employed to secure a densely packed matrix, composed of a binder and lightweight aggregates, produced from natural expanded silicate. The density and mechanical properties of the developed HLC are measured and analysed. The effect of hydrophobic GGBS on workability and strength is investigated.

In this study, bulk treatment was investigated by treating ground granulated blast furnace slag (GGBS), which then serves as a functional filler in the concrete mixture. Bulk treatment may be considered to be advantageous compared to surface treatment due to the lesser susceptibility to deterioration of the hydrophobic coating, protection within the matrix as an integral property rather than a single layer at the exterior surface, and would require less attention such as maintenance [1].

METHODOLOGY AND RESULTS

The water-resisting GGBS will be applied to a lightweight concrete (LWC) mix design. The treatment of GGBS was done by dry-ball milling the powder with stearic acid, a fatty acid, where a series of different settings for the planetary mill and stearic acid proportions were experimented to find the optimum performance in terms of water-contact angle. As shown in Figure 1, the highest water contact angle was observed with 1% w.t. of stearic acid. The water contact angle of 154.1° was obtained as shown in Figure. 1. Due to the high water-to-surface angle (>150°), the GGBS powder can be classified as super-hydrophobic. Figure 2 shows visuals of droplets on the hydrophobic GGBS (H-GGBS). Specimens were prepared, which include GGBS-0, -5, -10, -15 and -20 %. The samples consist of partial cement replacement using the super-hydrophobic GGBS in the matrix of the concrete mixture. The mixing procedure was based on previous studies carried out for a similar mix design [2].

Several tests were conducted to determine the properties and characteristics of the hydrophobic lightweight concrete (HLC) of which the results can be summarized as follows:

- The use of hydrophobic GGBS as a functional filler resulted in a slight reduction in strength of concrete (2.8 – 11.8%) and density (2.6 – 7.5%).
- The workability was seen to have significantly increased (47-63%) when 5% or more of cement was replaced by the super-hydrophobic GGBS.
- The hydrophobicity increases with higher H-GGBS replacement up to 15%.
- Water absorption reduced by 69 – 94% and chloride diffusion reduced by 73 – 91% relative to the reference sample.

The water contact angle was again measured for the treated concrete samples as shown in Figure 3. Moreover, Figure 3 displays the SEM images of the concrete samples which show that the increasing amount of bonds between the super hydrophobic GGBS and cement as the percentage replacement increases.

CONCLUSION

The objective of this study was to investigate the feasibility of using treated GGBS as a functional filler to reduce mass transport in concrete to increase the durability in applications such as in marine environments. It showed that an easy method of dry-ball milling a widely available by-product of steel manufacturing with a common fatty acid (stearic) can produce very promising results in terms of durability when mixed in concrete. ■

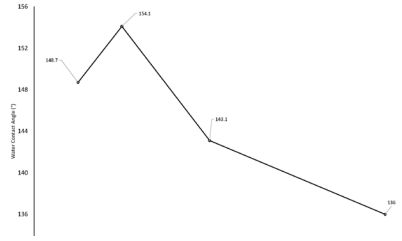

Figure 1. Treated GGBS Water Contact Angle showing the degree of hydrophobicity

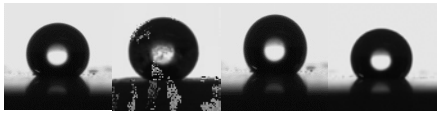

Figure 2. Water contact angle using DataPhysics OCA 50. %w.t. of stearic acid with GGBS powder (a) 0.5%, (b) 1%, (c) 2%, (d) 4%

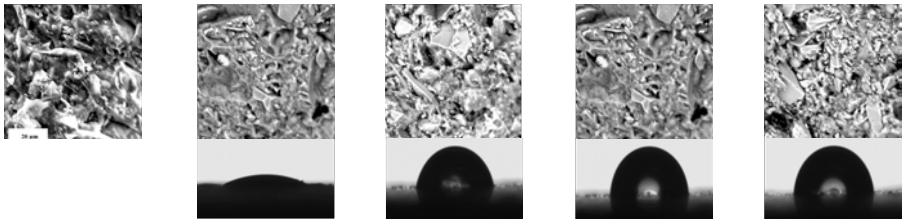

Figure 3. Water contact angle of concrete samples with hydrophobic GGBS

[1] H. S. Wong, R. Barakat, A. Alhilali, M. Saleh and C. R. Cheeseman, "Hydrophobic concrete using waste paper sludge ash," Cement and Concrete Research, pp. 9-20, 2015.

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Stories from a Fulbrighter

Author
ir. C. (Christel) de Bakker

The Fulbright program has a prestigious name in the research world, but, to be very honest, I wasn't aware of its existence. I only discovered it by accidence while searching on Google for an opportunity to spend six months of my PhD abroad. During my Masters I already studied for one semester in Stockholm, and as this period was highly enriching, I dreamed of such an adventure again. This time, however, I wanted to leave Europe, to step further out of my comfort zone and to broaden my view even more. I decided to aim high and contacted a lighting research group at the Lawrence Berkeley National Laboratory (LBNL). They almost immediately replied that I was welcome, but that I had to cover the high living costs of the Bay area myself. That's where Fulbright came in, as they award grants to promovendi who want to perform a part of their research in the United States. Applying is possible once a year and requires submitting an extensive research proposal along with three recommendation letters. I approached my (former) supervisors and submitted a proposal. As this process occurred entirely online, I had no idea of the level of competition. I was then also highly surprised when I found a letter in my mailbox that I was one of the winners. I received congratulations from all over and started to think that Fulbright might be more than just a grant.

This became highly apparent from the moment that I moved to Berkeley, August 2018. Anytime I mentioned Fulbright to an

Figure 1. The Fulbright community in the Bay area

Figure 2. Hiking in the Bay area was my favorite weekend activity

American, it felt like saying a magic word, as they always expressed high respect. The program lives up to its reputation, as my US experience has been in no respect comparable to my Erasmus period in Stockholm. While in Stockholm I made my friends at the first day and stuck with them for the entire period, in Berkeley I made new friends almost every week. Fulbright allows you to choose your own arrival date, which means that the community changes continuously. In addition, the Fulbright program is open for people from all over the world, so I met many non-Europeans. It was highly interesting to share our experiences with the American culture and to hear about how things are organized in their country. The enrichment Fulbright seminar about social innovation in San Diego was certainly one of the highlights of my stay. I spent three days with 83 researchers, from post-docs to professors originating from India to Australia, and they really felt like my family after these days. The lectures and workshops initiated very lively discussions. I'm sure I will meet some of them once again. The same holds for the Fulbrighters from the Bay area, with who I attend several traditional American activities: from a gospel choir concert in an original art-deco theatre, to a Civil Rights presentation by dr. Ian Haney Lopez (a professor on the development of racism in the US).

The Fulbright community was certainly helpful in meeting new people, but the downside of the free arrival dates was that some Fulbrighters left shortly after I met them. I thus also needed to arrange a social life outside Fulbright, but this was much more challenging than in Stockholm. At the LBNL, I was one of the youngest among mostly men. In addition, Americans tend to keep work and private more separated than in Europe, so going for drinks happened rarely. Luckily I had anticipated this and was living in a flat with international roommates, who were more than happy to explore the area with me.

Not only socially, but also professionally, this period has been more challenging than Stockholm. First of all, pursuing a PhD is in itself already challenging: you have to make a plan for four years, make all decisions on your own – everything is your own responsibility. This freedom was one of the reasons why I chose to pursue a PhD, but in combination with moving to a new country, this was sometimes overwhelming. It taught me that a stable and supporting group of family, friends, and colleagues is worth a lot. So, when the group at LBNL asked me whether I wanted to stay another six months, I felt deeply honored, but kindly rejected. Nevertheless, I look back at this period with warm feelings: I met the nicest people, could enjoy the beautiful nature in the Bay area, and, most importantly, learned a lot about myself and the world outside Eindhoven. ■

FULBRIGHT

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Parametrification of Building Engineering

Author
A. Andrejevic & J.Spiegeler

REVOLT!

The total yearly building industry revenue is around €63.3 billion, however 10% of this revenue is made up by failure costs [1]. This large amount of failure costs comes from redesigns, miscommunication and reworks that could have been prevented by good communication and more integrated knowledge during the design phase [2]. New design methods such as BIM-modelling or new integral contract forms are a first step towards a solution. Though these working methods provide seamless communication, they do not yet offer the integral operations that are required [3].

INEFFICIENCIES OF THE DESIGN PROCESS

Even when using BIM, in the case of a redesign the operational backforce still has to rely on traditional and time-consuming methods. For engineers, it is noticeable that every redesign is followed up by a lot of manual handlings, such as remeasuring geometry in 2D-formats (like pdf) and changing the input of their calculations in Excel. Only more complex issues are modelled within stand-alone or manually operated 3D-environments.

In practice, we have noticed that these traditional calculation methods take so much time that design teams rather seem to limit their design choices up front so that they only have to work out one certain and basic design alternative. Another effect is that engineers and architects do not dare to be creative, all in the fear of giving wrong and costly suggestions. Finally, it seems that only the experienced engineers get to go to design meetings because they know the building code the best and therefore make the least mistakes in their reasoning.

MISSING OPPORTUNITY FROM ACADEMIC LEVELS

At universities, more and more students learn to use digital advanced programs and also learn to program algorithms in 3D-environments such as Grasshopper in Rhinoceros or Dynamo in Revit. More literature about parametricism and computational design is written every year [4]. Despite these advances it seems in practice that these programs and calculation methods are insignificant and considered as far future material. Employees may see these 'automations' as risks to their own jobs and do not want to help initiate, while company managers may see these tools as merely an experiment and do not dare to use them in projects out of risk preservation.

THE SOLUTION

This is why we started omrt, which stands for "Office for Metropolitan Realtime Technology". We have DPA Cauberg-Huygen as main partner and work together with the TU Delft. We think, that a lot of efficiency in the design process can be reached by using the exponential advances in the digital industry to virtually create the 'toolbox of experienced engineers' by storing standard calculations in algorithms. We partly do the same activities as traditional engineering companies, however we do it digitally and connected to the 3D-modelling environment. We thereby strive to enhance the accuracy of feedback on design decisions. In addition, we enable the calculations to be visualised in 3D (and virtual reality), and finally we do not replace engineers (because they still need to facilitate all technical processes) but rather increase his current limited toolbox to a much

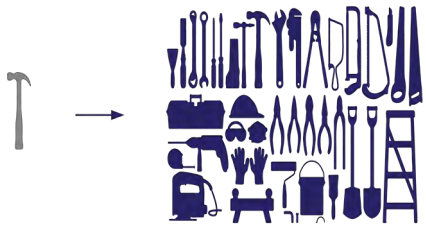

Figure 1. The current limited toolbox of engineers can be expanded tremendously by virtual programs and algorithms

greater extent. We would like to give two examples how omrt is operating in the aforementioned topic:

HYDEPARK PROJECT

DPA Cauberg-Huygen received the assignment to perform daylight calculations Hydepark project in Hoofddorp according to NEN2057. According to the building code, next door buildings do not have to be included in such calculations. But in this project the adjacent building was 40 metres high and the street width only 14 metres, which becomes questionable from a comfort and aesthetic point of view.

The daylight factor was calculated twice to see what the difference between the situations with, and without, the adjacent building was according to the NEN2057 calculation method. It seemed sufficient and the outcome could thus be used to convince the municipality, but merely a number did not convince the client

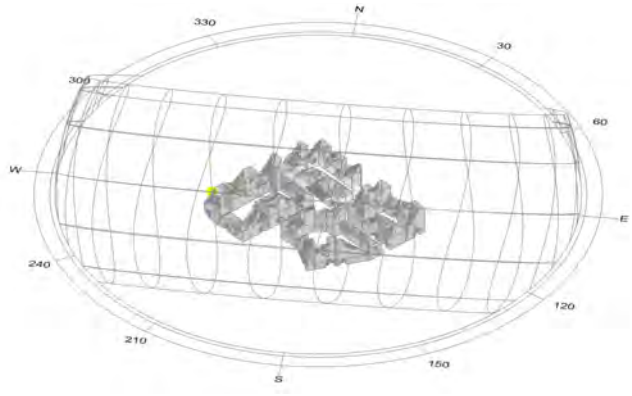

Figure 2. The sunpath around the 3D model of Hydepark

due to his limited understanding of that number.

Therefore, omrt created a script with Grasshopper in Rhino around the 3D model according to NEN2057 regulations (CIE-sky overcast) to create a realistic NEN-based visualisation in Virtual Reality of the intruding daylight. Following this, the client was able to communicate with the architect about the daylight intrusion with the help of a very basic tool; their own eyes (instead of factorial numbers).

In conclusion, this trial was one day of work for omrt and it formed a definite conclusion for the sizing of the windows because they could be changed parametrically on the spot with our script. Normally, such a process could take up to two weeks.

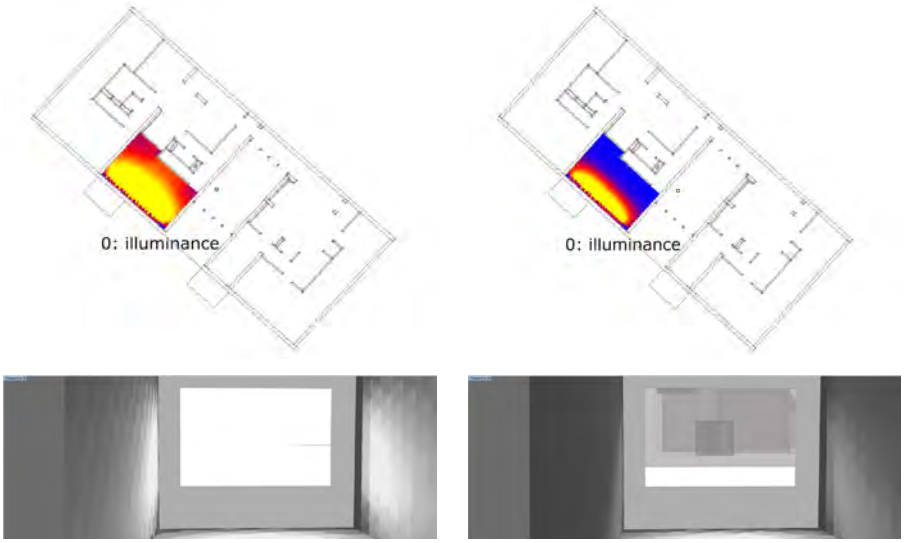

Figure 3. The daylight representation in VR without (left) and with (right) the adjacent building block

PITLAB – DOOR ARCHITECTS

For DOOR Architects, omrt is facilitating the computational support for their own stacked sea container office building 'Pitlab'. At the long end of the upper containers, a double façade will be installed with pepper plants in between and extra stone mass on the bottom. The purpose of this active façade is to function as a light controller, battery for heat exchange, and pre-ventilation channel providing oxygen.

Traditionally, the design process would go by reasoning and by experience in meetings. In contrast, omrt invited themselves to work a day at the office of the architect and to work out the design iterations 'real-time'. We asked the architect to set the boundaries of each variable of the design; i.e. the minimum and maximum allowed temperatures inside the building, the ventilation speed, or the daylight reduction options.

From this range of boundaries, a series of studies and optimisations were performed regarding ventilation within the double façade. From these studies, the two best design options were chosen by the architect and used as input new alternatives incorporating the daylight, humidity and heating variables.
The architects were stunned by the freedom within the design process because the engineering part was not directly steering towards end solutions, but was merely facilitating within the range of the preferred settings while regarding the building code regulations.

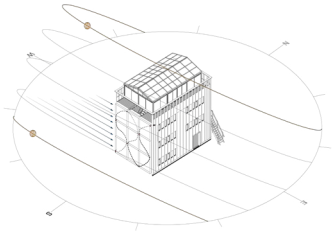

Figure 4. The Pitlab Model

CONCLUSION

With these two test cases, this new method of working has shown to be more interactive, facilitating, and fun than regular engineering services. The project owners understood the nature of the design decisions better and the architects received a better base for grounded decision making that expanded their design options.

THE FUTURE

The Royal Institute of Dutch Architects (BNA) has set out four possible future scenarios that define the role of the architect in the year 2030, in which each of these scenarios requires the architect to think more and more as an engineer [5]. As a result, the market seems to agree that an engineer versus architect gap closure would be beneficial, confirming our own beliefs [6]. So if you want to join this revolution, want to know more, or just want to grab a coffee with us, you can always contact us by mail, phone or through our website;

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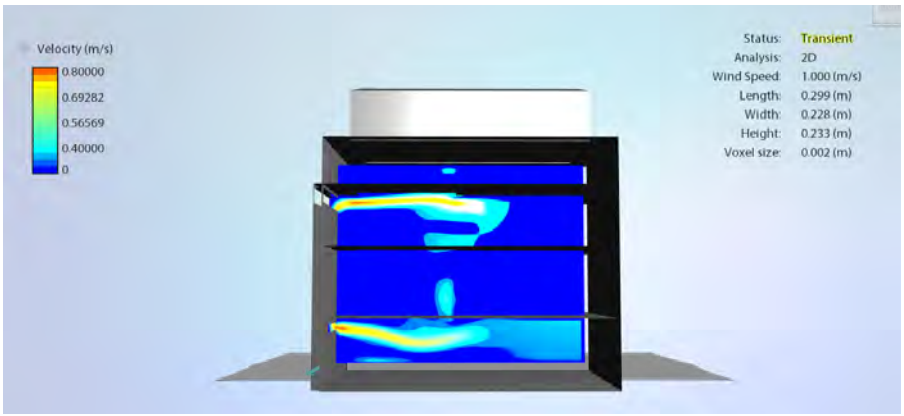

Figure 5. Analysis of the façade processed ventilation supply and mechanical suction going through the building

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Stichting
Promotie
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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.

Performance assessment of a dynamic insulation system

Author
ir. S.J.M. (Stefan) Koenders

Supervisors
ir. R.C.C.G. (Roel) Loonen
M.L. (Marie) de Klijn (MSc.)
prof. dr. ir. J. L.M. (Jan) Hensen

INTRODUCTION

BACKGROUND

Increased use of thermal insulation forms a key element of legislation and ensuing design guidelines that intend to reduce the environmental footprint of the built environment. With an emphasis on minimizing heat losses in winter, the widespread application of thermal insulation has proven to be very effective in the transition towards low-energy buildings in moderate to cold climates [1]. However, in modern-day building design, also some drawbacks of highly-insulated buildings are increasingly becoming apparent, as they can lead to heat trapping, with indoor overheating [2] or higher cooling demands [3] as a negative side-effect.

Over the course of a year, there are several periods in which it would be beneficial to have a large heat flux across the building envelope, rather than isolating indoor conditions from the exterior environment. This happens not only during cool summer nights when the ambient can act as a heat sink, but also on sunny winter days, when solar irradiance absorbed on the building's exterior can contribute to reducing heating energy demand. Construction elements with dynamically adjustable thermal transmittance properties could thus be a promising solution for reducing the energy consumption of buildings while improving the quality of the indoor environment [4].

CLOSED-LOOP DYNAMIC INSULATION

The research activities in this article focus on a novel type of closed-loop forced convective dynamic insulation system, here referred to as Active Insulation System (AIS). The system uses a structure of air ducts on the front and backside of the insulation panel in combination with two low-voltage fans to actuate an air flow. The system is sealed with aluminium foil on both sides to create a closed system. Figure 1 shows an exploded view and simplified section of AIS. When AIS is in the off-state (i.e. the fans are off), it acts as a regular insulation panel because the stagnant air contributes to achieving a high thermal resistance. However, when the fans are switched on, the insulation layer gets bypassed, thereby promoting heat exchange between inside and outside.

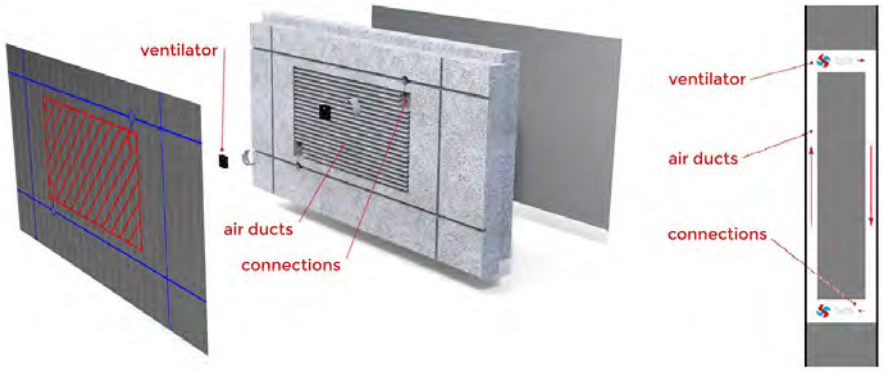

Figure 1. Exploded view and section of Active Insulation System *(www.active-insulation.com)*

AIS is a relatively low-tech solution, especially when compared to some of the other ideas for making variable thermal insulation. At present, only little is known about the technical performance potential of AIS. Such insights are necessary for making sensible cost-benefits analyses, and to provide directions for moving the research and development process into areas with high potential [5].

RESEARCH OBJECTIVE AND PAPER OUTLINE

Since AIS is a newly developed dynamic insulation system, the performance and characteristics of the system still need to be determined. This makes it difficult to compare the performance of AIS with other systems. The objective of this paper is therefore to investigate and assess the performance of AIS in the built environment.

DEVELOPMENT OF A MODELLING AND SIMULATION STRATEGY

SYSTEM DESCRIPTION AND REQUIREMENTS

The working principle on which AIS relies is heat transfer by means of air circulation in a closed system with one warm and one cold side wall. The AIS layer is typically installed in a multi-layer envelope construction, such that heat transferred by the air will be exchanged with the surfaces that are in direct contact with AIS. The system is designed to either block or increase the heat transfer through the façade construction of a building. The enhanced heat transfer is achieved by activating the fan in the system when a certain temperature difference between indoor and outdoor occurs. If there is no potential for useful heating or cooling through the envelope, the fan is off and the system is inactive. The combination of still air and a low conductivity material result in a high thermal resistance in off-mode.

Due to its possibility to function as both a heating system and a cooling system, it is evident that the control of AIS should change over time as a function of outdoor conditions. For heating, the activation should be based on an increased surface temperature due to solar radiation or a high outside temperature. If cooling is desired, activation should be based on a low outdoor (surface) temperature or possible radiation to the sky.

When AIS is in the 'on' state, it is often not sufficient to represent the AIS layer using a very low thermal resistance, because this approach would disregard the fact that the air circulation in AIS can sometimes function as an active heat exchanger. Moreover, research has shown that dynamic thermal storage effects are an important factor to consider when analysing the performance of dynamic insulation systems [6].

MODEL DESCRIPTION

The whole-building performance simulation tool EnergyPlus (v8.6.0) is used to model the performance of AIS. Starting point of the implementation is the existing Ventilated Slab model developed by Chae and Strand [7]. Ventilated Slabs and AIS both function on the principle of forced convection through hollow cores in a construction material. Activation of the system can be temperature-based, which meets the current requirements as it allows for dynamic control based on e.g. outdoor climate conditions. Heat exchange takes place between the air and the slab, which allows for storage of thermal energy in the slab. When the heat reaches the surface of the slab through transient conduction, the whole system acts as a low temperature radiative slab.

Even though there are many similarities between the implemented Ventilated Slab model and AIS, there are also a few major differences. The modifications that were made in the Ventilated Slab model to implement the characteristics of AIS are presented in Figure 2. First of all, AIS is divided into two parts: an indoor side and outdoor side (step 1). In the Ventilated Slab model, this can be modelled as two separate slabs that are connected in series (step 2). Finally, the heating and cooling coil and outdoor air mixer are removed, as AIS does not use conditioned outside air, resulting in two ventilated slabs in series with a supply fan to control air circulation (step 3).

The Ventilated Slab model uses a modified heat balance so that a heat source/sink can be implemented in the construction element. This source/sink term is caused by air flowing through the cores of the slab and its value depends on the temperature difference between the air in the cores and the interior temperature of the slab. The same modelling method has been used before for hydronic radiant systems, and was extensively validated.

A schematic thermal resistance diagram of a typical wall (1) and a wall equipped with AIS (2) is shown in Figure 3. If the fan of AIS is off, the system behaves the same as a typical wall. The main difference between the two situations is the heat being transferred by AIS between point 1 and 3. Because of this heat transfer, the temperature at point 3 (T3) will be relatively similar to the temperature at point 1 (T1). This represents the bypassing of the thermal resistance of AIS (Rcond, 2 and Rcond, 3).

QUALITY ASSURANCE – STUDIES PRELIMINARY SIMULATION

FAÇADE SYSTEM CHARACTERIZATION (U-VALUE)

Before proceeding on to the dynamic simulations on building-level, the model implementation is verified in a case with known boundary conditions.

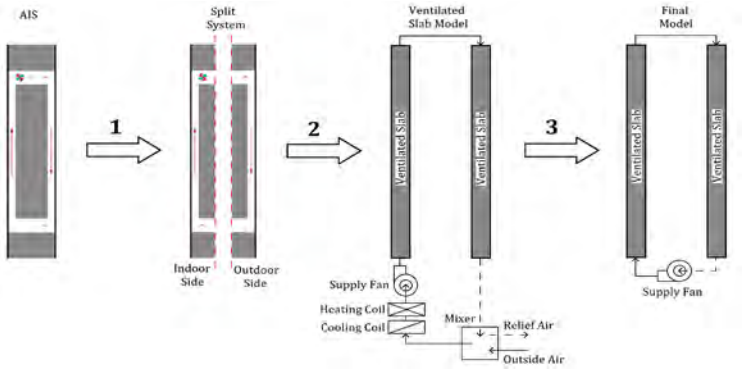

Figure 2. Schematic process of implementation of AIS in the Ventilated Slab model.

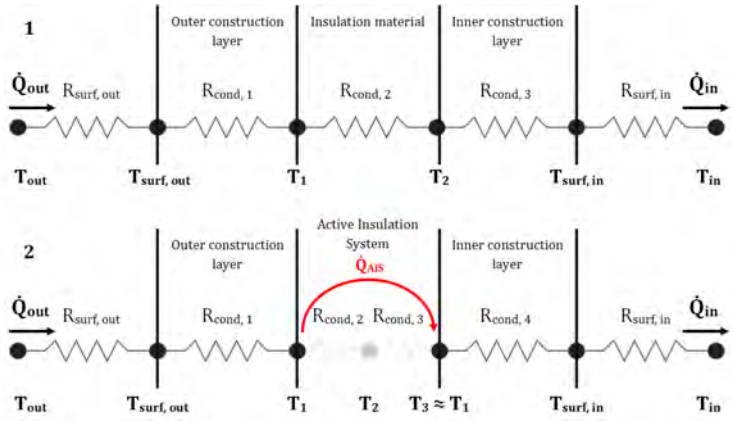

Figure 3. Thermal resistance diagram of (1) a typical wall and (2) a wall equipped with AIS.

For this purpose, the U-value of AIS is numerically determined by mimicking a hot box situation in compliance with EN-ISO 8990. The calculations are done using the AIS specifications in Table 2. The total thickness of the system is 160 mm.

Two hot box simulations are performed, one when the system is off, and one when the system is on. The off-state results in a predicted U-value of 0.185 W/m²K; this value is identical to the value obtained by hand calculations following the assumptions in the ISO standard. When the fans are activated, the U-value of the slab increases to 1.657 W/m²K and thus a ninefold increase of the heat exchange rate.

Table 1. Characteristics of the different components in AIS

Component	Specification
Insulation Material (EPS Insulation)	λ = 0.033 W/mK ρ = 30 kg/m³ cp = 1500 J/kgK
Air Channels	Channel diameter: 0.005 m Channel spacing: 0.01 m Channel length 0.8 m Channels per side: 20
System Fan	Fan: 50 x 10 mm 5 Volt Mass flow: 0.0047 m³/s (≈ 10 cfm)

CONTROL CONSIDERATIONS

The model as described before has shown to be able to adequately predict the behaviour of AIS in both the inactive and active situation. An additional aspect to check is whether the operation logic (i.e. control strategies) of the original Ventilated Slab model is also suitable for AIS. An in-depth study to investigate this issue was done, and from this study it can be concluded that with a slight modification in the EnergyPlus source code, to bypass a check that causes unwanted deactivation of the system, and a dual setpoint strategy based on outdoor surface temperature, the control system is suited for predicting the performance of AIS.

CASE STUDY DESCRIPTION

A typical Dutch detached residential building is used to analyse the impact of AIS on energy use and indoor overheating risk. Table 2 presents a brief overview of the building characteristics. Based on recommendations from earlier research [8], the weather conditions used for the simulations are from a continental climate, in this case Stuttgart, Germany. The base case building does not have an air conditioning system, as a goal of the research is to study the effect of AIS on overheating during the summer.

Table 2. Reference Building Characteristics

Envelope part	Properties
Envelope	R-Value façade: 6.00 m²K/W R-Value ground floor: 5.00 m²K/W R-Value internal floor: 0.32 m²K/W
Windows	U-Value glass: 0.70 W/m²K U-Value frame: 2.40 W/m²K g-Value: 0.501
Shading	External blinds, lowered if solar radiation > 350 W/m²
Ventilation	1.5 dm³/sm², heat recovery ventilation with summer bypass
Infiltration	0.400 dm³/sm², corresponds to an air change rate of 0.08
Setpoints	From 06:00 – 23:00: 20°C, setback temperature 18°C

COMPARISON OF PASSIVE COOLING MEASURES:

The passive cooling measures that are compared in this study are shown in Table 3. Night ventilation is modelled using a fixed air change rate per hour. The control strategy for night ventilation is based on an extensive literature study [9]. The shading system used is a highly reflective, low transmittance shading screen, with an activation setpoint of 250 W/m² incident irradiance. Overhangs are placed at the east and south facing windows.

An AIS panel consists of a static part and an active part (Figure 1). The active part is the actual heat exchanging surface with the air ducts and fan, whereas the static part consists of regular insulation around the mounting points. To take the impact of this static and dynamic part into account, three simulations are done with different active surface areas, respectively 100%, 50% and 25%.

PERFORMANCE INDICATORS

For comfort evaluation, the adaptive thermal comfort model for dwellings described by Peeters et. al. [10] is used. This adaptive model links the indoor comfort temperature to the outdoor temperature and also allows for higher indoor temperatures during periods with several consecutive warm days. A 90% acceptance is reached with an allowed comfort region of 5°C and an 80% acceptance with a comfort region of 7°C. Assessment of the exceedance hours will occur during hours with presence from March until November, as these are the months with temperatures that can lead to overheating of the dwelling.

The primary energy consumption to achieve the predicted heating demand will be calculated for the different cases, as one of the benefits of AIS is the expected reduction in heating demand. A water/air heat pump with a COP of 3.0 is considered. The price per unit of energy is €0.18/kWh for electrical energy, based on typical consumer prices.

RESULTS AND DISCUSSION

THERMAL COMFORT

Figure 4 compares comfort conditions in the living room for the different cases, expressed as exceedance hours of the comfort boundaries. Even with a low effective surface area of AIS, the amount of exceedance hours can be reduced significantly. Increasing the effective surface area to 100%, decreases the exceedance hours even further.

Similar results show for night ventilation with higher air change rates. However, achieving a constant air change rate of 3 or 5 is relatively difficult since , among other things, natural night ventilation is influenced by temperature differences, wind speed, wind direction and pressure differences.

Table 3. Characteristics and control strategies of the studied passive cooling measures

Passive Cooling	Characteristics	Control Strategy
Night Ventilation	1 ACH per hour	06:00 – 24:00 $T_{ambient} < T_{operative,inside}$ & $T_{operative,inside} > 25°C$ 00:00 – 06:00 $T_{ambient} < T_{operative,inside}$ & $T_{surface} > 22°C$ & $T_{ambient} > 10°C$
	3 ACH per hour	
	5 ACH per hour	
Shading	HR-LT screen:	T-sol = 0.1 R-sol = 0.8 Lowered at 250 W/m²
	Overhang 1.0 m	-
	Overhang 1.5 m	-
Active Insulation System	25% effective surface	Lower setpoint heating = 20°C Higher setpoint heating = 22°C Lower setpoint cooling = 22°C Higher setpoint cooling = 24°C
	50% effective surface	
	100 % effective surface	

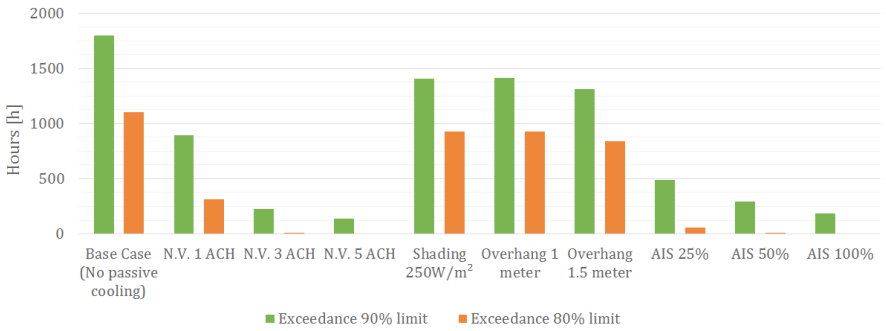

Figure 4. Amount of time the operative temperature in the living room exceeds the 80% or 90% comfort criteria for the different passive cooling measures.

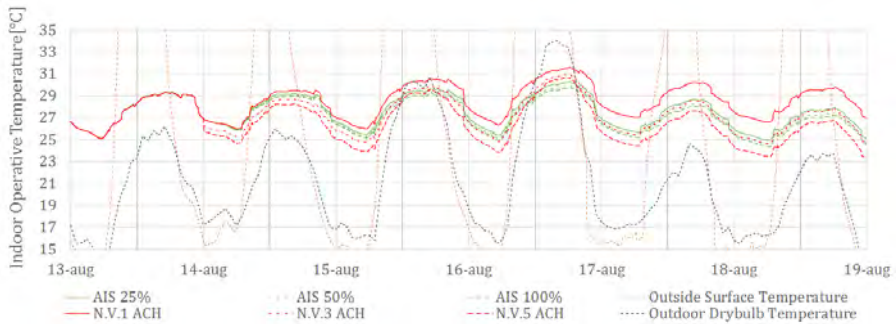

Figure 5a. Inside surface temperature gradient of the south facade for the AIS and night ventilation cases.

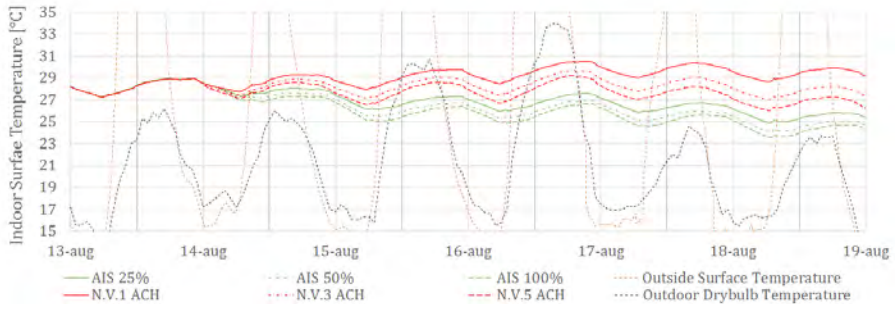

Figure 5b. Operative temperature gradient in the living room for the AIS and night ventilation cases.

TEMPERATURE DISTRIBUTION

As AIS and night ventilation show similar effects in terms of decreasing the number of exceedance hours, a detailed study was performed for a summer period (13 August – 18 August). From Figure 5a, it can be seen that the operative temperature in the living room does not deviate much between the different AIS cases, and is similar to the temperatures achieved with night ventilation. A comparison of the indoor surface temperature, on the other hand, shows a much bigger difference between the two measures (Figure 5b). By cooling the thermal mass directly, AIS can achieve lower surface temperatures for all cases. The graph shows that, as time progresses, AIS can reduce the surface temperature, while the surface temperature stays roughly similar when using night ventilation.

HEATING DEMAND

Figure 6 shows the annual specific heating demand of the living room. Applying AIS is the only situation where the heating demand decreases, in

which the highest effective surface area leads to the lowest heating demand. In comparison with any of the cases, the Active Insulation System can reduce the heating demand with 16%-22%, depending on the amount of effective surface area of AIS. This is a result of heat transfer to the living room on sunny winter days when the outside surface heats up due to solar radiation.

AUXILAIRY ENERGY

Of all compared cases, AIS and night ventilation based on mechanical ventilation use auxiliary energy. The power of a small fan used in the AIS panel is estimated at 0.5 W. For night ventilation, the energy consumption is based on the power output of a commonly used residential heat-recovery ventilation system. AIS uses between 19 kWh_{el} and 66 kWh_{el} auxiliary energy yearly. Night ventilation uses significantly more auxiliary energy as a result of the much higher power of the fan, between 31 kWh_{el} and 289 kWh_{el} per year.

ENERGY COSTS

With the auxiliary energy consumption, the overall yearly energy costs are calculated. The primary energy demand for heating is calculated based on the specifications of the heating system and the annual specific heating demand. The total annual energy costs are shown in Figure 7, specified for heating and auxiliary energy. From the results it can be seen that even though AIS uses auxiliary energy to achieve a reduced heating demand and improved thermal comfort conditions, it has the lowest yearly costs. In comparison with mechanical night ventilation, where thermal comfort is similar or in some cases better than AIS, AIS uses significantly less auxiliary energy. These auxiliary energy costs for night ventilation can be neglected if natural ventilation is used. However, as stated before, the simulated constant ventilation rate is not achievable with natural ventilation, as building parameters and varying weather conditions influence the ventilation rate of natural night ventilation.

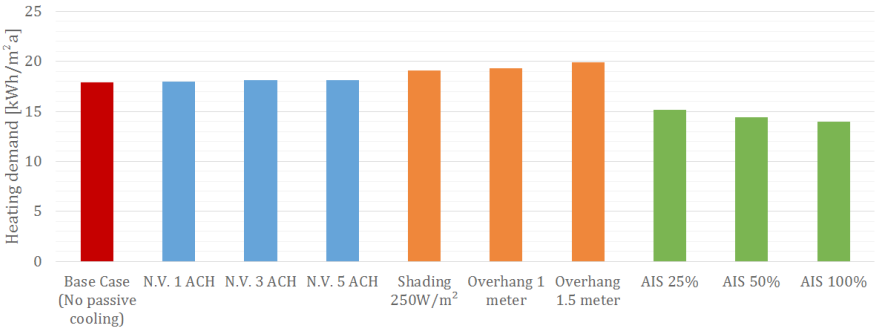

Figure 6. Heating demand in the living room for the different simulated cases. In green, blue and orange are all different variants for AIS, night ventilation and shading respectively.

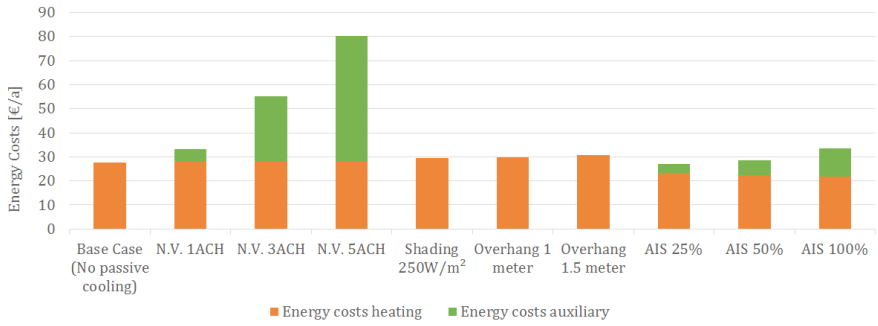

Figure 7. Annual energy costs for the living room with a heat pump installed. A division between the costs for heating and the auxiliary energy is made.

CONCLUSIONS

In this research, a newly developed dynamic insulation system for low-energy buildings based on forced convective heat transfer is studied. A computational model is developed to simulate the performance of AIS and the performance of AIS is compared in different situations. First analysis of the application of AIS in a representative building envelope construction showed that a low U-value of 0.185 W/m²K can be achieved in off-mode and a U-value of 1.657 W/m²K in on-mode. Applying AIS in a case study resulted in 72-90% less comfort exceedance hours, depending on the effective surface area applied. Similar results were seen with higher night ventilation rates. However, AIS also reduced the specific annual heating demand with 16-22%, while using 75% less auxiliary energy than night ventilation. ■

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Stage of afstuderen bij Nelissen ingenieursbureau?

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At BaseClear, sustainability is part of our DNA

Author
Deerns

More than 18,000 people divided over almost 200 companies and organisations work at the BioScience Park in Leiden. From start-ups to Nasdaq listed corporates. The park in Leiden belongs to the top five most successful European science parks. One of the faster growing companies at the park is BaseClear, a research organisation employing sixty people in DNA research. The company is currently building a new business premises, the first at the BioScience Park in Leiden to have a BREEAM Excellent label.

BaseClear is the largest independent commercial DNA research laboratory in the Netherlands. It carries out DNA research, mainly for other companies for which they are an extension of their R&D department. BaseClear's DNA analyses focus primarily on improving products and processes. By reading, understanding and then improving DNA, BaseClear helps customers such as DSM, Danone, Friesland-Campina and DuPont to optimise their products. This ranges from improving the enzymes in a detergent to eliminating a disease in a crop. Quality controls, food safety inspections, forensic research and paternity testing are also areas in which BaseClear is active.

PASSION

The BREEAM Excellent label for the new build of BaseClear is a logical choice. The company, where mainly biologists work, wants to be a company that is involved in society. Its staff members are aware in their choices and way of life and BaseClear encourages this. This has also in part determined the composition of the construction team. BaseClear has engaged Popma & Ter Steege as the architects because this firm is passionate about sustainable building. The architect has made a general cost and investment estimate based on the list of wishes and requirements. Because the work to be done is contracted out directly by the owner, focus can be directed to the total cost of ownership. So BaseClear does not have to deal with the traditional division between investment and operating costs, making the choice for investing in more efficient technology easier.

BaseClear has pursued the maximum end result from the very beginning. By putting sustainability at the centre, this has become a shared, cross-discipline challenge. This integrated approach to the new build is essential for achieving the sustainability ambition. Decisions have to be made in many areas that influence each other and which therefore need to be coordinated and are bounded by a budget. This requires in-depth understanding and insight, a broad view and, above all, the will to collaborate between the parties involved, including Deerns as a system consultant.

COMPACT BUILDING

A BREEAM score consists of nine parts, each with their own credits. Management, Health, Energy, Transport, Water, Materials, Waste, Land Usage & Ecology and Pollution. A laboratory uses significant amounts of energy. There were a lot of measures to choose from to achieve BREEAM Excellent. The shape of the building had to be as compact as possible, creating a good relationship between the building envelope and the contents. Compact building also ensures a well-functioning building with short walking distances and limited use of materials. The most striking additional measures that have been taken are a water channel for rainwater drainage, nearly 300 m2 of PV panels on the roof, LED lighting, energy efficient systems and connection to the oversized ATES system of the Biopartner Foundation. BaseClear's policy also contributes to the BREEAM-excellent score by encouraging cycling and public transport.

STREAMLINE

Although the new build houses a lot of technology and complex logistics, the ambition was always to create a friendly, open and welcoming building. A lot of people visit BaseClear every day: customers, development partners, students. The design is characterised by gentle curves that turn into long straight lines. The streamline design is combined with a lot of glass. The reception hall on the first floor is connected to the entrance by a large, wide wooden staircase. An atrium is located centrally in the building. The laboratory and all the technical systems have been brought together on the third floor. BaseClear has its own in house lecture room. ■

PROJECT INFORMATION

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Study Abroad Göteborg, Sweden

Author
T.H.M. (Tom) Houterman

Since January 2018 I started studying for one semester at Chalmers University of Technology in Göteborg. The regular articles about studying abroad would say this was a lifetime dream of theirs, for me this was a different story. Going to study abroad wasn't on my mind for a long time, but this didn't stop me from doing it. Going abroad was more of a spontaneous decision. It has been one of the best decisions I have ever made. The first step is always a scary step to take, but I can recommend to just do it!

Figure 1. Reindeer in Sweden

With looking for a study abroad, a new journey began. First step to take was to explore every possible partner university. A personal interest of mine is to travel the world, an important aspect of my choice was the location (options to travel to other cities) and the city's possibilities. Of course, the offered educational program of the university must match your interest. So, for me it was a combination of educational program, location and city's possibilities.

Early in the year, at the beginning of January I travelled to Sweden to have a look around in Upsala and Stockholm. I arrived a week before the start of the academic semester in Göteborg. It is recommended to start looking for a living area when you are in Sweden, because of rental fraud. I was quite lucky and found a cheap place to stay quite fast. While a lot of people I met over here had some difficulties in the beginning, eventually everyone found a space to live.

D-day, the first day in a new environment is always nerve-racking and you never know what will happen. Everyone is in the same situation as you, 150 Erasmus students, all individuals just like you. It is nothing to be afraid of, it is a time of making a lot of friends, partying, having fun and a lot more. On the other hand, there is the educational side of the study abroad. Chalmers is high on the list of top ranking universities in the world, so I was quite confident about the level of education there. You can compare the level of education to the TU/e.

Eventful life: that is the best description of my study abroad. I have done a lot during my study abroad. I travelled to a few new places; my first trip was to Lapland where I did dog sledding, drove a snow mobile, went ice climbing, visited Sami people, saw reindeers and the Northern Lights in Kiruna and Abrisko. On this trip I also went to Narvik, Norway for a day. Other cities I visited are Copenhagen, Malmö, Riga, Oslo, Stockholm, Helsinki, Prague, Warsaw and Krakow. Beside traveling, I also experienced Gothenburg to the fullest, a few examples; friends and I spent the night in a cabin with a sauna next to an ice lake. The idea of the sauna is to get into the ice lake after the sauna. We also did a lot of sightseeing. We barbequed in the snow and went to lots of parties and festivals.

Nowadays more and more people are going to study abroad, and I have to say, they are definitely making the right choice. It is an experience you will never forget, and it enriches your world. You personally develop yourself and at the same time you have the best time of your life. ■

Figure 2. Night out in Sweden

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