Academic year 2018 - 2019 #2 | June

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

Study Trip 2019: Russia

s.v.b.p.s. Mollier

Microorganism Application in Designing Hydrophobic Concrete

ir. Y. (Yifeng) Zheng

Occupancy-based Lighting Control

dr. ir. C. (Christel) de Bakker

OCCUPANCY-BASED LIGHTING TAKEN TOO FAR...

Foreword

Diyako Shadmanfar

Dear INSide reader,

The INSide committee is proud to present you the second edition of our magazine to close off this academic year. We can look back at an interesting year for Mollier with the first BPS exposition organized. Also, as you might have guessed from the cover, this edition of the INSide we look back at this year`s study trip which brought us to Mother Russia!

Always looking into providing a platform for our fellow BPS-students, Unit BPS, and sponsors, this edition of the INSide features a wide variety of articles. Yifeng Zheng has written an article regarding his master graduation project on the application of Microorganisms in Hydrophobic Concrete. Other articles of fellow BPS students dive into the masterprojects with topics ranging from the effect on indoor airflow by new windows in Atlas, to CO_2-concentrations in babycribs in daycare centers, to control strategies for advanced solar shading systems. Recently promoted PhD-canditate Christel de Bakker has provided us with an article summarizing the research she has conducted over the last four years regarding occupancy-based lighting. This edition, we kick off a new rubric called Basic BPS. The aim of this rubric is to introduce fresh master students and bachelor students to basic concepts and topics within our field of BPS. For this edition, dr. Hamid Montazeri gives a quick overview of the application of CFD in the built environment.

Our sponsors also provided us with articles, Kuijpers gives us a nice insight into the company with a Q&A between CEO Aukje Kuypers and former Mollier Members, now working for Kuijpers Jelle Reinders and Pim van der Putten. BAM and Arcadis have provided us with insightful articles as well, preparing us for the future.

To conclude, the INSide committee always works hard to maintain the quality and evolve the magazine where we can. We are always looking for new enthusiastic editors in the committee. Feel free to contact us, if you`re interested

Enjoy reading!

Yours Sincerely,

Diyako
Editor In-Chief

Editorial Team INSide
Bram Dorsman, Meghana Kulhalli, Diyako Shadmanfar, Don Bremmers, Margo van den Eijnde

COLOPHON

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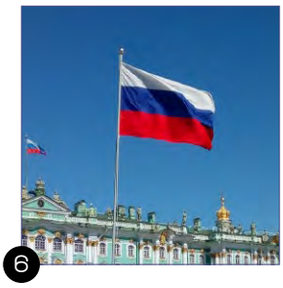
Visiting address
TU Eindhoven
Vertigo 2nd floor

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

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

Inside This INSide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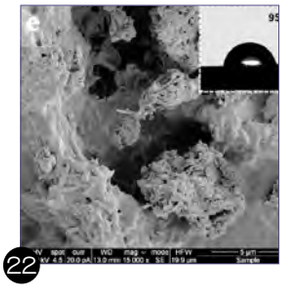
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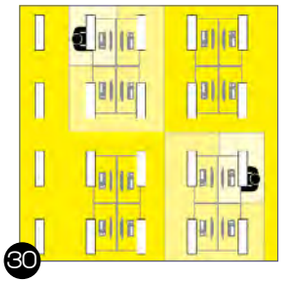
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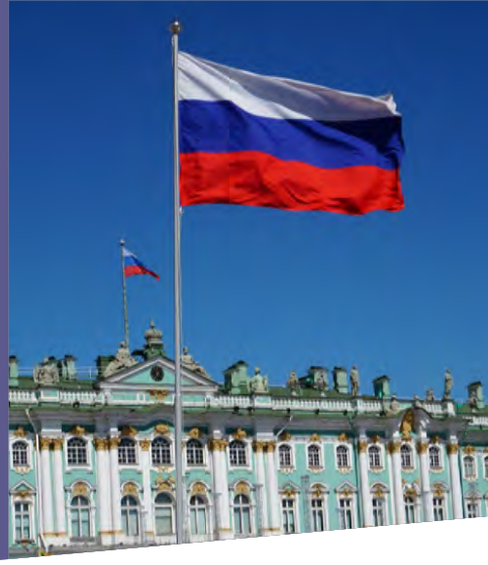
MOLLIER & MEMBERS

BUILDING PHYSICS & SERVICES

COMPANIES

Study Trip 2019 Russia



Authors:
Study Trip Participants 2019

DAY 1

Monday morning, around 8:00, most of the group took the train to Schiphol at Eindhoven Station. We gathered at the meeting point at half past nine. After taking a group photo with the banner, the trip could start for real!

The security checks went well and with time to spare we arrived at our gate. Unfortunately, the flight had a one hour delay. After a flight of around 3 hours with great service, we arrived at St. Petersburg. Reaching the hostel by metro and bus took us an hour. After settling in, we went for a delicious pizza and closed the day off with some Georgian beers.

Our first impression of St. Petersburg is very positive, so we are looking forward to the next days.

DAY 2

Today was our first full day getting to know St Petersburg and Russia in general. We began at 7:30 with a delicious breakfast delivered by our wonderful study trip committee.

At 8:30, we started our way to meet with Sasha, our tour guide for the day. As a born and raised St. Petersburger she knows all about the city, the main spots and how to avoid crowded touristic places/times.

First, we visited the Palace Square in front of the Winter Palace, which is, in fact, larger than the Red Square in Moscow. From this square we could see the outside of the buildings that form the Hermitage complex, which is famously known for its size. Afterwards, we went for a stroll in the city center, walking by the Neva river, and having a look at the other side of it, where we could see the fortress and the old port. Sacha provided information about the history and the importance of these buildings for the city. Later on, we walked to one of the main spots in the city: the Church of the Saviour on Spilled Blood. The building itself and its mosaics, which represent the life of Christ, are very well conserved.

Thereon, we walked by a few souvenir street shops, with a lot of matryoshkas and Putin images, until we arrived at Kazam, which is an Orthodox Church, which architecture esembles a Greek temple (huge dimensions and columns).

After lunch, we continued our day with a different type of tour: we went to visit a Green Building owned by Gazprom, which has won the Leed Gold Certificate in 2018. It was very interesting to learn about how the building was built (in 2013) and maintained. We had a presentation given by the main engineer of the project and a tour through the building facilities.

We then visited the Gazprom building, we were having dinner together. This dinner took place in a vegan restaurant named Jiva, which was specialized in making vegan burgers. The food came just in time so we could make it in to the cultural activity of the evening: watching the Swan Lake ballet performance at the Alexandrinsky Theather (which was very, very fancy).

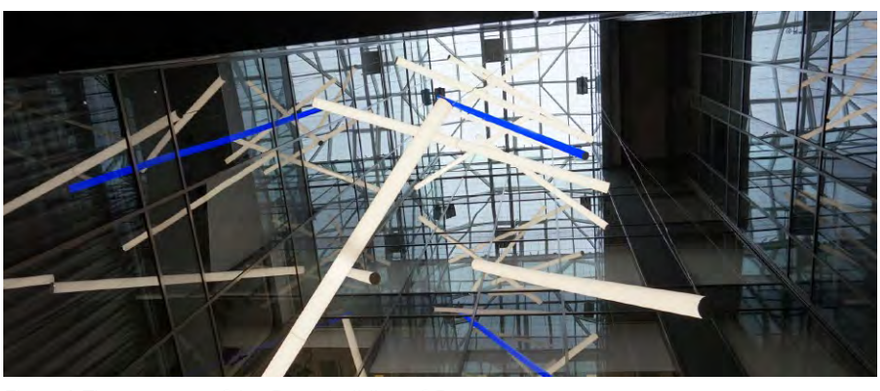


Figure 1. The entrance of the Green building of Gazprom.

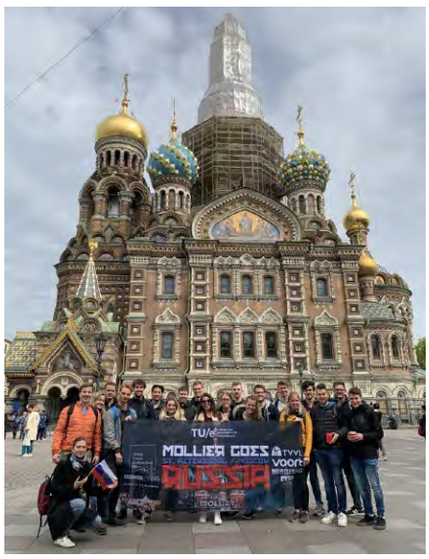


Figure 2. Standing before the Church of the Savior on Blood.

The ballet was very nice and the classical Tchaikovsky concert was amazing. Some of us didn't have the best spots to see all dancers, but the ambiance in the theatre and the music which was played were reason enough to have an enjoyable time. After the ballet, the group had free time to go to bars try out the Russian nightlife and drinks.

DAY 3

We visited two companies this day, our first company visit was at Eco Union, where we were introduced with their eco label which analyses the life cycle of products. They explained that they are an independent company that fulfills a necessary task, which unfortunately is not regulated by the government. We had an interesting discussion about the labelling in Europe, the expectation was that European people trust the European labelling more than Russian people and are more informed.

In order to check whether a label can be trusted, they developed an app called Ecolabel Guide which uses AI to detect any label on a product packaging and tells you more about the background of the label.

The second visit was at a Dutch company Heinen & Hopman. They introduced us to the challenges they face when designing the services in modern ships. The projects vary from fishing boats to container ships and even icebreakers for arctic waters. The main challenges occur due to the extreme climates at sea, the limited amount of energy and the fact that there is a lot less space available compared to a building. They also explained that the room which is available for the services is set before they design the systems, this results in systems which are specifically designed for a vessel. This combined with the low level of interest in the HVAC, makes it necessary to be flexible and to work around other parties in order to achieve the best comfort at sea.

Some people also visited the viewing point that watches over the Lakhta tower. This building is still being constructed, but it is already the highest building in Europe. Unfortunately, it was not possible to enter the building due to the phase of the construction.

In the evening we ate at a very cheap Russian restaurant (Ikopeyka) that served a buffet, however: after most of us where finished eating we found a few reviews that made us wonder whether we would make it to the next day... Hopefully to be continued!

DAY 4

The fourth day of the study trip started off with a nice sleep in, breakfast started at 8.45. Unfortunately, the extra sleep was not enough for Martijn, who by accident added salt to his morning coffee instead of sugar.

Figure 3. The view on the Lakhta tower.

Figure 4. Having a presentation by Renaissance Construction.

At 9:45 we left the hostel, nicely dressed in our studytrip sweater to go to Renaissance Construction. It was a one-hour travel to get there by public transport.

When we got there, we were welcomed by Elena and Anastasiia who were waiting for us outside the office. We were guided to a conference room, where we were able to grab some water and coffee. We got several presentations from different engineers; they all were able to tell something about their own expertise. They mainly told about the Lakhta Center (the highest building of Europe), where they did the realisation of the tower and the engineering as well as the realisation of the wings besides the towers.

A structural engineer then told us about the structural design and integration of HVAC of Lakhta Center. The available ceiling height was very limited, making this a very challenging project. They had to make the ducts cut through the steal beams. Very useful during this difficult project was Navisworks, which was used as a clash control program. In total several different models were used for the wings of the Lakhta Center. They also elaborated upon other software that they commonly used.

They also told about the construction of a storage building for liquid gas in the Yamal area (at the North of Russia where extreme lows of -50°C are reached). This project was built in Murmansk (city in Russia next to Finland), from where the huge construction parts were shipped to the Yamal area.

Then for the technological highlight of the day, we had a VR experience in the equipment room of the Lakhta Center wings. Some of the students were able to walk through these crowded spaces using the VR glasses.

We finished off the visit with a very big, luxurious lunch in the company restaurant. This was good preparation for the next stop, the Vodka Museum.

It was a one-hour travel to the Vodka Museum. We got a tour where some fun facts were told about the history of Russian Vodka. The exhibition was varied, going from knick-knacks to historical political statements and the history of corks and glasses. The practical part was next, three types of vodka were waiting for us: plain, grass and a gin like vodka. These shots were accompanied by three different Russian snacks: anchovy with onion on bread, the fat of bacon on bread and a salted pickle.

The dinner was luxurious and a refined taste for student standards. However, not all food was ready on time, so some had to wait for their meal. Youri also got his dessert before his main dish, which was an unwanted unique experience.

We finished off the day in a café crowned as 'de Stamkroeg'. Everybody played some card games and drank some beers. We quit right before Bram was a full donkey, so he dodged the bullet (vodka shot) there.

DAY 5

After several days of company visits, this day was a day filled with fun- and cultural activities. First we went to the Izaäkcathedral to climb 200 steps to the upper part of the cathedral. Due to the beautiful weather we had a perfect view of the city of St. Petersburg. When we were enjoying the view of the city, we saw a beautiful rooftop terrace. Down again, we walked into a hotel to find out that it was a 5-star hotel. After talking briefly to the staff, they were happy to let us drink a coffee on the rooftop terrace and enjoyed again a beautiful view in the sun.

At the same time another group went through the city on a segway to view some highlights of the city. To enjoy the beautiful weather, almost everybody was resting in a park.

As a fun activity, we had the opportunity to go to a shooting range to experience the feeling of a real Russian pistol under supervision of an instructor.

Some people wanted to try more types of weapons and decided to go for the ultimate Russian experience.

After this last activity of the day we ended the day with a nice burger at Nevski Prospekt.

DAY 6

After a good night out, we got up quite early in the morning for breakfast at 8:00 in order to be on our way to Peterhof Palace on time: a two-hour trip with the metro and a small van in which some people even had to stand. In due time, we arrived at Peterhof Palace – the Versailles of Russia – to admire the vast wealth of the Russians. Due to time constraints, we only saw the palace itself from the outside, but we could enjoy the gardens for some hours.

In the garden we found small palaces and a lot of beautiful fountains. It was really refreshing standing next to the fountains with the weather being as sunny as it was. The day was perfect for being outside and just wandering around the gardens and enjoying the surroundings. It was visible that the design of the gardens was well thought out and perfectly realized. Adding to the experience, there was an act at the palace that people could see from the gardens and the bridges. There were dancers and opera singers. You could hear the singing through a big part of the park so a lot of people could enjoy it.

After a couple of hours of roaming around, we went back to the city. Some chose to go by boat, and some took the cheap bus. The boat was faster than the bus and it was amazing to be able to see some things from the water we only saw from the ground standing next to it. When arrived at the city, the boat group went for a drink and the bus group went back to the hostel to freshen up.

We all met up for dinner in an English pub where we had some nice English food to change it up, after which we went to the Hermitage for the city-wide night of the museums. Unfortunately, it turned out that only a small section of the building was open for exhibition and the main museum wasn't opened at all this night. So again, as yesterday, we left the Hermitage a bit disappointed. Most people went back to the hostel to play some games while others remained in the city to get a few drinks. Despite of the Hermitage being closed, we all made a nice night out of it.

DAY 7

Today was our last day in St. Petersburg, and also our day free to spend in this beautiful city. Although the night was short for most people, a big group woke up early and went to the Hermitage, which is one of the biggest museums of the world with several exhibitions. Both the building itself and the different exhibitions were very impressive. Besides that, other plans were made such as: enjoying the nice weather in the park, buying souvenirs, exploring the rest of the city and visiting other museums like the etnographic museum and the Faberge museum. A Faberge egg is an artsy Russian egg, and according to Nora it was "Eggscellent". The day ended eventually with some drinks and games.

DAY 8

Around 8:00., people started to wake up. This day, our trip to Moscow was the main activity. Where some had the priority to sleep in, a few fanatics wanted to do some more cultural activities in the morning. A few went to the museum of the St Isaac's cathedral, while others decided to visit the fortress of St. Petersburg, where also a beach with a beautiful view along the shores was located, and where the cannons were fired at 12:00 sharp.

In the afternoon, it became time to leave the gorgeous St. Petersburg behind and take the train to Moscow. When we arrived at the railway station, we had the brief hope that a high speed train would be the one bringing us to Moscow, but we had the "slow" train waiting for us at the other side of the platform.

Around half past seven, we arrived in Moscow. After a short metro ride, we reached our hostel, where we would be staying during this week. What we all immediately noticed was the beautiful metro station, which is a signiture characteristic of Moscow.

Figure 5. The fountains in the garden at the Peterhof Palace.

Figure 6. The Hermitage.

Afterwards, it was time to have dinner, at an Italian place which also served sushi, and at a typical Russian restaurant. At this last restaurant, the food was excellent only the staff a bit grumpy. Later that night, we all took some rest after the long day of travelling.

DAY 9

Early in the morning, half of us were delighted with sunshine and the sound of traffic at half past five. After a bit more sleep, we enjoyed a delicious breakfast in our new hostel. After a short ride in one of the most beautiful subway systems in the world, we arrived at the current highlight of Moscow: Zaryadye Park. This park was built a few years ago in the heart of the city with a budget of more than 500 million dollars and shows the ecology of the various climatic areas Russia has to offer. After a somewhat disappointing tour, a short visit to an industrial cooling cell defined as ice cave and the bridge with the largest span which isn't a bridge, we went to the

Figure 7. The Saints Peter and Paul Cathedral on the fortress.

starting point of the Tour du Kay.
Kay showed us some of Moscow's highlights, such as the Red Square, Saint Basil's Cathedral, the GUM shopping center, the Bolshoi Theater and one of the seven sisters. The Saint Basil's Cathedral is one of the most recognizable buildings in the country and contains several churches connected by a maze of corridors. The seven sisters are some skyscrapers in Moscow that were built as a symbol of power by Stalin. The end point of the tour was at Bunker 42.

This bunker, which is no longer in use, is located 65 meters below the city and used to house a nuclear command base. After a long descent and an interesting tour, we were part of a simulation in the old control room, where Arjan had to destroy an American city-which he happily did.

After a good Vietnamese meal, served in a Russian way, and a test of our first-aid skills, we ended the evening in our new 'stamkroeg'. At the end of the evening two people from the Russian Green Building Council joined us, who provided many interesting insights into Russian society.

DAY 10

Today, we started off early with breakfast at 7:30 before heading to BPS International by metro and bus. BPS international is part of a Russian-German holding which includes development, general contracting and management structures. This allows them to offer the full extent of the project.

We got a presentation about the company and BIM. BPS international also uses 4D and 5D BIM in their projects. They also used BIM for the building their office is located in. After the presentation, we got a tour of the several installation rooms where all the pipes, pumps and sensors are located. Then we got the chance to look into the Revit models of some of the projects BPS International is working on.

Figure 9. Gathering around the installations in the building of BPS International

After the visit we went to the canteen nearby to get some lunch before heading to the second company visit of the day: Apex project bureau.

After an hour of travelling we arrived at Apex project bureau. Apex' key field of work is architecture and with their 600 employees, it is quite a big company. Their main work is mostly related to residential buildings. With their designs they try to break away from traditional. designs. They make use of a very large open plan office where everybody can work.

First, we got a small tour around the company and then we were seated for a presentation. The presentation was about Apex in general and then the BPS department came over to present about their work. The BPS department only has 4 people working on several simulations and advices during the several stages of a project.

After the visit to Apex, we went back to the hostel to get ready for dinner. Some of us went to a bar nearby to quench their thirst, while others freshened up in the hostel.

We went for dinner at a nice Georgian restaurant, where most of us had some traditional dishes. Everyone had a really nice dinner and most of us went to a bar do get a few beers before bedtime.

DAY 11

Today we visited Moscow State University of Civil engineering. At 10:00, a student Daria welcomed used with an introduction about the university. After this introduction, we got a lecture about aerodynamics in architecture and construction from Alec. Afterwards, he gave us a tour in a labratorium were we saw a windtunnel. At 11:00, we went to the research center "Smart city" where we got an innovative impression of a smart room. Before the lunch, we went to two constructive laboratories were we saw a steel bar breaking with a lot of noise at a tension of 520kN. After this intensive morning, it was time for a break so we went to the canteen where we got some nice lunch. After lunch we visited the Nano technology research centre.

We ended with a visit to the heat, gas and ventilation research center. At this research center different small installation systems were shown. In Russia, it is more common to have this kind of center at a university.
After this interesting visit, we had some free time. Some people went to the big impressive shopping mall 'Gum' at the red square, others visited the All-Russian exhibition center. At this exhibition center, all the pride of Russia and the former Soviet Union was presented (from buildings to spaceships). The day was ended together while enjoying a drink.

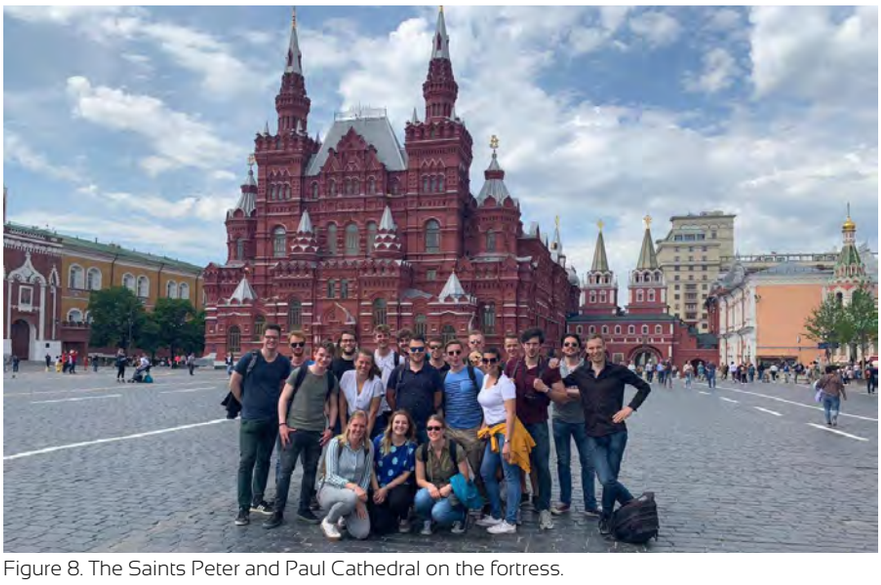


Figure 8. The Saints Peter and Paul Cathedral on the fortress.

Figure 10. The House of peoples of Russia in the All-Russian exhibition centre.

DAY 12

Today was one of the most exciting day so far. We got up rested after a good night of sleep and headed to the North-West of Moscow for the meeting with Guy Eames, our contact person from Russian Green Building Council. We have visited a Holiday Inn hotel, where we were given a presentation regarding the installations in this 30-year-old building. It was equipped with quite an uncommon system with decentralized heat pumps for increased flexibility of temperature in various rooms.

The second part of the day was organized by Reinessance Construction, a mother company of Ballast Nedam. We were received near the Neva Towers by Dennis, Tom and Ricardo from BN, who flew from the Netherlands to show us their project in Moscow. We have also been joined by an architect of Neva Towers who told us a lot about the buildings and implemented technologies. Every participant received safety gear and we headed to the 45th floor of Tower 1, still under construction, where we could see the current state of the project. After some explanations from the engineers on site, we descended down the Tower 1 and into the very top of Tower 2, to enjoy the view over the city from the terrace.

For most of us it was the first time visiting a high-rise building (320m) during its construction, which was very exciting. We have ended the day with a drink in Moscow City area together with Dennis, Tom and Ricardo.

DAY 13

About 9:00 in the morning, everyone started to wake up. Tour du Kay would be taking us to the Kremlin today. After a good breakfast with the necessary coffee, the time had come to go to the Kremlin. We arrived just in time to see the changing of the guards ceremony.

The time till lunch was filled with the visiting of the multiple churches and cathedrals in the center part of the Kremlin. Via the Red Square and past Lenin's Mausoleum, we walked towards our Georgian lunch restaurant. After lunch, we went to the cathedral of Christ the Savior, an impressive cathedral situated at the river bank of River Moskva.

Via the Novodevichy monastery, which was unfortunately wrapped in scaffolds, we went back to the hostel to get ready for the night. Dinner was enjoyed in the Stamkroeg, and was ended with a Jägermeister. We finished our evening with a night out at the party island of Moscow (and of course, celebrating Ola's birthday in style.)

Figure 11. The tour on the 44th floor (185 meters high) of one of the Neva tower under construction.

DAY 14

At the first dawn (or what felt like it), the early birds woke up to start the day with a visit to the mausoleum of Lenin; a dark room where the good man has been laid down in a suit, which can be described as a lurid though interesting affair, especially because of the services of the building, partly by the good air quality in the room, Lenin's skin looks still fresh, although he is already dead by almost a century.

While one group was admiring Lenin (like true Russians), others woke up a little later, after which they could start their day. Some went out for souvenirs in the city centre, while others were chilling in the park (until the sprinklers came up and did their thing), visiting a military museum or the Kazan cathedral, or experiencing the street scenes. Some of the people felt fancy and went to a rooftop bar with a three star restaurant and some melting candy.

After having dinner in several restaurants, all of the studytrip people gathered in a pub called pub no pub, where we had a final group drink with the necessary card games. In this setting, the committee got a present for their hard work organising the trip: a real Russian hat (one size fits all) to experience the true Russian ambiance at home.

Afterwards, some people went to have an after-party in an Irish pub, again with the obligatory card games, amazing food (according to Gert-Jantje), whereafter the night greeted us again and our last full day of the study trip was ended.

DAY 15

The last day of our study trip started with some nice breakfast with scrambled eggs made by members of the Study Trip Committee. Most of the students were a bit sleepy and tired because of all the activities we all have been doing during these two last weeks but we could all enjoy one last group meal together.

After that we had time to finish packing our luggage and took a long, long, long ride with metro and bus until the Moscow international airport (SVO). At the airport we were finally able to rest after the up and down the stairs with our heavy luggage and 2h between the hostel at the city center and the far away airport.

One final look at the duty free shops with some Russian souvenirs, and the we got on the plane back to our home sweet home, the Netherlands.

Here's the end of a two week journey with lots of fun, interesting educational activities and nice moments! ■

Samen maken we je start op de arbeidsmarkt grensverleggend

Of het nu gaat om afstuderen of een startersfunctie, bij Ballast Nedam krijg je de kans om je installatietechnische loopbaan vorm te geven. Zo krijg je de mogelijkheid om te werken aan grensverleggende projecten. We zijn benieuwd naar jouw visie en geven je unieke kansen om je ideeën daadwerkelijk te ontwikkelen.

Werken bij Ballast Nedam

Onze medewerkers zijn onze belangrijkste succesfactor. Vanuit deze overtuiging bieden we een gezonde, veilige en motiverende werkomgeving waar ruimte is voor persoonlijke ontwikkeling. Ons snelgroeiende bedrijfsonderdeel installatietechniek is altijd op zoek naar jonge professionals. Inmiddels werken er al drie ex-Mollier leden in ons gezellige team. Binnen Ballast Nedam draag je niet alleen bij aan het integrale installatie-ontwerp, ook zie je van dichtbij hoe het daadwerkelijk gerealiseerd wordt!

Tijdens of na je studie

Bij Ballast Nedam maken we graag kennis met studenten die zich willen oriënteren op hun toekomst. Het is dan ook mogelijk om bij Ballast Nedam een masterproject uit te voeren, een traineeship te starten (waarin je aan verschillende fasen van het project kan proeven) of te beginnen met een vaste baan bij ons team van installatietechnici.

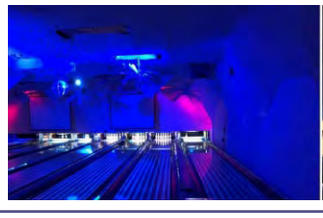
Ben je enthousiast en wil je met ons meebouwen? Kijk dan voor de mogelijkheden op onze website: **www.ballast-nedam.nl** of neem direct contact op met onze Ballast Nedam Campus Recruiter Damia Carli via **d.carli@ballast-nedam.nl**.

Ballast Nedam

Mollier Activity Calendar

NEW YEAR'S BOWLING

To start off 2019, Mollier went bowling on the 10th of January to get back into the Mollier spirit! While some new records were set, some people also needed bumpers to help them along through the evening. After destroying some lanes, devouring some snacks and gulping down drinks, the gang had a small after-party in the city and we were then set for another year of productivity and fun!



LUNCH LECTURE | RHDHV & ARCADIS

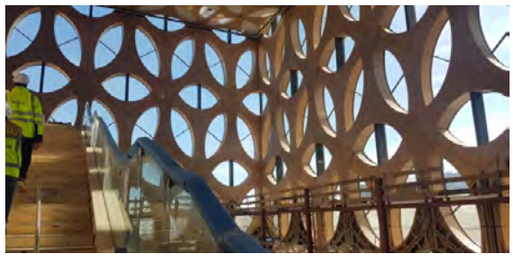
On the 13th of February, the first of the many Mollier Days of the year. The afternoon started of with a lunch lecture by Royal HaskoningDHV and Arcadis. RHDHV spoke about parametric design and their applications in their projects. Arcadis introduced what opportunities students of BPS have at a workplace like Arcadis. Over sandwiches and drinks, we also had a chance to personally interact with the speakers for more questions.

BEERPONG BATTLE III

Thereon, keping up the annual tradition, study associations KOers and Mollier battled it out to prove their prowess at beerpong! Later in the afternooon, the SkyBar! Underground was the battleground for the evening. Board against board, members against members, friends turned into competitors, as the tallies rose and fell. At the end of the evening, KOers defeated Mollier in a close match. The camaraderie shared was only strengthened after an entertaining evening. We hope to keep this tradition going with KOers!

EXCURSION NATURALIS KUIJPERS

On the 26th of February, Kuijpers led a group of Mollier members on a tour of the Naturalis Biodiversity Centre in Leiden. The challenges involved in the installations of technical equipment, satisfying requirements of the various spaces, some more difficult than the others with respect to heating and cooling, taking into account laboratory spaces and public spaces was a pleasantly complex project which is nearing completion! A behind-the-scene look at the technical spaces was helpful to put the scale of the project into perspective!



LUNCH LECTURE | HEIJMANS & STRUKTON

For the second Mollier day of the year, on the 20th of March, we had an insightful lunch lecture by Heijmans about their traineeship and their various tasks and functions. Strukton had an interesting presentation about their tools and programs in data monitoring and management. We also had an opportunity to discuss future possibilities within the companies and what one can expect from working in such a company. The enthusiasm of students meeting ex-Mollier members was as energetic as always!

JANUARY FEBRUARY

WINDTUNNEL DRINK

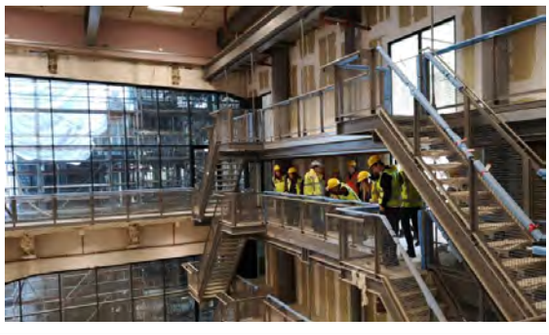
Continuing the day, we organized an informal drink at the TU/e windtunnel along with the Unit BPS Lab personnel. In an effort to introduce the windtunnel to the students and the applications and practicalities of it, the staff gave us a short tour of the facility, explained the various parts and the practical application of wind engineering that we study in theory in our courses at the unit. Walking through the different segments of the structure and learning their functions was also very informative and a simpler way of seeing the principles in reality. We look forward to more such hands-on informal activities in the future!

LUNCH LECTURE | NELISSEN

For the next lunch lecture of the year, Nelissen came by on the 3rd of April to talk about the innovative heating and cooling system they developed and implemented for an educational building. They also won an award for this innovation and understanding how the system works, the collaboration required and the nuances that came with its implementation made for a very informative lunch lecture! Seeing the project evolve from a concept to execution was a very interesting learning process.

EXCURSION HEIJMANS FENIXLOODSEN

In collaboration with study association OfCourse! for Construction Management and Engineering, Mollier hit the road to Rotterdam for a visit to the site of the Fenixloodsen. The site manager took us on a tour to show the various stages of construction of this building complex. From recreational spaces in the ground floor to residential appartment spaces above, this project poses challenges with coordinating the different functions and their requirements in one tower. The group then had a drink together which also was a great opportunity to ask questions about the project and the company itself.

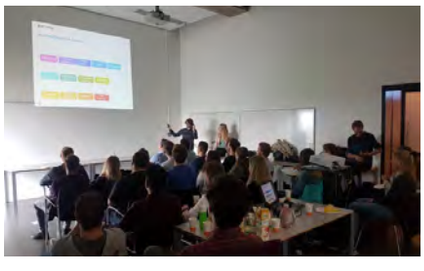


OMRT PARAMETRIC DESIGN WORKSHOP

For all the students who were further interested in developing their parametrric design skills, OMRT hosted us at their office in Amsterdam on the 29th of April. We worked on developing a facade screening geometry in grasshopper and running simulations to see which of the design options had the most heat gain reduction and daylight allowance. The winner also won a parametric camping chair!
Over a cozy lunch, we also discussed the future and possibilties in the field of paramteric design.

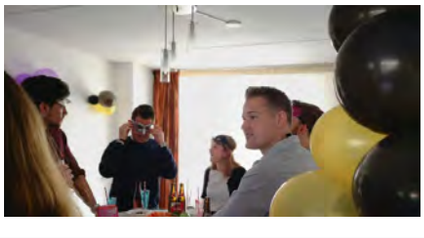
LUNCH LECTURE | BALLAST NEDAM & DEERNS

The third Mollier day also started of with a lunch lecture on the 1st of May. Ballast Nedam spoke about their fast growing MEP department within the company and explained what they did in their projects. They also went into what each of them did in their day-to-day work life and what a starter's job at the company look like.
Deerns dropped in to talk about what their company has to offer in their building physics department, what the beginning of your career looks like and also about their new Concept Studio. Collaborative learning in an international environment was a key highlight.



COCKTAIL PARTY

After a series of educational activities, Mollier decided to change it up a bit. Bringing in the warm spring sun, we headed out flaunting masks and dresses and sipped on some freshly made cocktails! The committee ensured that no glass was left empty as drinks flowed all evening. Dancing to some tunes and relaxing over friendly conversations, we had a much deserved fun activity to welcome the summer days to come!



There have obviously been more activities since, until the release of the magazine. These updates can be found on our website mollier.nl!

Alumni At Work

Author
drs. ir. R. (Ricardo) Poortvliet

About nine years ago, I graduated from the master Building Services, the end of one era and the beginning of a new one. After three beautiful years on the TU/e, I was finally ready to enter the business world; And it was about time! I studied Electrical Engineering at Avans Breda for four years, but the actual student life started when I entered the Mollier-clan. In my first year, I travelled from my hometown Raamsdonksveer to Eindhoven, but by missing the best parts of the parties of Mollier (after 10 PM), I decided to move to Eindhoven.

In the second year of my study, I decided to join the board of Mollier as Treasurer. Together with Jelle Roelofs and Ehsan Baharvand, we had a great board year. Such a great board year that I decided to make myself available for a second board year; in which I was Chairman of Mollier. A board together with Rick van Pruissen and Sander ter Mors. All great people, great memories, and a contribution to my career and personal life.
After my second board year, which effectively ended in October 2010 (as the constitution was in October in those days), it took me two more weeks to graduate.

A new era began with my first job at BAM Techniek. I didn't have any company experience which could give me some insights in different functions and roles, so I decided to go for a job rotation program (or technical traineeship). In a period of two years I was a Workpreparator, Engineer, and Technical Developer. All within a period of eight months. This gave me some good insights in what fitted me best and what not.
After my traineeship, I decided to become a Technical Developer at BAM Techniek in Apeldoorn. I became a Tender Manager three years later for smaller projects (with a contractual value below € 10 million).

As I needed a new challenge in my career, I decided to join my current employer Ballast Nedam. Ballast Nedam was starting its own M&E (Mechanical and Electrical) department and I could become one of the first people to join (as a Technical Developer once again, but now on big projects). And up until now there have been a lot of challenges within Ballast Nedam (there is never a dull moment), which currently makes this company the right match for me.

As I moved from Technical Developer to Tender Manager during my career, I experienced that there were a lot of self-educated managers. They learned it on the job and applied management techniques based on their gut-feeling. Of course gut-feeling is a good thing, but I wanted to become a manager which also knew which theoretical models could be used to manage projects (and especially people, since it's all about people). To get insights in the psychology, finance, accountancy, and marketing business I started a second master education at the Nyenrode Business University in Breukelen, which I graduated in December 2018 earning my second master's degree.

Next to my professional career, I am married to my wife Maaike. We currently live in Houten, but have bought a new-built house in Tull en 't Waal (which is near Houten). We don't have any kids since we like to travel and see the different cultures of the world (which was probably fed by the study trips of Mollier). So that's about it for now, hope to see you guys soon on the yearly 'Schoone Leij voorjaarsuitje' or during the change of the board at the constitution drink.

Figure 1. The 14th Board of Mollier. Sander, Ricardo, and Rick.

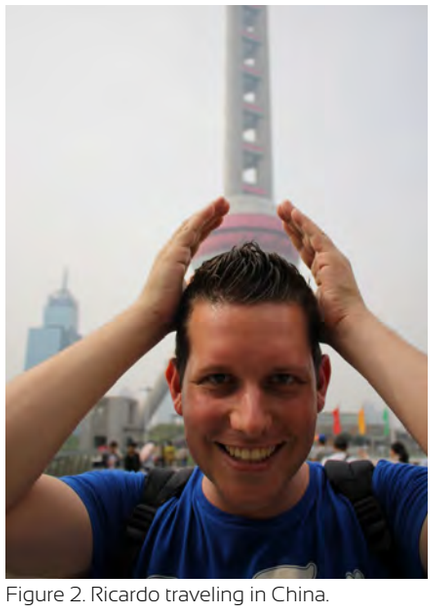


Figure 2. Ricardo traveling in China.

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Cooperative skills indispensable for the company of the future

Author: Kuijpers

Aukje Kuypers
Jelle Reinders
Pim van der Putten

Jelle Reinders and Pim van der Putten had a conversation with Aukje Kuypers (CEO at Kuijpers). Jelle and Pim (both graduated in Building Physics and Services (BPS) work at Kuijpers and served as active members of Mollier.

Figure 1. From left to right; Jelle Reinders, Aukje Kuypers, Pim van der Putten

Jelle: "The first time I came into contact with Kuijpers was at the strategy meeting in Zeist in 2012. As students, we were involved as the moderator and facilitator at one of the sessions aiming to arrive at a strategic plan for 2013-2018. Kuijpers is launching a new strategy project for the forthcoming five-year period. Are you planning to involve Mollier/BPS students again?"

Aukje: "As an organisation, we were very enthusiastic with this working method. Do you think it contributes added value?"

Jelle: "Yes, definitely!" Aukje: "Then it would seem logical to work with students this time round as well. We may want to involve younger students or even kids. One thing is certain: a different dynamic emerges and that's precisely what we are after in a process like this."

Aukje: "Do you think it's interesting for students to be involved in a different way? To be brought on board at an earlier stage of the process?"

Jelle: "I expect students would enjoy that, as it would create a kind of student counsel. They could provide direction, help to set the pace and, of course, develop ideas and have a glimpse of the company and their people."

Aukje: "It's fantastic that you got to know Kuijpers as students and that we're now sitting together around this table! You're in a perfect position to assess how we've done. We've expressed our ambition to create zero-energy, healthy installations only."

Pim: "Do you have insight in the share of zero-energy installations created so far?"

Aukje: "We've arrived at roughly 50%. I'm satisfied: dialogue surrounding sustainability with our customers kicked off properly in 2013. There are examples of zero-energy and gas-free buildings (JADS Den Bosch and Fries Museum in Leeuwarden). This often leads to two proposals: in addition to a solution for the regular request (if this isn't energy-efficient), we propose a green alternative acting on our own initiative. Nowadays, all new buildings have to be highly energy-efficient; the green option comes into its own within the context of renovating existing buildings. Certainly at the outset, many customers were not yet ready to take huge strides in the sustainability arena."

Jelle: "How did it feel for you as Managing Director, being keenly aware of that dot on the horizon, when customers in the early days chose for the cheaper instead of the more sustainable solution?"

Aukje: "I'm positive about the steps we have taken so far; our people are communicating in a fitting manner with our customers and business relations. You can't expect customers to elevate sustainability to the top of their list of priorities overnight. By genuinely listening to one another – and having patience – you see customers become more open to such ideas – in part driven by the Netherlands' ambition and the associated measures and legislation. We increasingly hear: 'Actually, the advice we got a few years ago was exactly what we needed. If only I'd invested then. I have to do double the work now.'
Customers also increasingly understand that the spirit of the times has changed. Yesterday's idealism has become today's realism."

Pim: In my opinion, there are a number of areas in which Kuijpers could improve. Take R&D, data analysis and information management for example. I'm working at the Tenders, Design and Calculation department at the moment and I can't help noticing that we have loads of information at our disposal that could potentially be of use company-wide. We have yet to come up with an effective way of sharing it. I see a lot of potential in setting up an R&D centre or department. However, I only see a limited number of graduates from universities of technology (TU/e) at Kuijpers. This presents a great opportunity!

Aukje: I see the potential as well. We could most certainly get more out of this. There are plenty of designs related to the information management theme for us to create graduation assignments for a range of disciplines. Would you be willing to supervise such a traineeship?

Pim and Jelle: Yes, of course!

Aukje: "What is important in a job, if you're recently graduated?"

Pim: "When studying, you're often preoccupied with new developments and addressing a huge variety of issues. What's more, you practically always work in teams. Students nowadays identify with dynamic, complex issues. I deliberately opted for a position within tender management. This means I'm always confronted with different viewpoints and continually changing team compositions."

Jelle: "It's important having opportunities and having a good working environment. I'm with engineering now, which initially involved less teamwork. But as I'm awarded more responsibility, I automatically have to cooperate more. You're tossed in the deep end and immediately want to come up with multidisciplinary solutions.

Naturally, you need to consult your colleagues and other companies. I like to work like this, but it's not everyone's cup of tea. Although I do think this is more ingrained in our generation. The approach at colleges and universities usually hinges on working in multidisciplinary teams. What appeals to me about Kuijpers, is that there are so many opportunities. However, you have to take the initiative and make something of these opportunities for yourself. That's fair enough, and it tallies with the initial briefings on recruitment."

Aukje: "That's nice to hear. We invest a lot of time and attention to this. In some cases, people aren't (entirely) comfortable in a certain position. If you talk about it, you can do something about it together. But if you don't, you run the risk of losing someone. Not only is that a pity for Kuijpers, it's unfortunate for the colleague in question as well."

Pim: "The fact that Kuijpers is a family business and that these values are firmly embedded in its corporate culture, were determining factors for us choosing for Kuijpers. How do you maintain your corporate culture, despite the company's enormous growth?"

Aukje: "First, I have a question in return. In your opinion, what are the specific values and characteristics of a family business?"

Pim: "Open, accessible, human and independent top the list of values I expect and these must be directly evident and confirmed during the application process. People that are cut from the same wood work here: open and friendly." Aukje: "Previously, social cohesion existed as the bottom line. This applies to groups of around 100 people. Fuelled by the company's growth, there is now a need to organise gatherings, because we are literally removed from one another in increasing numbers. Figuratively, we try to keep the gap as small as possible.

At a glance, it's all about small details: doors not being shut, no walls or only low barriers. This impacts your brain – be it conscious or not. The glass table we are sitting at didn't fall from the sky. It represents transparency. There are no hidden agendas and nothing is swept under the table. We aim to connect people – not only at individual sites or subsidiaries, but throughout the company. We sometimes do this specifically surrounding a theme or specific functions / knowledge. Sometimes, it's purely about meeting.

What's more, it's important to establish a link between stories about the past and today's reality. Just imagine, we've worked with some of our customers for close to 90 years."

Aukje: "How do you think we could involve the younger generation more intensively and effectively in the company?"

Jelle: "There's already plenty of room for initiative. Traditionally, you're supervised by your manager who's been around for longer. I think you can learn a lot from someone who is closer to your own perception of the world. I'd be happy supervising trainees, for example. "

Pim & Jelle: "What advice would you give to today's students?"

Aukje: "It would have to be to 'do what you enjoy doing most'. That's what I learned in my formative years. There was absolutely no pressure to join the family business. If I look at the future, I'd say the most important thing is to know who you are and what you stand for. Cooperative skills are extremely important in the circular world we are aiming to evolve into. I even dare to say that what people call 'soft skills' should be called 'hard skills' and vice versa. Because your personality is what it is – you can always pick up skills and knowledge."

Aukje: "And what advice would you give to Kuijpers?"

Jelle and Pim: "Hang onto the people's vitality and continue to place people centre stage, lead the way in terms of new technologies and high-reaching ambitions, and keep the friendly atmosphere and open family corporate culture intact." ■

Kuijpers is a professional engineering service provider with a workforce of more than 1,200 employees, generating a turnover of €230 million (2018). We design, construct, maintain and operate engineering solutions in buildings and industries. Offering this comprehensive service package, we contribute towards a healthy working and living environment. Our ambition is to create zero-energy, healthy installations only.

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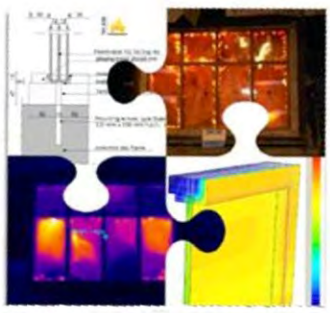

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Not Energy, But Materials are Our Main Problem

Author
R. (Ronald) Rovers

Since the energy crisis in the 1970s, all attention has been focused on energy measures in the built environment for years. And recently they received an extra push, due to the fact that climate change actions have now really penetrated mainstream activities.

Now we face the challenge of making that energy-generation more sustainable, that is, making the transition to renewable energy. This will mainly be established by, for example, using heat pumps, small or large-scale via surface water, combined with a large share of wind turbines and solar panels. Therefore mainly based on ambient heat and solar energy. In other words, energy is not the problem, there is more than enough. But that entire energy supply is going to rely heavily on the use of materials needed for the generation, conversion and distribution: the energy problem is being shifted to a material problem. And in principle there is only a limited supply of these materials, the earth is finite in that regard, moreover, the saturation of ores decreases [1], and with that the energy to invest to gain equal quantities of concentrated materials exponentially increases [2]. As Amini (2007) describes it: the earth is on a road to "exergy countdown".

The 'potential for change' (the exergy) within the earth system is drastically declining, stocks are running out, resources are diluting, and are becoming unusable. Lost in the background. In other words: more wind turbines and solar panels are needed to provide the energy to extract and collect the materials for the energy transition: Energy and materials are inextricably linked.

It is therefore urgently needed that material impact is given its rightful place in that transition approach. The Trias Energetica also applies to materials, but then as Trias Materia. Or better yet as combined energy and material approach: the Trias eXergetica [3].

Which is beyond the scope of this article. The focus should now primarily be on the "embodied energy" of the use of materials. This attention has finally increased in recent years, illustrated among other things by the research groups as part of the IEA Implementing Agreements, such as that of EBC, and in particular the completed Annex 57: This focused specifically on embodied energy of buildings, and the 17 countries collaborating in his agreement collected an enormous amount of material, such as the data from around 80 pilot projects [4]. Striking: virtually no analysis mentions the embodied energy of the installations in the building. They are also just moderately represented in the databases with product data. This has only been explicitly investigated in one pilot case, and then it appears that those installations represent a seriously large share in the total embodied energy.

In the zero-energy office in Berlin, realized as a pilot by the German government, this amounted to 2.7 GJ/m^2 of floor. This, however, is only one calculation. The research in this area should be scaled up considerably since the number of installations with zero-energy and energy-plus buildings only seems to be increasing, just imagine the number of solar panels.

In the formal approach of evaluating embodied energy in buildings, many issues to be solved remain. As a representative for the Netherlands, I made an inventory of these issues. In summary, it comes down to this:

1. The use of reference buildings: When using a building from the past, you are stuck to improving a bad concept. And that remains a (slightly less) bad concept. On the contrary, in principle one should always refer to the best possible concept. A reference building today should show the best possible solution (zero-energy, low embodied energy) to compare how far off the new building design is.

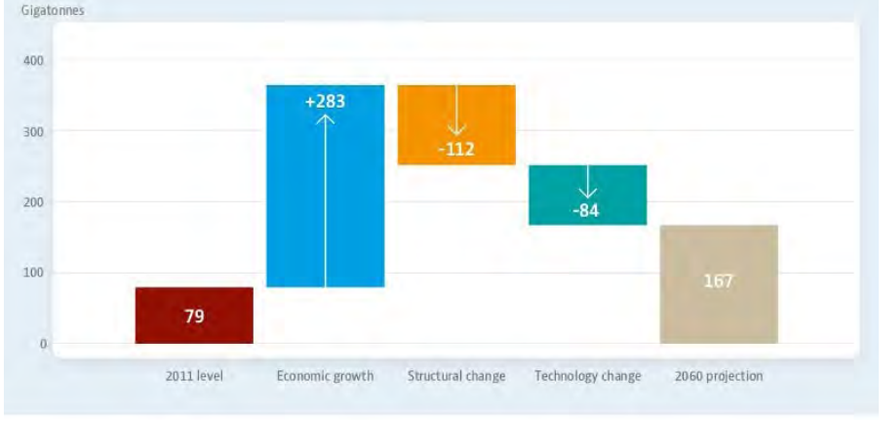

Figure 1. Global materials Outlook by OECD, febr 2019: Material consumption wil increase fourfold in the next decades, could maybe be limited to doubling if all recycling and decoupling strategies will be applied.

Figure 2. Low embodied energy and long lifespan: Wood based construction in Troyes, 16th century.

2. Lifespan of a building: This is a tricky thing. Various countries and methods use different lifespans to normalize the impact, while it is unknown how long the building will actually last. In fact, lifespan in a calculation should never go beyond 50 years in normalizing calculations, to avoid impacts being shifted to the next generation [5]. Apart from that: the material impact takes place today, not in 40-50 or even 75 years, and therefore contributes to CO^2 emissions today. So there is a case to not normalize over the entire lifetime, given our climate targets (the same discussion is unfolding about biomass).

3. Buildings system boundaries: Recycling of materials at end of life stage does not count as an advantage for the current building, these are in fact the input of materials for a new building. While practice now often already charges a bonus when it could be recycled in the future. However, the benefits of recycling are part of the subsequent building. The building to be demolished is the 'raw material mine' for the new building. In other words: the C and D category from the international TC 350 studies guidelines (CEN) should therefore fall outside the system boundary of a building evaluation [6].

4. Raw materials system boundary: evaluating buildings is one thing but in fact tells nothing about quality loss of raw materials: a nail in a building is already a huge deconcentration (loss of exergy) of the raw material iron from the iron mine. If we want to close raw material cycles, we will have to evaluate raw materials separately, and not just focus on applications such as buildings.

5. Embodied energy data is mainly available expressed in primary energy: that creates, among other things, an uneven playing field for companies that already produce on the basis of renewable energy, with a much lower impact. Embodied energy data preferably should be available in end use energy, so that the right energy mix can be attached.

6. Primary energy itself, is an outdated method, if we assume that in principle the sun is the only one that adds energy to the earthly system. For fossil energy, the entire 'solar to fossil' route is being neglected. While for solar panels, the efficiency from the sun as source is calculated. To compare this with a fossil standard is really outdated (even sometimes as 'tons of oil equivalents'). Solar energy (input) should be the standard reference. [7,8].

These aspects have been included in the preparation of a new Annex 72, concerning embodied plus operational energy, 'lifecycle energy' of buildings [9].

That all is of course the theoretical approach. For daily practice it is possible to use existing data as a rough indicator of the material impact. In the design process, for example, these work sufficiently and indicate the right direction. The inventory of embodied energy data from Bath University can serve as a reference [14]. With a rough estimate of the material input of the new design, the embodied energy can be calculated quickly. From that, a indication can then be obtained with regard to the 'year of climate neutrality' of a building: The year in which the building does not contribute any net CO^2 emissions: Given a zero-energy building, net zero-CO^2 is reached when a surplus of sustainable energy is produced, which compensates over the years for the invested embodied energy (incl. for example solar panels themselves). Divide the Embodied Energy (EE) by the annual surplus of building produced energy (PE) and you know when a building is net-CO^2 neutral. All of which, of course, will have to be done well before 2050, given the set targets by the Paris Climate Agreement [10]. It is highly necessary to include materials in the evaluation, which will lead to other building and installation choices. ■

[1] Mudd, G M, 2009, Historical Trends in Base Metal Mining: Backcasting to Understand the Sustainability of Mining. Proc. "48th Annual Conference of Metallurgists", Canadian Metallurgical Society, Sudbury, Ontario, Canada, August 2009

[2] J.H.M.Harmsen, A.L.Roes, M.K.Patel, The impact of copper scarcity on the efficiency of 2050 global renewable energy scenarios. Energy, Volume 50, 1 February 2013, Pages 62–73.

[3] http://www.ronaldrovers.com/from-trias-energetica-to-tetra-materia-12/ and http://www.ronaldrovers.com/from-tetra-materia-to-trias-exergetica/

[4] IEA EBC Annex 57 Embodied Energy: All reports can be found here: http://www.iea-ebc.org/projects/project?AnnexID=57 The pilot building is in report Subtask 4 page 324 case studies.

[5] R.Rovers (2019) Broken Cycles, finding a balance between resources and people, in print . Dutch version has been published: https://eburon.nl/product/gebroken-kringlopen/

[6] TC350: http://portailgroupe.afnor.fr/public_espacenormalisation/CENTC350/index.html

[7] primary energy: http://www.ronaldrovers.com/time-to-abandon-primary-energy-calculations/

[8] growing fossils: http://www.ronaldrovers.com/fossils-versus-renewables-embodied-land/

[9] ICE database available her: (this spring a updated version will be published) http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html

[10] Climateneutral Year: http://www.ronaldrovers.com/co2-rekenen-klimaatneutraal-jaar-x/

[11] Global Material Resources Outlook to 2060 :http://www.oecd.org/environment/global-material-resources-outlook-to-2060-9789264307452-en.htm

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- Windhinder

AKOESTIEK
- Bouwakoestiek
- Omgevingsgeluid
- Industrielawaai
- Zaal- en ruimteakoestiek
- Trillingen
- Laboratorium

DUURZAAMHEID
- Energieconcepten
- BENG / NOM
- Energieaudits
- Circulariteit
- Materialisering
- Duurzaamheids-certificering

VEILIGHEID
- Brandveiligheid
- Fire Safety Engineering
- Omgevingsrisico’s
- Externe veiligheid
- Omgevings-vergunningen
- Bouwveiligheid

MILIEU
- Ruimtelijke ordening
- Vergunningen en toezicht
- Omgevingsgeluid
- Industrielawaai
- Trillingen
- Luchtkwaliteit

BOUWKWALITEIT
- Vochtonderzoek
- Kwaliteitsborging
- Bouwplantoetsing
- Productonwikkeling
- Toezicht
- Laboratoriumonder-zoek

Microorganism Application in Designing Hydrophobic Concrete

Supervisors
ir. Z. (Zhengyao) Qu
dr. S. (Shuaiqi) Guo
dr. ir. Q. (Qinglian) Yu
prof. dr. ir. H. J. H. Brouwers

Author
ir. Y. (Yifeng) Zheng

INTRODUCTION

The durability of concrete is a sophisticated and long-standing topic in the field of building materials. It can be briefly described as the ability of resisting weathering, abrasion, and chemical attack [1], [2]. Generally, concrete is considered a hydrophilic material. Due to the capillary forces, water can easily be absorbed by the open pores where the concrete surface contacts with water [3]. The absorption of water and other soluble aggressive species is a major driving force to the physical and chemical degradation processes in concrete structures, as it can corrode the steel reinforcement and so lead to the collapse of the entire concrete structure.

In this study, we demonstrated that liquid cultures of bacteria can be used to create concrete with hydrophobic properties in a concentration-dependent manner. These key findings help to dramatically improve the feasibility of using bacteria as a hydrophobic agent for cement through bypassing multiple time-consuming procedures required for growing and harvesting bacterial biofilms. Our results indicated that the hydrophobic properties are achieved through drastically increasing the roughness of the concrete topology at nano-to-micro-meter length scales. These morphological changes are caused by the micro calcite formations possibly through biomineralization processes. Furthermore, bacteria addition had distinct impact on the hydration kinetics and phase formation of the cement. Taken together, this study gives unprecedented insight into the mechanism and the design of bacteria-based hybrid concrete with hydrophobic properties

EXPERIMENTAL

MATERIALS

The cement of CEM I 52.5 R used in this study was provided by ENCI (the Netherlands). CEN standard sand (EN 196-1) is used as aggregates. B.subtilis 3610 and E.coli are used as bio-modification bacteria. Luria/Miller LB-Medium or LBPlus Medium (which contains 1 % glycerol and 0.1 mM MnSO4) are used to culture bacteria.

PREPARATION

The preparation process of bacteria-based concrete is shown in Figure 1. Bacterial cultures were prepared by first inoculating 15 mL of liquid Luria/Miller LB-Medium (Sigma Aldrich) with bacteria from a frozen glycerol stock. The cultures were grown at 37 °C in a shaking incubator (250 rpm) overnight. Next, 100 µL of this overnight culture was plated on (1.5 % v/w) agar plates enriched with Luria/Miller LB-Medium or LBPlus Medium (which contains 1 % glycerol and 0.1 mM MnSO4) and incubated for 24 h. The mortar was prepared with a ratio of water: cement: sand = 0.5: 1: 3.

RESULTS AND DISCUSSION

THE WATER-RESISTANT PROPERTIES OF MORTAR CREATED BY THE ADDITION OF BACTERIAL BIOFILMS

We set out to create bacteria-modified concrete by first reproducing some of the key experiments found in the literature. Grumbein et al. [4] claimed that B. subtilis biofilms grown on different growth media (LB and LBPlus) exhibit hydrophilic and hydrophobic behaviors, respectively.

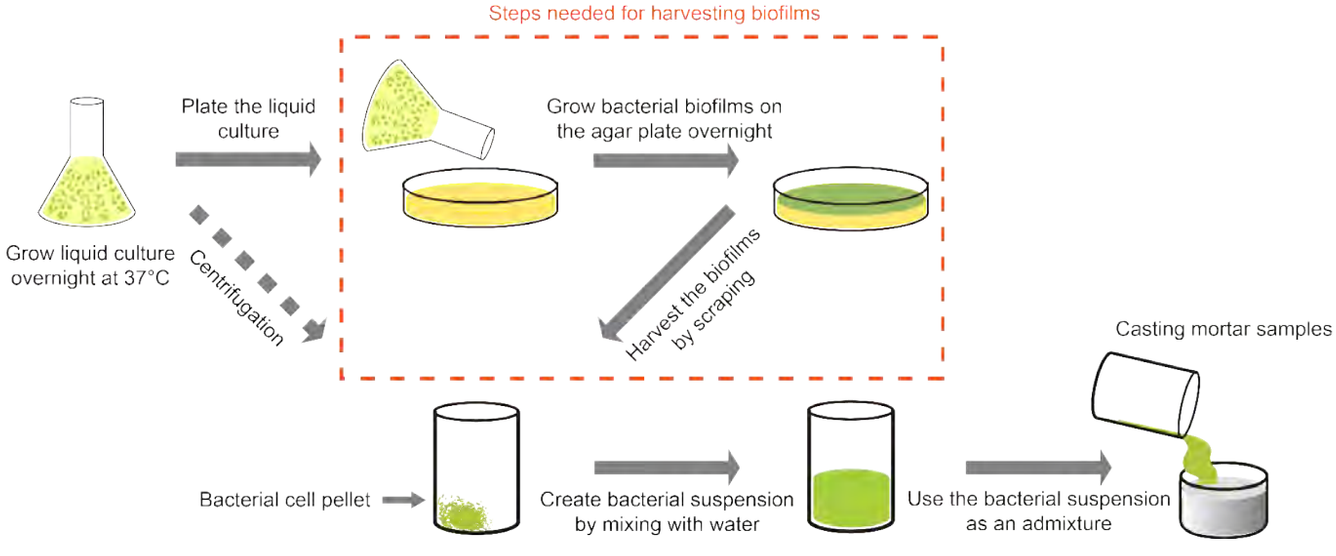

Figure 1. The preparation process of the bacteria-based hybrid mortar with hydrophobic properties.

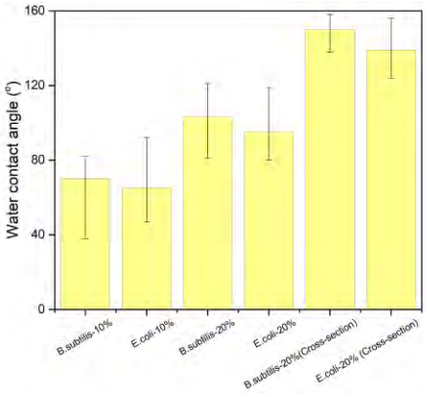

Figure 2. Water contact angle of the bacteria suspension containing mortar.

Surprisingly the authors were then able to create concrete with hydrophobic properties using either the hydrophilic or the hydrophobic biofilms. However, in stark contrast to these observations, we did not observe significant differences in the contact angle values from the biofilms grown with either LB (125°) or LBPlus (138°).

To test the key question whether hydrophobic concrete can be truly created from hydrophilic bacterium, we selected E.coli BL21 (DE3), a well-characterized innocuous strain with hydrophilic properties for further investigations. Next, three types of biofilm-hybrid concrete were created, consisting of those mixed with B.subtilis biofilms grown on either LB or LBPlus , and E.coli biofilm grown on LB. Water droplets were placed on the surface of each sample. As expected, similar contact angles were observed for samples created from B.subtilis biofilms cultured by different media, with 61o and 66o for those with regular LB and LBPlus, respectively (Table 1). Remarkably, the hybrid concrete created from the hydrophilic E. coli biofilm showed a contact angle of 64o, which has essentially the same performance compared to those made from the hydrophobic biofilms of B.subtilis. This result indicated that bacteria with innate hydrophobic properties is not a requirement to create hydrophobic concrete.

CONCRETE WITH HYDROPHOBIC PROPERTIES CREATED BY BACTERIAL LIQUID CULTURES

With an aim to simplify the production process and improve the hydrophobic properties of the microorganism-based concrete, the effect of the addition of bacterial liquid cultures rather than formed biofilms was investigated. In this way, at least one day can be saved from growing the biofilms (see Figure 1), and the labour-intensive steps involved with harvesting the biofilms off the agar plates are avoided.

Bacterial suspension of either B.subtilis or E. coli was cultured overnight until an OD600nm of ~ 4. The cultures were then directly mixed with cement and sands. The hybrid concrete sample created from liquid culture of B. subtilis grown on normal LB presented a contact angle of 55°. The hybrid concrete made with liquid E.coli culture gave a contact angle of 53°, which again has essentially the same performance to that of concrete created from the hydrophobic B.subtilis. Thus liquid-culture-modified samples presented competitive results concerning contact angle comparing with the biofilm-modified samples. The results further supported the hypothesis that hydrophilic bacteria endow sufficient water-repellent properties to concrete and neither biofilm formation nor a hydrophobic bacterium is required. Without these stringent requirements the design of microorganism-based hydrophobic concrete can be simplified significantly, and this opens door by applying a wide range of microorganism that could bring in additional novel functions such as self-healing, the removal of odor and other environmental contaminants.

Next, we investigated if hybrid mortars with greater hydrophobic properties can be created by increasing the concentration of bacteria. Cell pellets from bacterial cultures were harvested by centrifugation and resuspended in smaller volumes of water to achieve bacteria and cement ratios of 10%wt and 20%wt. The 10%wt B. subtilis sample presented a contact angle of approximately 70°, but the water droplet was quickly absorbed by the concrete. Surprisingly, sample with 10%wt E.coli demonstrated better water penetration resistance where the droplet could persist on the concrete surface for tens of seconds and presented a contact angle of 65° (Figure 2). When the bacterial content was raised to 20%wt, very promising results of 103° and 95° were obtained for the hybrid samples created with B.subtilis and E.coli, respectively. Excitingly, the cross-sections of these two samples demonstrated even higher contact angles, which reached up to 150° for B. subtilis and 139° for E.coli (Figure 4). These samples demonstrated super-hydrophobicity, where water droplets rapidly roll across the slightly tilted concrete surface. Indeed, with the addition of either 20% E.coli or 20% B.subtilis, the water resistance of the hybrid mortars is greatly improved. These bacteria-based hybrid mortar only

Table 1. Water contact angle values of the biofilm-modified mortar samples.

	Mortar Types		
	B.subtilis/ LB	**B.subtilis/ LBplus**	**E.coli/ LB**
Water Contact Angle (°)	61	66	64

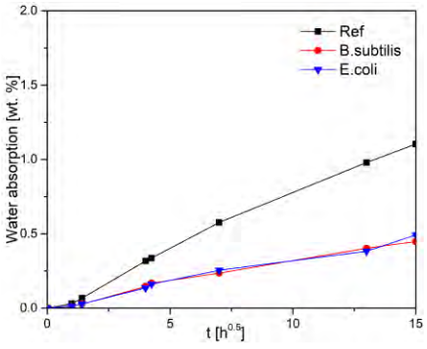

Figure 3. The water absorption of the bacteria-modified mortars.

absorbs water that is roughly 40% of the reference sample (Figure 3). Taken together, the results demonstrated that bacteria concentration is a key factor for creating hydrophobic concrete. Counterintuitively, the results further consolidated the notion that the hydrophobicity of bacteria is not a key factor in creating concrete with hydrophobic properties.

Intriguingly, clear morphological differences were observed between the inner and outer surface sections of the same bacteria-modified samples (Figure 4c to Figure 4f). The spike-like structures observed in SEM were most likely calcite, a regular product generated during the cement hydration.

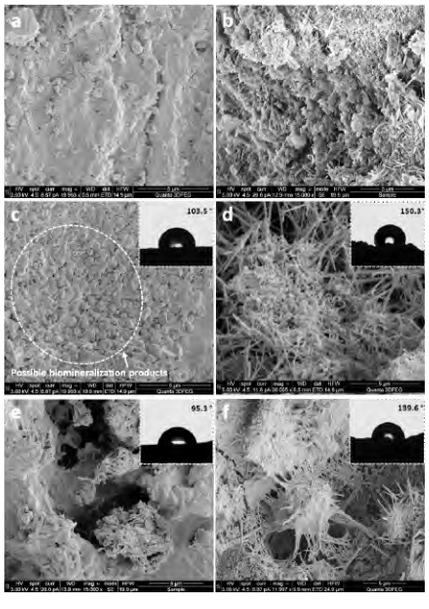

Figure 4. The morphology and water contact angle of the bacteria-modified (20%wt) concrete and reference samples:
a) Top surface of the reference sample,
b) Cross-section of the reference sample showing its inner layer,
c) Top surface of the B.subtilis hybrid mortar,
d) Cross-section of the B.subtilis hybrid mortar showing its inner layer,
e) Top surface of the E.coli hybrid mortar,
f) Cross-section of the E.coli hybrid mortar showing its inner layer.

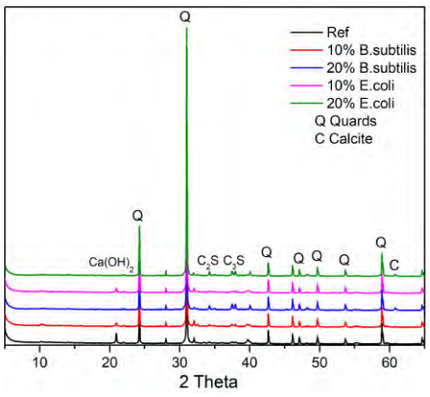

Figure 5. X-ray diffractograms of the bacteria-modified and reference mortars

A moist environment can promote the formation of spike-like ettringites which are roughly 5 µm in length, or shorter. The lack of growing spaces due to the occupation of bacterial agents could lead to the formation of smaller spike-like ettringites in the inner layers such as those observed by SEM. These short "spikes" increase the nano- and micro-roughness of the concrete and can endow the concrete with hydrophobicity in a similar fashion as the "lotus-leaf effect" [5], [6].

X-RAY DIFFRACTION (XRD) INDICATED AN INCREASE IN CALCITE DEPOSITION WITH THE BACTERIA-MODIFIED CONCRETE

Figure 5 shows the XRD results of the reference sample, E. coli-modified mortar samples and B.subtilis -modified samples with different addition dosage. The calcium carbonate in both bacteria modified samples is calcite. With the increase of the bacteria dosage, the intensity of the calcite peak is increased while the intensity of Ca(OH)2 peak is decreased which indicates that the bacteria is involved in the precipitation of the calcium carbonate, and therefore more Ca(OH)2 is consumed. This is in line with the SEM results (Figure 4) in which calcite cubes can be observed and therefore, is further confirmation that bacteria can change the micro structure of concrete resulting in the increase of the roughness. The intensity of portlandite peak was decreased with the increase of bacteria content. Larger C2S and C3S peaks were observed in the bacteria-modified mortars which suggest a slower hardening process than that of the reference, which is in line with the hydration results as discussed in next section.

EFFECT OF THE BACTERIA SUSPENSION TO THE HYDRATION OF CEMENT

Figure 6 depicts the calorimetry measurements of the effect of suspension of E.coli and B.subtilis on cement hydration. Figs 6a show the heat flow during the exothermic reaction of ordinary Portland cement (OPC) over time. As reported previously [7], OPC always presents a main peak during the hydration process as shown in the reference (Figure 6a). However, both bacteria-modified samples presented two peaks. The first small peak appeared at 4 hours and the second large peak appeared after around 3 days. The large peak appeared later reflects the hydration kinetics, indicating the retardation of the reaction. It is possible that the bacteria decrease the concentration of Ca2+ in cement pore solution by forming calcite around themselves and thus delays the formation of hydration products. It also showed that the retardation of B.subtilis is more significant than that of E.coli, possibly due to its biomineralization capabilities.

BACTERIAL-MEMBRANE-MODIFIED CONCRETE HAS INFERIOR WATER RESISTANCE COMPARED TO THOSE MODIFIED WITH LIVE CELL

Do the hydrophobic properties of the bacteria-modified concrete emerge from the innate property of the phospholipid-based cell membrane or other properties of bacteria such as biomineralization which require them to be alive? To investigate this key question, hybrid mortars were created with bacterial membrane obtained after cells were lysed by high pressure with a French press instrument (Figure 7a).

Mortars made with the addition of 1 g cell membrane of either B.subtilis and E.coli presented better wetting-resistance than the reference sample. This is not surprising given the hydrophobic

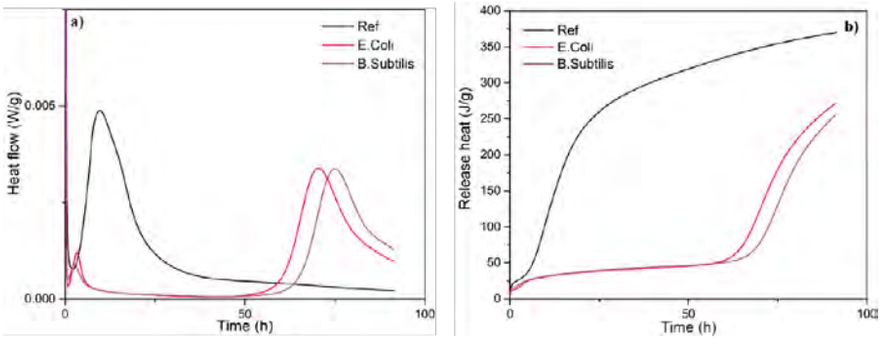

Figure 6. Effect of 20% bacteria suspensions of B.subtilis and E.coli on the cement hydration of OPC paste at 20 °C: a) Heat flow, b) Released heat.

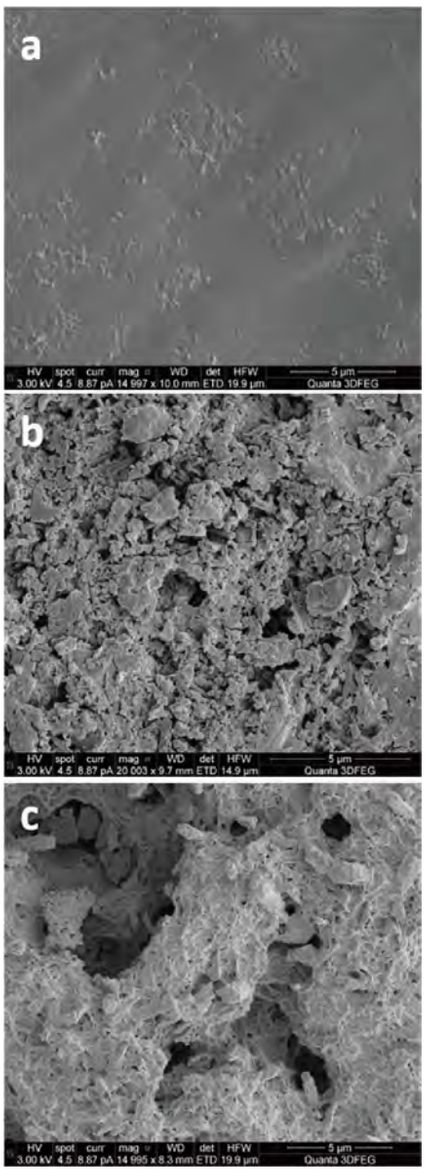

Figure 7. Morphology of hybrid concrete created by adding bacterial membranes.
a) Cell lysate of B.subtilis.
b) Surface section of the hybrid concrete created with B.subtilis membrane.
c) Surface section of the hybrid concrete created with E.coli membrane.

properties of the phospholipid which is the main composition of bacterial membrane. The water droplets on mortar made with B.subtilis membrane showed higher contact angles than that of E.coli. This is likely because of the innate hydrophobic property of the hydrophobin-like protein BslA on the cell membrane of B.subtilis [8]. Intriguingly, no obvious spike-like structures were observed in the membrane-modified hybrid concrete by SEM analyses (Figure 7b and Figure 7c), which suggests that the lifeless cell membrane could not alter the micro-structures of concrete, however functions as a hydrophobic agent.

According to these results, bacterial cell membranes can endow concrete with water-resistance. Nevertheless,

when tested, the water droplets could not be sustained over a long period without the support of multi-length-scale roughness. Thus, it is infeasible to design a hydrophobic concrete only by adding cell membranes because of its more complex preparation process and its inferior performance.

COATING APPLICATIONS OF BACTERIA ON CONCRETE SURFACE

Given the promising effects shown by mixing bacteria with the bulk concrete, we further explored the possibility of creating mortar with hydrophobic properties by simply applying bacteria on the concrete surface as a coating agent. The B.subtilis and E.coli-treated (0.5 g cell pellet) concrete samples were created either immediately after casting or after three days of hydration (referred as post-hydration coating in Figure 8). All samples demonstrated hydrophobic properties by yielding contact angles larger than 90° (Figure 8). The simple coating application does not alter the mechanical and chemical properties of the bulk concrete while efficiently resisting water penetration by the outer surface. Compared to other chemical coatings, live bacteria can potentially regenerate themselves and occupy exposed surfaces without extra maintenance. Again, the coating application did not appear to have restrictions relating to the choice of bacteria based on their hydrophobic properties. This sets the stage for a wide variety of future investigations on these attractive topics.

CONCLUSIONS

The application of bacteria in designing concrete with hydrophobic properties can be dramatically simplified by replacing the biofilms with bacteria collected from liquid cultures. Importantly, the choice of bacteria does not appear to be limited to those that are inherently hydrophobic. Bacteria concentration is a key factor that influences the concrete hydrophobic properties. Samples with higher cell concentrations presented higher contact angles.

The mechanism of microbial-based hydrophobic concrete appears to be multi-faceted. This involves the hydrophobic membrane of bacteria, as well as the structural alterations of concrete at nano-to-micro-micrometer scales. The morphological changes are potentially caused by biomineralization and other metabolic processes of the bacteria. It appears that the underlying biomineralization of living bacteria may induce calcite precipitation on the surface, resulting in a higher water resistance and can therefore lead to enhanced concrete durability. ■

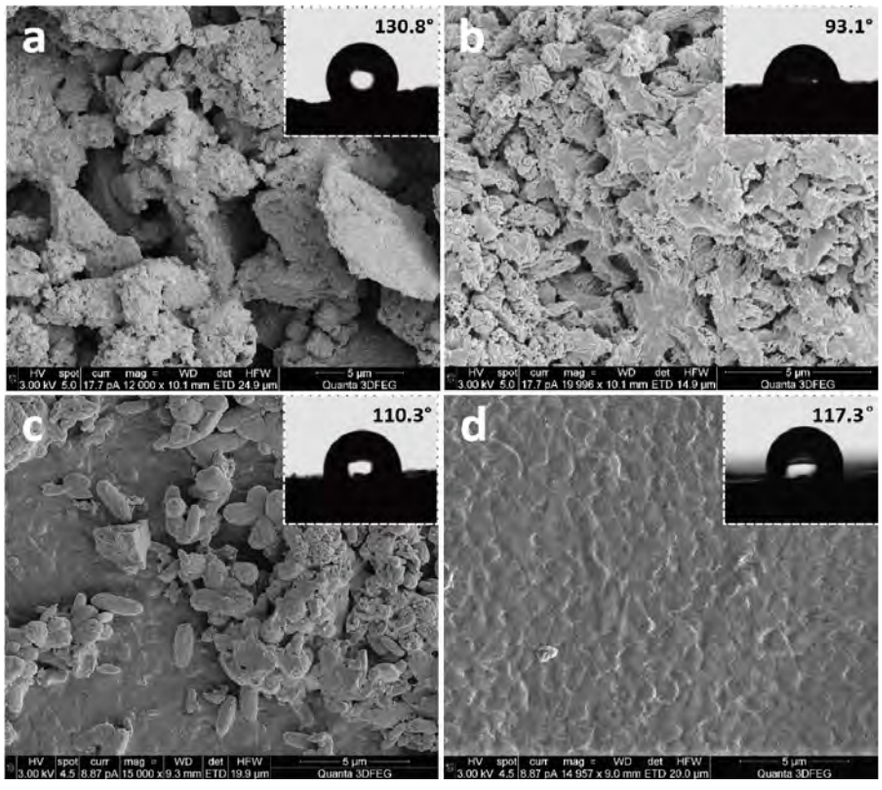

Figure 8. SEM and contact-angle measurements on concrete samples with bacterial coatings: a) Coating with B.subtilis b) Coating with E.coli, c) Post-hydration coating with B.subtilis, d) Post-hydration coating with E.coli.

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BAM Graduate Programme & Expertice center

Authors
BAM
ir. W. (Wies) Westerhout
ir. R. (Rolien) Wisse

BAM GRADUATE PROGRAMME

In august 2017, I (Wies Westerhout) graduated from the study BPS. During my graduation I discovered some things about myself: I don't like working the whole day on my computer and I get more energy out of organizing and managing things than doing research. During conversations at the meet & greet of Mollier, I found out that I am always asking companies: "How do you know that your design can be build? In theory everything is correct, but how to really build it?!?" This rought me to a contractor instead of consultancy or engineering company.

To follow this path by making choices on doing and experiencing things I applied for the Graduate programme at BAM. A big company with a lot of diversity within the company and a host of possibilities to experience. The innovative and sustainable appearance of the company fits my vision of the future. During this 2 years traineeship I switch every half year from a freely selectable function. During these years I got some courses to discover my strengths and weaknesses and improve my soft skills. Besides, with the other trainees we organize a monthly TOP-day (trainee development program) to develop ourselves and discover the company, have a yearly trainee weekend and have a drink or dinner with each other.

I started the first half year of my traineeship at Schiphol. BAM has a maintenance contract for all the fire safety installations in the terminals of Schiphol. With a team of around 60 'BAMmers' the safety of all installations and the adjustments on the installations were managed. My role in this project was the 'right hand' of the contract manager who was responsible for this maintenance contract. I faced multiple challenges; by implementing tools for the servicemen, reporting the monthly state to the costumer (Schiphol), improve the planning tool for the chief serviceman, optimize some working processes, and being part of a tender team for the new multidisciplinary maintenance contract of half of the terminals at Schiphol (which we have won ☺!). An amazing half year where I have learned a lot and met so many friendly and helpful colleagues.

Figure 1. Traineeweekend Berlin.

The second half year I worked at the head quarter of the Dutch building part of the company (BAM Bouw & Vastgoed). Where I had a coordinating role in the overall tender process of the company. To ensure that all the risks and possibilities of a tender are known, and to obtain internal approval from the board members, a system has been developed. I improved the implementation of this system by all BAM regional companies in the Netherlands. This gave me the opportunity to visit all the regional companies, met new colleagues through the whole company, and advise the management of the regional companies how to implement and deal with this system. In addition, I was given the opportunity to occasionally join the BAM Bouw & Vastgoed direction meetings or executive board meetings where the decisions were taken whether we start tendering, or submit tenders and under what conditions. I was also supportive by making the tender policy and advise the direction about this policy and progress with my experience of implementing this system. I have experienced this as a very instructive half year with great opportunities. However, I notice that I still like to get a little closer to operational work and less policy-based.

Now I just started for a few weeks on my 3th half year. Because I want to learn all the parts of BAM I chose to work in the Infra branch, which is maybe a little bit 'out of my comfort zone'. Since the beginning of February I'm working on a Infra tunnel project 'The Rotterdamsebaan' in The Hague. Where I'm in the team of the tunnel installations as a workplanner. Back in the operational work, hardcore technics and like a Dutch saying "with my feed in the clay";)! In summary, I'm sure I have made a good decision to start my career at BAM to discover with this traineeship all the facets of construction, and what it involves.

EXPERTISE CENTER OF BAM FM (FACILITY MANAGEMENT)

You might not expect it from a 'big contractor', however, BAM is a very innovative and progressive company. Rolien Wisse, who studied Building Technology in Delft, works at the center of expertise of BAM Facility Management. "In my daily work I'm developing and promoting the Smart FM proposition. This includes working on smart solutions to improve maintenance services and ultimately improve the quality of buildings which are in use! Before, I worked in a consultancy firm focused on Indoor Environmental Quality. There I became very motivated to create actual effect in buildings by not only giving advise but also acting on this knowledge. At BAM, I have the opportunity to truly improve buildings while using data in an innovative matter."

Smart FM solutions are already implemented on several contracts, for example a large PPP contract on the Ministry of Foreign Affairs. We have insight in the conditions and functioning of 1300 area's. One of the optimizations we have done based on these insights is the adjusting the air valve switching to prevent early replacements, temporary discomfort and disturbances.

Within BAM many people are working on data-driven solutions as well. Including themes as energy monitoring, smart grids and smart mobility. All these initiatives are collected in the BAM Smart City proposition. The broad spectrum of services of BAM offers an opportunity to a more integral approach. Thereby we can help municipalities to realize more sustainable, smart, mobile and livable cities.

If you want to have more information about smart cities, check the website: www.bam.com/smartcity ■

Building the present, creating the future!

If you have any questions about us, our experience or BAM, don't hesitate to contact us:

- wies.westerhout@bam.com
- rolien.wisse@bam.com

USER, CUSTOMER AND BAM BENEFIT FROM SMART FM SOLUTIONS.

OCCUPATION MONITORING

With available data or additional sensors the occupation in the building is monitored. Thereby insight in the occupation for each floor, area or workplace can be given and used. This can be used to optimize housing solutions or data-driven cleaning and reducing the inconvenience by coordinating a good maintenance schedule.

PREDICTIVE MAINTENANCE

By data-driven services we prevent complaints or disfunctions of the systems in te building. This is possible by creating dashboards with this data to give an insight and the behavior of the assets. When deviant behavior occurs what can lead to inefficiency or failure of the system an notification is made automatically which will be resolved with an appropriate action.

COMFORT MANAGEMENT

Buildings are meant to improve our lives. However this is not always the case. Due to comfort management we create insight in different parameters to give the users of the building real-time dashboards to improve the real-time climate of the building. Beside we use this data to improve the internal climate for instance with algorithms, this results in better comfort and optimization for reducing energy.

SMART LEGIONELLA PREVENTION

Energy efficiency and saving water can be the result with smart legionella prevention. Legionella will occur in low temperature (below 60°C) and stagnant water. A lot of tap points have lower temperatures, and can be stagnant when they are not used for a longer time of period. By using sensors the use and the temperature of the waterpipes and tap points can be measured. This can give information if flushing waterpipes is needed or not; this saves water and energy. Besides advise can be given about Legionella prevention matters or saving water. In corporation with Startup company Octo this proposition is developed whereby they developed a sensor anticipating on our needs.

Figure 2. Advantages Smart FM Solutions.

The effect on indoor airflow by PAF windows in the new Atlas building

Supervisor
ir. M.A. (Marlies) Verbruggen
dr. ir. T.A.J. (Twan) van Hooff

Author
ing. M.C. (Marc) Scholman

INTRODUCTION

The old Main Building from 1963 on the campus of the TU/e was a large outdated utility building that needed to be renovated. The innovative climate façade consists of window modules which include parallel opening windows (PAF (Figure 1.)). This research is focused on the effect of the PAF windows on the indoor airflow. This parametric study gives a first impression of the effect that PAF windows will have on the indoor airflow inside the Atlas building. It will show a global effect of the airflow flow through the use of a PAF window and can prove or disprove the theoretical concept based on isothermal simulations.

GEOMETRY, DOMAIN, GRID

The full-scale geometry is a simplified version of the Atlas building. The computational domain is based on the best practice guidelines by Franke et al. [2] and Blocken [3]. The dimensions of this domain are 776 x 580 x 252 (L x W x H) m^3. The computational grid is completely structured. The grid consists of hexahedral cells only, with a high spatial resolution near the building and especially the openings and PAF windows. A coarser mesh has been used at a certain distance of the area of interests. This results in a grid for this case with 3,841,272 hexahedral cells.

SOLVER SETTINGS

The 3D steady RANS equations are solved with the standard k-ε turbulence model (SKE) [4]. For the pressure-velocity coupling, the SIMPLE-Consistent (SIMPLEC) is used. According to best practice guidelines it is best to use higher-order discretization schemes for spatial discretization since they are more accurate than first-order schemes [3]. Therefore second-order discretization schemes are used.

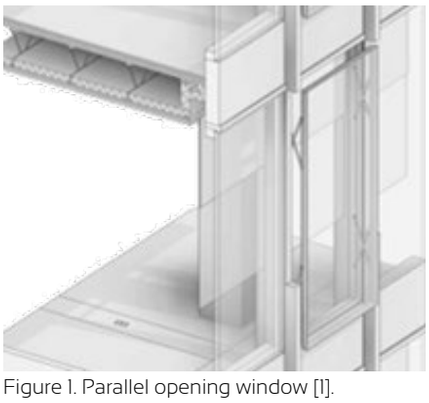

Figure 1. Parallel opening window [1].

BOUNDARY CONDITIONS

In the user defined function, the wind speed, turbulent kinetic energy and turbulent dissipation rate are defined [5]. The corresponding value of u*ABL is 0.690 m/s for a reference velocity at 10 meters height of UREF = 5.0 m/s. The wind direction of 0°, 45° and 315° will be used.

COMPARISON DATA

The evaluation is based on the x-velocity, which can be seen in Figure 2.

- Wind direction 0°: in the vertical center plane, the airflow shows a higher velocity of the airflow near the window which reaches further in the room for the volume in the middle of Atlas.
- The airflow in the volume in the middle shows a higher dimensionless mean x-velocity with wind direction 0° compared with 45°. Wind direction 0° show a minimum dimensionless mean x-velocity of 0.17.
- The left volume has the highest dimensionless mean x-velocity of the airflow with the wind direction of 45° at all measurement points. The highest measured dimensionless mean x-velocity is 0.72.
- The general airflow inside both volumes shows similarity for all wind directions, near the ceiling the velocity of the airflow is higher compared to the airflow near the floor.

CONCLUSION

The dimensionless mean x-velocity of the indoor airflow highly depends on the approaching wind direction. Effects related to thermal aspects were not included because the simulations were performed with isothermal conditions. X-velocity flow results of the different simulations show that fresh air comes in the building through the whole opening created by the PAF window at the side where the wind is approaching. Emitted old air will flow through the whole opening created by the PAF window at the leeward side of the building. Like both volumes, the general airflow shows similarities for all wind directions; near the ceiling, the velocity of the airflow is higher compared to the airflow near the floor. ■

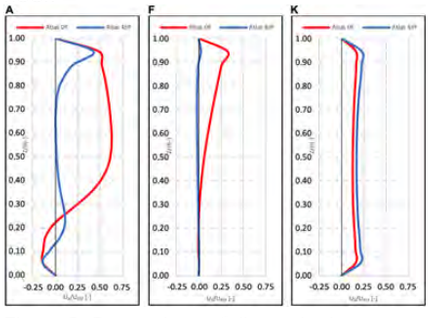

Figure 2. Comparison of dimensionless mean x-velocity in the vertical center plane.

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Occupancy-based Lighting Control

Author
dr. ir. C. (Christel) de Bakker

Supervisors
prof. Dipl.-Ing. A.L.P. (Alexander) Rosemann
prof. dr. H.S.M. (Helianthe) Kort
ir. M.P.J. Mariëlle Aarts
prof. dr. ir. E.J. (Evert) van Loenen

INTRODUCTION

In general, office buildings just provided occupants a sheltered place to perform their work activities. Current developments in automation and information technology start to transform these buildings into autonomous objects, with, for example, smart controlled luminaires responding to occupancy changes [1]. Simultaneously, workers are more flexible in working hours and locations, resulting in a large variety of individual occupancy patterns.

This means that the time that all desks are occupied in the large, shared open-plan office is limited. Here, automatic occupancy-based lighting control at room resolution means a waste of energy. This can be minimized by smart controlled luminaires at desk resolution. This PhD research investigated this opportunity to tailor the lighting use to the actual occupancy of the office space by developing an automatic occupancy-based lighting control strategy at this resolution, "local lighting control". By taking a user-centred perspective the comfort of the workers is safeguarded.

METHODOLOGY

Throughout the research, a user-centred perspective was taken to guarantee workers a comfortable work environment. This approach is in line with the WELL building standard, which states that the built environment should consider its effects on office workers' health and well-being in addition to its environmental impact [2].

The development of the strategy occurred in five steps:
1. review of current literature [3],
2. determining its energy saving potential [4],
3. design of a comfortable strategy for bullpen offices [5, 6],
4. investigating users' preferences for luminance distributions,
5. determining its acceptability in the real office environment.

When reviewing literature, we used a structured approach to identify relevant articles from (1) general databases, (2) topic-specific databases, and (3) topic-specific journals. They were analyzed with assessment criteria on their (1) study characteristics, (2) office characteristics, (3) lighting system characteristics, (4) lighting control design, and (5) post-occupancy evaluation. The results of this review give direction to step 2 and 3, but will not be further discussed here.
For more information, we would like to refer the reader to the original paper [3].

For the second step, we first developed a simulation model to estimate the occupancy patterns of five job function types; it was validated by comparing its results to earlier studies and real measurement. As the results were similar, the model was then used to calculate the energy saving potential of occupancy-based lighting control at three different resolutions for a set of office cases that differed on (1) function type distribution, meaning the mixture of job functions, and office policy (2), meaning the flexibility granted by the company regarding employees' working times.

All following studies were focused on the user: we employed a single occupancy scenario and excluded daylight in all to exclude them from confounding the results. For step 3, we started with testing the switching-off approach as used in cubicle offices [7]. Testing was with 9 participants in a real open-plan office without partitions [5], the so-called bullpen office. Subsequently, a dimming approach was tested in a controlled laboratory set-up, as shown in Figure 1.

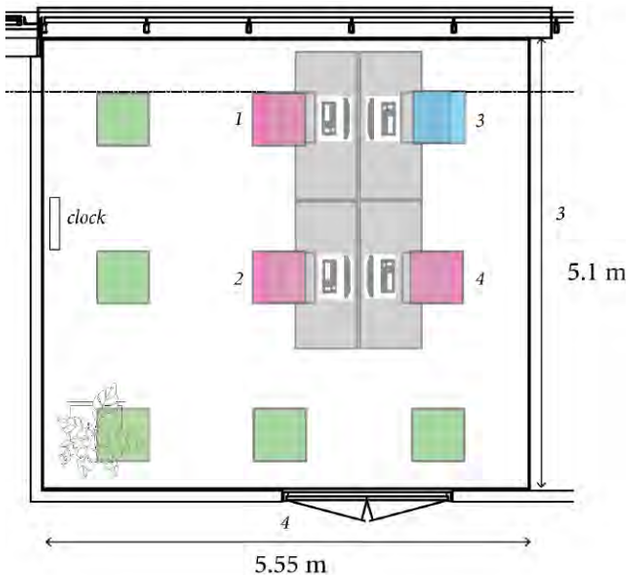

Figure 1. Plan of the lab room, with the desks and chairs (grey), clock and plant, and the task luminaire (blue), surrounding luminaire (pink) and background luminaires (green); the participant sat behind desk 3.

In this study, 25 participants were included. Subsequently, in this same environment, users' comfort was given a closer look by investigating their preferences for luminance distributions in relation to time-of-day and subjective alertness (N = 25; step 4). Their set-up included a medium-sized office. In a follow-up study; the preferences of occupants were also investigated in a large office set-up in a subsequent study (N = 43).

Lastly, we tested the acceptability of local lighting control in the real office environment, namely a Dutch bullpen office (N = 9). To determine the influence of office lay-out, the acceptability of local lighting control was also measured in a cubicle office to represents offices in North-America (N = 11).

RESULTS AND DISCUSSION

ENERGYSAVING POTENTIAL

The results from the simulation study indicated that local lighting control saves 20-25% more energy compared to central lighting control, meaning control at room resolution, across the office cases [4]. This finding suggests that local lighting control is relevant to apply in any office.

DESIGN OF THE STRATEGY

Occupants were dissatisfied with the lighting distribution when it concerned the switching-off approach. This can be explained by the large contrasts between switched-on and –off luminaires [5]. Therefore, we developed a strategy that reduces this contrast by dividing the office space in a task, surrounding, and background area, and applying different dimming levels in these areas, as visualized in Figure 2 [6]. In a controlled lab study, participants evaluated different combinations of levels across these areas: all were rated positively by the majority of the participants (≥ 70%) except the extreme combinations [6]. As a result, we recommend to use a dimming instead of switching-off approach in bullpen offices. Moreover, the results of this study indicated that both energy savings (55-65% compared to central lighting control) and sufficient comfort levels (favorable evaluation by ≥ 70%) can be achieved when a low dimming level is applied in the background area. Lastly, large individual differences were detected in the evaluations, indicating a need to study preferences for luminance distributions in more detail.

PREFERENCES FOR LUMINANCE DISTRIBUTIONS

In the first study, participants chose medium luminance values in the surrounding area (35-65 cd/m^2) and low values in the background area (20-50 cd/m^2) anytime during the day. As Task:Surrounding:Background ratio, they mostly preferred a uniform type, "Task & Surrounding > Background", or the type "Task > Surrounding > Background". Subjective alertness caused for a subset of the participants variance in their preferences. Then we found too large individual differences to recommend one generic dynamic scenario. Hence, we suggest that local lighting control considers this aspect in real-time.

The second study showed that participants preferred lower luminances in the large office set-up compared to the medium-size set-up, especially in the background area. Again, we detected large individual variation, but users mainly preferred a uniform luminance ratio or of the type "Task & Surrounding > Background". Interviews were conducted to understand their motivation for their choices: these indicated that the lighting in the surrounding area serves their visual comfort, while they select a certain background level to create a particular feeling or atmosphere.

ACCEPTABILITY IN THE REAL OFFICE ENVIRONMENT

The first study taught us that the lighting changes, due to local lighting control, distract some occupants [8]. Comparing the results of this study to the second study indicated that the acceptability of these distractions is much lower in cubicle offices, as shown in Figure 3 [9]. Instead of office lay-out, however, differences in job function and the amount of interaction between employees seem to be the underlying cause.

CONCLUSION

In summary, this research showed that local lighting control is feasible to achieve energy reductions while also taking into account users' comfort with the work environment in bullpen offices. With local lighting control, luminaires are clustered flexibly based on the real-time occupancy. As a result, the lighting use is minimized in the unoccupied part of the space while the luminance distribution can be tailored to users' preferences. These include a low background luminance and non-uniform ratios, and depend on users' subjective alertness in the moment. By tailoring the lighting to these preferences, local lighting control positively benefits office workers' well-being. ■

Figure 2. Concept of local lighting control for an example office case: different dimming levels in the task, surrounding, and background area when individual absences occur.

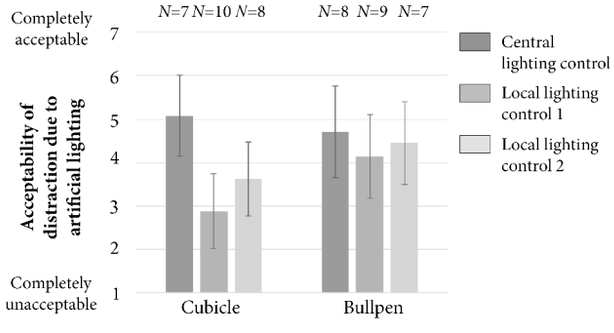

Figure 3. Acceptability of distraction due to electric lighting during central lighting control, local lighting control 1, and local lighting control 2 being applied in the cubicle and bullpen office; acceptability scores are displayed as EMM's and error bars as SE's.

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BPS Basics: CFD in the Built Environment

Author
dr. H. (Hamid) Montazeri

You probably have experienced the high wind speeds near the Vertigo building. Can we measure the wind speed near the building, perform an assessment, and ensure that there is a sufficient degree of wind comfort and wind safety? You might suggest that we install sensors near the building to measure the wind speed. Well, while that is a good idea, we would then have to install numerous sensors to collect sufficient information for our analysis. This could be time-consuming and probably expensive, but this is still possible since the building is already built.

What if we are at the design stage of a new high-rise building inside the campus? How can we ensure that such wind discomfort issues are prevented or mitigation measures are taken into account in our design? In this case, performing on-site measurements are obviously not an option. We can perhaps do this analysis in our wind tunnel using a reduced-scale model of the TU/e campus that includes the building under development. Now assume that we want to perform fire safety assessment for the Vertigo building. Or we want to know if a fire starts on the fifth floor, how the smoke and flame will spread. I do not think we are allowed to assess these using on-site measurements nor inside our wind tunnel. In this case, "CFD" can thus become a suitable option. CFD allows us to solve flow problems that do not have known analytical solutions and cannot be solved in any other way.

WHAT IS CFD?

The acronym CFD stands for Computational Fluid Dynamics that refers to the solution of fluid flow problems by numerical simulation. Anderson [1] provides the following definition:

"Computational Fluid Dynamics is the art of replacing the integrals or the partial derivatives in the governing equations with discretized algebraic forms, which in turn are solved to obtain numbers for the flow field values at discrete points in time and/or space. The end product of CFD is indeed a collection of numbers, in contrast to a closed-form analytical solution."

The governing equations of fluid dynamics are (1) continuity, (2) Navier-Stokes, and (3) energy equations that are based on the conservation of mass, momentum, and energy, respectively. Note that Navier-Stokes equations that are named after "Claude-Louis Navier (1785-1836)" and "Sir George Gabriel Stokes (1819-1903)", are obtained by applying Newton's second law to fluid motion, and describe how the velocity, pressure, and density of a moving fluid are correlated. If we can solve these governing equations, we can obtain solutions for a wide range of fluid flow problems. However, these equations are Partial Differential Equations (PDE), for which there is no general solution "yet". Therefore, we need to solve these equations numerically with the help of the computer.

Figure 1a. Aerial view of the tower (red) and surrounding buildings.

HOW DOES CFD WORK?

Assume that we want to evaluate a new facade concept that is intended to significantly reduce the wind speed and therefore improve wind comfort on the balconies of a tower in an urban area [2]. The concept consists of a staggered semi-open second-skin facade in front of the balconies, which partly shields them from the wind. The main tower (tower in red color in Fig. 1a) and other new buildings under development (in white color) are not yet built. Therefore, we cannot conduct on-site measurements. In addition, the facade openings and the depth of the balconies are rather small. These scale issues make wind-tunnel testing very difficult – or even impossible. Therefore, CFD can be the only option for such an analysis.

To perform the CFD simulations for this case study (like any other CFD simulation), we need to take three steps:

I Pre-processing,
II Solution
III Post-processing.

STEP ONE: PRE-PROCESSING

We first develop a geometrical model of the buildings and place them in a computational domain (Fig. 1b). This can be done in pre-processing software such as Gambit, AutoCAD, etc.

We then need to make a "grid" (or mesh), which means that the computational domain is sub-divided into a large number of (computational) cells in which the flow will be solved (Fig. 1c).

This step can be executed with the aid of the pre-processor Gambit, Ansys Meshing, etc. While the grid is ready, we apply the corresponding boundary conditions at the boundaries of the computational domain. We are now ready to start the "simulations".

STEP TWO: SOLUTION

Solvers perform the actual computations. These solvers can be developed in-house by the user, but also commercial solvers (e.g., ANSYS Fluent), or (free) open-source CFD software (e.g., OpenFOAM).

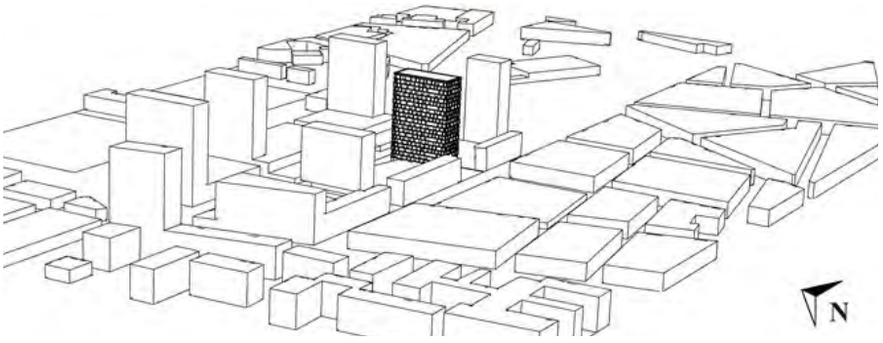

Figure 1b. Corresponding computational geometry of the tower and the surrounding buildings.

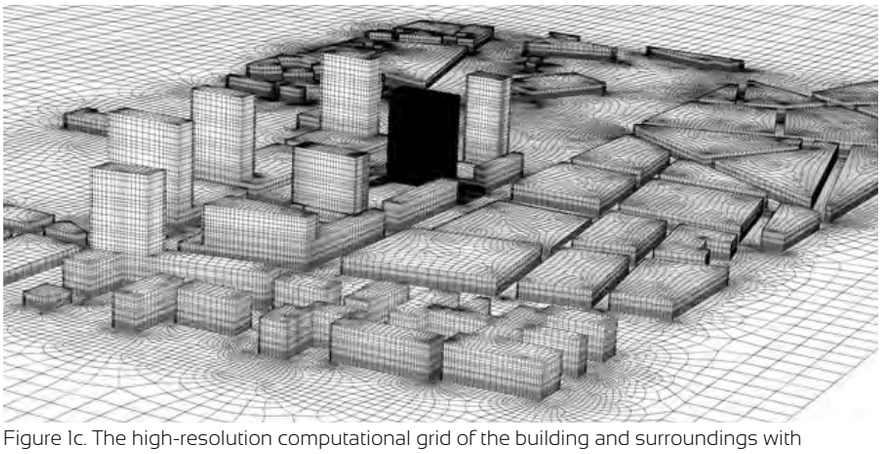

Figure 1c. The high-resolution computational grid of the building and surroundings with 16,292,495 cells.

STEP THREE: POST-PROCESSING

The obtained results are now available in the form of numbers. In this phase, the results are visualized and presented in the form of static and moving pictures, graphs, tables, etc.

WHY USE CFD?

CFD offers several advantages compared to other approaches:

- It is relatively inexpensive and fast. For example, measurements are normally performed sequentially, while several CFD simulations can be performed in parallel using different computers.
- Parametric studies can be performed easily and effectively.
- Simulations can be performed at full scale. Wind-tunnel measurements are usually performed at reduced-scale.
- CFD can reproduce situations that we do not want to (or maybe cannot) reproduce in reality. For example, we can perform the fire safety assessment of Vertigo in a few hours, while we are sitting inside the building, next to the computers that are simulating the fire.
- CFD provides complete information on different parameters in the whole computational domain. Note that this is not the case for on-site and wind-tunnel measurements, since they are generally only performed at a limited number of selected positions.

WHY CAN CFD BE DANGEROUS?

Although CFD is a very powerful tool, the accuracy and reliability of the simulations results are of concern. Errors and uncertainties can cause CFD simulation results to differ from their exact values.

Error is defined as a recognizable deficiency in any phase or activity of modeling and simulation that is not due to a lack of knowledge about the physical processes [3]. Two examples are "usage error" and "discretization errors".

Usage errors (user errors) are due to the application of a CFD code in an improper manner, because of lack of experience, care or proper training. If you compute the airflow around the Vertigo building with an assumption of inviscid flow, you should not expect to obtain accurate results, right?

Discretization errors depend on the quality of the computational grid. If we can increase the number of cells in the computational domain in such a way that the grid spacing tends to zero, we can then ensure that discretization error tends to zero. However, given the limitations in time and computing resources, very high cell numbers should be avoided.

The grid convergence study (grid-sensitivity analysis) is a useful procedure for determining the level of discretization error in CFD solutions.

Uncertainty is defined as a potential deficiency in any phase or activity of the modeling process that is due to the lack of knowledge [3]. They may or may not exist. Two examples are "input uncertainty" and "physical model uncertainty".

Input uncertainties are due to the limited information or approximate representation of geometry or boundary conditions. Do we need to include the trees next to the Vertigo in our computational geometry? Does the presence of these trees can influence the airflow pattern and our wind comfort assessment? Performing a "sensitivity analysis" will give us the answer.

Physical model uncertainties: For example, turbulence modeling in CFD simulations is not yet fully understood. Therefore, we can determine the level of uncertainty cause by different turbulence modeling approaches using a sensitivity analysis. Therefore, obtaining accurate and reliable CFD results is not easy since it requires sufficient knowledge and experience. This is getting more problematic given the rapid development of user-friendly CFD software that allows unskilled users to generate colorful and impressive figures and animations. That could be one of the reasons that professionals always criticize CFD results, although the very good performance of CFD has been proven on several occasions for a wide range of applications.

WILL CFD BE USEFUL FOR BUILDING ENGINEERS?

Well, chances are very high that you as young engineers will get in touch with CFD at some point in your career, either as users in design offices, engineering consultancy firms, research institutes or universities or as decision makers judging CFD-based designs and CFD simulations made by others. Therefore, it is essential that you have the necessary background and knowledge to perform "accurate" CFD or evaluate the CFD results performed by others [4].

CFD can be used for a wide range of applications in the indoor and outdoor built environment, including but not limited to: wind comfort and safety around high-rise buildings, outdoor ventilation in urban areas, urban wind energy harvesting, natural ventilation in buildings, indoor air flow and quality. ■

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Ice Breaker: Evgeniya Mamulova

Hi! My name is Evgeniya but, given the high mispronunciation rate, I'm better known as Eugene. I was born in the Siberian city of Krasnoyarsk; accidentally, if I may add. At the tender age of six months, after having wrestled my way from under a bear and thus having proved my worth to my parents, I was brought to Cyprus. Having spent my entire childhood on the tiny island has sure taken a toll on my bear-fighting skills.

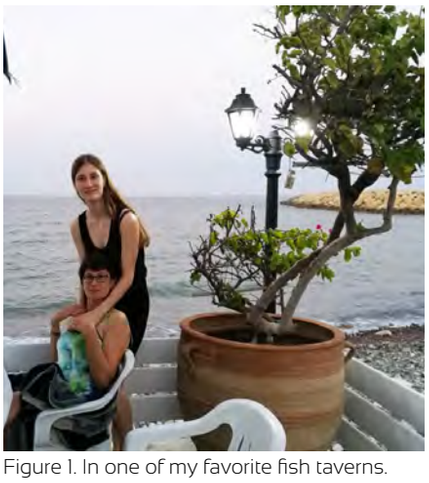

Figure 1. In one of my favorite fish taverns.

I was raised with the mindset that I would go to study abroad and, as someone who was lucky enough to learn Russian, English, Greek, French and Italian, I had many options. My education was a mixture of scientific, artistic and linguistic disciplines, with the first being a necessary foundation and the other two being hobbies. When the time came to choose a field of study, architecture was almost too obvious of a choice.

In 2014, I began my bachelor of architecture in Venice, Italy. Full immersion into the world of design was exactly what I needed. Mathematics to me was like sunlight to a vampire; quite literally, seeing as I adopted a nocturnal lifestyle based on rigorous studying and, admittedly, video games. I eagerly participated in numerous workshops and exhibitions, including the Architectural Biennial. During my

Figure 2. Matching my outfit to my painting.

second year, I came into contact with architectural engineering: I had a brilliant professor who successfully transmitted her passion towards building technology to her students. As much as I'd like to say that I had always envisioned myself as a building physicist, I only began shifting my perspective from that moment onwards.

Disclaimer: This story is about to get serious. As I continued my studies, my persistent research into the environmental issues of today left me dissatisfied with my long-term role in society. I spent my last year in Scotland,

Figure 3. Architecture Biennial 2016.

where I cherry-picked my subjects from the building technology and civil engineering sectors, in order to gain better technical understanding of my field, but all I found was a discipline gap. Upon graduating, I moved to Milan, where I worked as an architectural assistant for six months. Despite having met brilliant designers who practically became my family, I already had one foot at the TU/e, ready to work my way towards engineering buildings that are more environmentally friendly. As someone who has directly expierenced the gap between design and engineering, I hope, one day, to play a role in improving this dynamic.

Figure 4. My team at the 967Arch.

I chose this university because it is notoriously research-inclined and I am open to the possibility of following an academic path. I am particularly interested in making buildings as intelligent as possible: I believe in the power of data in the hands of those who can tame it (metaphorical bears can be just as problematic). I enjoy short-term travelling as much as the next person, but true happiness, for me, lies in being a citizen of the world: I just moved to Eindhoven and I'm already considering the prospect of an internship in a different city. I'm also an avid believer in keeping both a healthy body and a healthy mind, so when I'm not raiding the Mollier candy cabinet, I am most probably at the SSC. ■

Control Strategies for Advanced Solar Shading Systems

Supervisors
ir. S.B. (Samuel) de Vries
dr. ir. R.C.G.M. (Roel) Loonen

Author
M.F.S. (Mohammed) Al-Sailani, BSc.

INTRODUCTION

Daylighting and outdoor views have a positive impact on human health and productivity in workplaces [1]. Automated operation of solar shading systems offers the potential to positively influence views, daylighting performance and visual (dis)comfort. This requires a control strategy which is able to achieve the desired performance goals in relation to the changing outdoor and indoor conditions. Model Predictive Control (MPC) has been shown to offer a promising solution; however, such control strategies are faced with many practical obstacles (e.g.: they are complex, slow, and require detailed sensor and input information). The objective of the study was to investigate whether a control strategy can be developed through analyzing the behavior of an MPC in a simulated environment. The daylighting performance of a vertical Venetian blind control has been analyzed in this research as a case study. To fulfill the objective, three research questions have been explored in this study:

1. What is the optimal control strategy, with regards to daylighting performance and visual comfort, for automated vertical blinds?
2. How do performance trade-offs made by the MPC lead to different decisions regarding the orientation of the blinds under different conditions?
3. How can a rule-based control strategy be developed through analyses of the behavior of the optimal control results?

METHODOLOGY

As a case study, a reference office room that is 4.5 m wide and 8 m deep with 85% south window-to-wall ratio was used for analysis. The three-phase simulation method in Radiance was used for calculating the horizontal and the vertical illuminance values. To maximize the illuminance across the workspace with the least amount of glare, a penalty function was used as shown in equation 1. The optimization model calculates the penalty function for each blind configuration at each time step. Then the blind slat rotation with the least penalty is chosen for each time step. In this way, the control strategy always intends to find a balanced trade-off point between the competing performance objectives. The optimal case shading control is compared with a reference case control. In the reference case, the blind slat rotates to align its surface normal with solar azimuth angle all the time.

$$P = \sum P_{illuminance} + 5 \cdot \sum P_{glare}$$

Where, P is the total penalty function, $P_{illuminance}$ is the illuminance penalty function and P_{glare} is the glare penalty function.

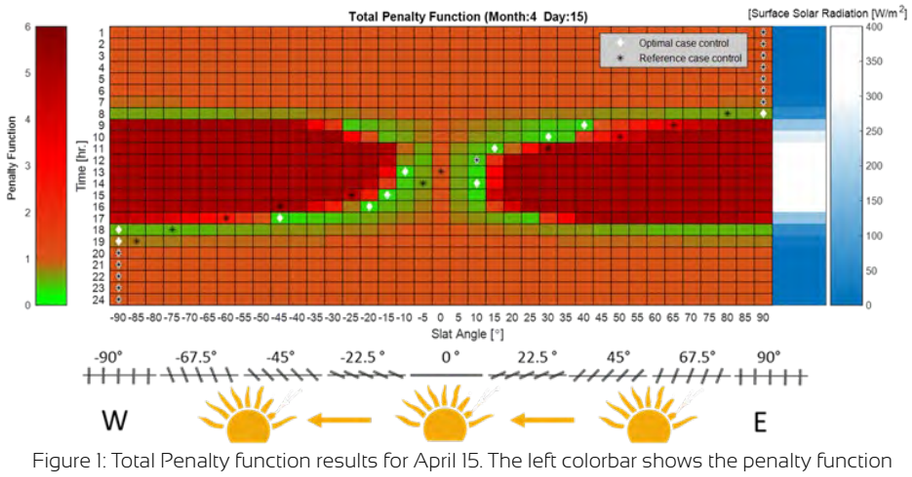

Figure 1: Total Penalty function results for April 15. The left colorbar shows the penalty function results. The right colorbar presents solar radiation incidence on the window. The blind slat angles are on the x-axis and the time of the day is on the y-axis. The diagram at the bottom shows the configuration of different slat angles with respect to the sun location.

RESULTS & CONCLUSION

Results show that the optimal daylighting control strategy reduces glare and improves illuminance in the workspace compared to the reference case. The spatial daylight autonomy (sDA 300 lux/ 50%) is 55% for the optimal control case compared to 33% for the reference case. The optimal case has 2% of the annual occupied hours with simplified daylight glare probability (DGPs) >0.35 compared to 26% of the hours in the reference case. Figure 1 summarizes the total penalty function on a sunny day for each blind configuration in different hours of the day with the reference case and optimal case blind control. Results show that the performance trade-offs made by the MPC are dependent on the sky condition or the sun position. The behavior of the MPC shows a pattern that could be described in a rule-based control. Such rules could be extracted using data analysis methods. Developing a rule-based control based on analysis of the optimal case data seems like a promising direction as the resulting system could offer similar performance to an MPC strategy whilst facing much less practical and economical challenges in its implementation. ■

[1] Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of green buildings on employee health and productivity. American Journal of Public Health, 100(9), 1665–1668.

[2] Loonen, R. C. G. M. (2018). Approaches for computational performance optimization of innovative adaptive façade concepts Eindhoven: Technische Universiteit Eindhoven.

VALSTAR SIMONIS

ADVISEURS INSTALLATIETECHNIEK

Als adviseur bij Valstar Simonis houd ik mij bezig met het organiseren van projecten, zoals het aansturen van teams en het overleggen met onze klanten, maar ook met het maken van ontwerpen. We helpen onze opdrachtgevers dagelijks met het ontwikkelen van duurzame, gezonde gebouwen waarin hun medewerkers, studenten of patiënten zich prettig en comfortabel voelen. Zo was ik bij de renovatie van het gebouw Atlas op de TU/e campus eindverantwoordelijk voor het ontwerp van alle installaties.

Na 7 jaar bij Valstar Simonis blijf ik mij nog elke dag ontwikkelen. Er is veel aandacht voor persoonlijke ontwikkeling, waarbij het belangrijk is dat je kunt groeien in de dingen die je leuk vindt. Je merkt ook dat er naar je ideeën wordt geluisterd en krijgt de kans om die ideeën uit te proberen.

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Tijdens mijn afstudeeronderzoek kwam ik in aanraking met een duurzaam project van Deerns in Curaçao: Sea Water Airconditioning (SWAC). Dit is een manier om gebouwen te koelen met zeewater waardoor veel energie kan worden bespaard. Dit soort oplossingen zijn nodig om de transitie naar duurzame energie te maken. Dat Deerns dit met innovaties mogelijk maakt, is voor mij de reden om bij Deerns te werken.

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Helping to change the skyline of Eindhoven at Arcadis

Author
M. (Mick) Hendrix

Fresh out of college in 2017 I started as a trainee at Arcadis within the team Sustainable Building Services & Physics. This group of around 40 consultants and engineers is located at 2 of the 11 Arcadis NL offices, in both Rotterdam and Maastricht.

With a background in architecture and a focus on building physics in my Master degree I got the chance to learn and work on a broad range of projects from day one. This includes new designs for new developments, but also sustainability studies and refurbishments of monuments. While working at Arcadis I have been able to increase my knowledge step by step and take on increasingly challenging responsibilities. In 2018 I got the chance to be part of the design team for the project District-E.

District-E is developed by Amvest and designed by Powerhouse Company. It consist of three high rise towers next to the train station in Eindhoven, at the current location of the VVV office. The project combines a multifunctional programme including housing, offices, a hotel, restaurant, sky bar and retail functions. Within the design team Arcadis is responsible for building physics, acoustics and MEP for the project.

The TU/e has also been part of the project team. During the preliminary design phase the university and Prof. Dr. ir. Bert Blocken simulated the design using Computational Fluid Dynamics (CFD) to determine the expected wind speeds around the towers and public spaces. They consulted Powerhouse Company in design adaptations resulting in an optimal wind climate, which is quite a challenge for a high rise project in a predominantly low rise city.

Within the field of building physics Arcadis works on determining external noise levels, soundproofing of the façade, internal partition walls and floors, solar studies, daylight simulations and optimising the façade materials in relation to energy use and fire safety. As a consultant you, together with the different disciplines in the design team, make sure all of the individual requirements eventually culminate in a coherent design of the building envelope.

Located next to both a busy train station and connecting roads, determining the noise levels (Lden, for each sound source) of the project is critical. The role as a building physics consultant here is to aid the architect in determining where they can project dwellings in the towers. Dutch law outright prohibits building dwellings where certain sound levels are exceeded. Therefore, the surrounding area, sound sources and towers are modelled in 3D to simulate the noise levels at the façade.

Figure 1. View from Stationsweg, Powerhouse Company - March 2019.

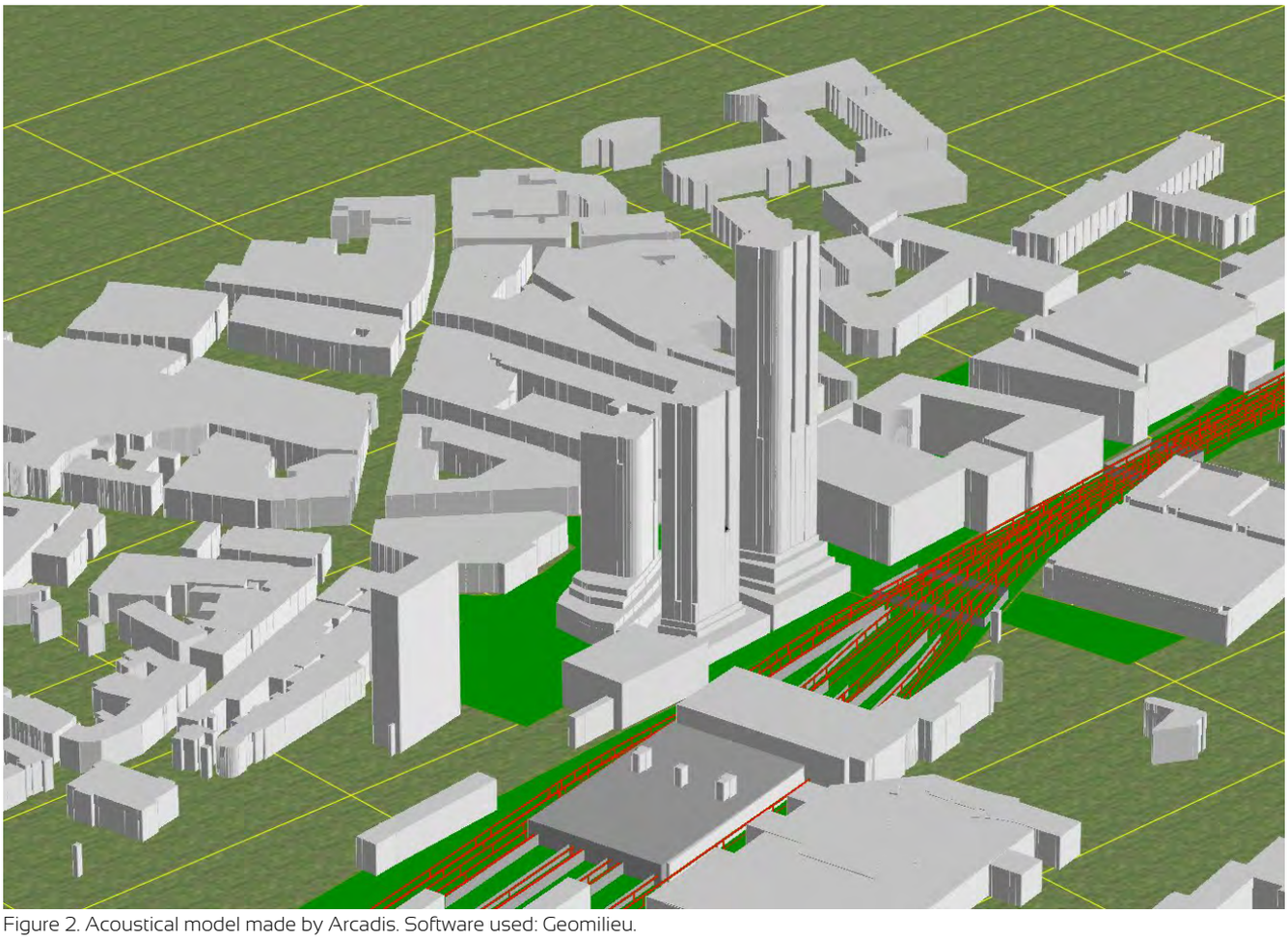


Figure 2. Acoustical model made by Arcadis. Software used: Geomilieu.

These noise levels are also used to calculate the required sound insulation of the façade (GA,k) to guarantee acceptable sound levels within the apartments. This includes consulting the design team in choosing appropriate materials and dimensions for dividing walls and floors between technical spaces, apartments or hotel rooms to maintain acoustic privacy and provide sufficient airborne (Dnt,A) and impact (Lnt,A) noise insulation between spaces.

Another aspect to consider, especially for high rise developments, is reduction of sunlight at adjacent residential buildings. The municipality of Eindhoven requires at least 2 hours of direct sunlight for a dwelling and a reduction of no more than 50% of sunlight hours per day in gardens or at balconies due to new developments. To calculate possible sunlight reduction we created a (geolocated) 3D model of the area with and without the new development to simulate the amount of time adjacent buildings receive direct sunlight. This data gives insight to make sure the project meets the requirements of the municipality.

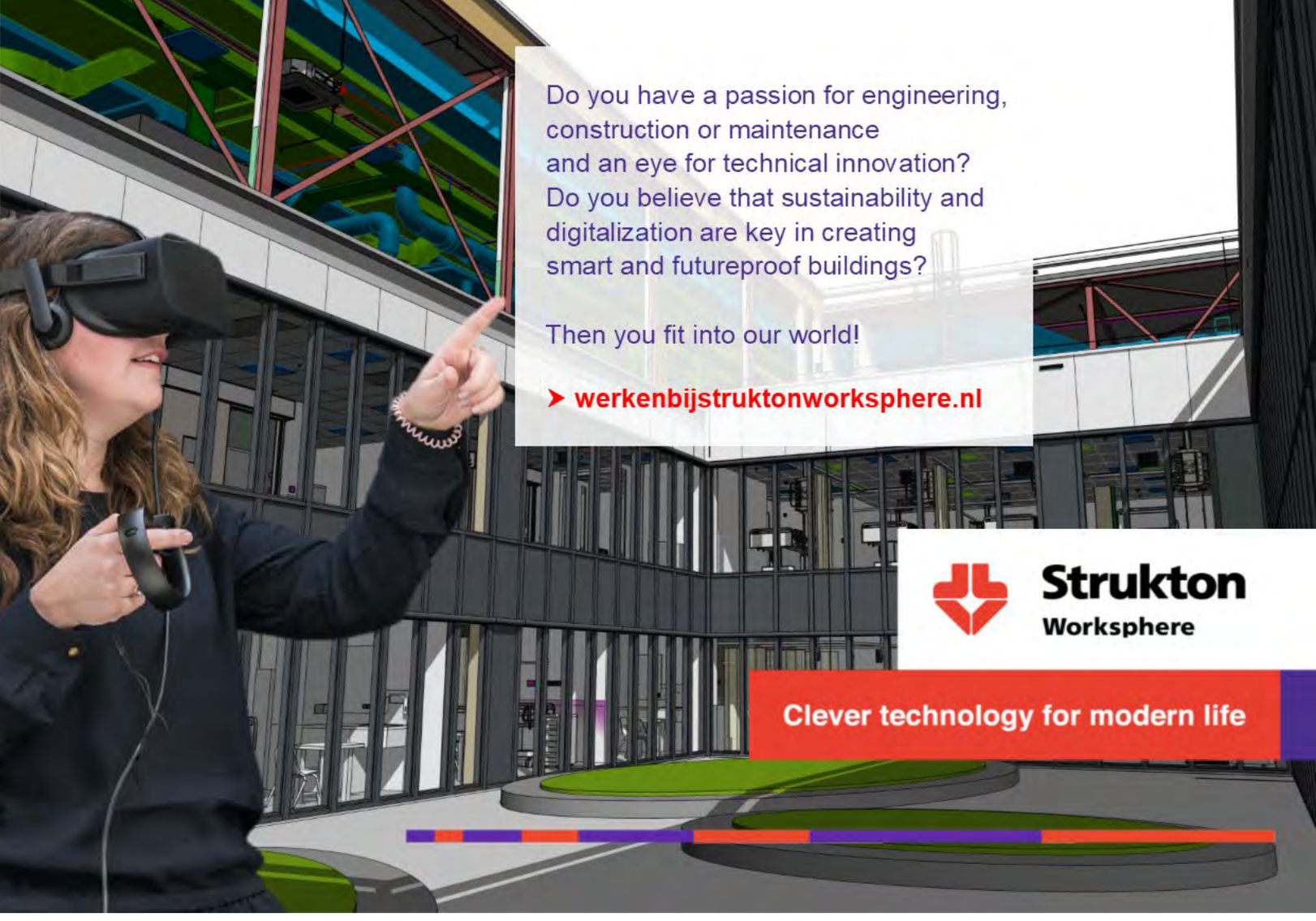
Apart from sunlight at adjacent buildings the daylight entry in District-E is assessed, both for minimum requirements of the Dutch Building Decree and feasibility studies for BREEAM requirements using both average- and point daylight factors (calculated using an overcast sky model). Both obstructions of adjacent buildings (including the towers of District-E itself) and specifications of the glazing are taken into account to determine the daylight factors. These calculations in part drive the architectural design and the open-closed ratio of the façade design.

This ratio of glazing versus closed exterior walls in the building envelope also impacts the total thermal resistance of the façade. For a sustainable high rise building with low energy the use of triple glazing is a must, while thermal insulation thicknesses is limited in curtain wall façades. In the context of compact, high rise housing the exterior façade often makes up less than 1/6th of the total envelope of a single dwelling. So even though the façade is a relative small part of the apartment, a lot of functionality has to be incorporated in it.

Having determined different requirements of the building envelope Arcadis works together with one of Europe's leading façade manufacturers to make sure the façade engineering meets a complex mix of requirements. This includes acoustical and thermal insulation requirements of glazing, façade mullions and materials for a pleasant indoor environment and as little energy use as possible, but also large enough glazing for adequate daylight entry. The design also has to meet strict fire safety standards, so together with the project fire safety consultant the façade materials are assessed.

It is always a challenge to fit all these aspects within the architectural design, but that is what makes building physics and the design process so incredibly fascinating. ■

More information about Arcadis and what we do can be found at www.arcadis.nl and you can ask our campus recruiters.
For further information about the project District-E visit www.district-e.nl.



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CO_2 Concentration near Sleeping Infants inside Baby Cribs

Author
ing. G.J. (Gert-Jan) Braun

Supervisor
prof. ir. W. (Wim) Zeiler

INTRODUCTION

The indoor air quality is very important for the well-being of occupants, especially in the case of young babies [1]. This research focused on the air quality of the air surrounding sleeping infants inside a crib. To study the effects of different sleeping positions of the baby within the crib, a measurement setup was created in the laboratory. The breathing of an infant was simulated by means of a baby doll with air supply mixed with CO_2 and measured at different sensor locations for different sleeping positions. The effect of the position of the baby on the CO_2 concentrations inside the crib are compared with the background level in the sleeping quarters.

METHOD

To measure the effect of the closed surfaces and the breathing position of the baby on the different measurement positions, a measurement setup was created at the Eindhoven University of Technology. Since it was not possible to measure conditions using real babies, a doll was attached to a breathing simulator to mimic the practical conditions. Figure 1 shows the doll placed in the test crib.

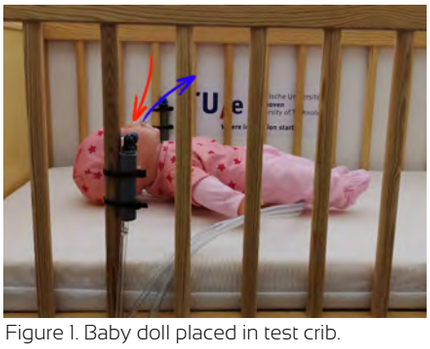

Figure 1. Baby doll placed in test crib.

Figure 2 shows a schematic overview of the four CO_2 sensors that were used to measure the concentrations around the nose, bars on the room and wall side and the background level. The room sensor that measured the background CO_2 concentrations was placed at the same height as the sensors in the crib.

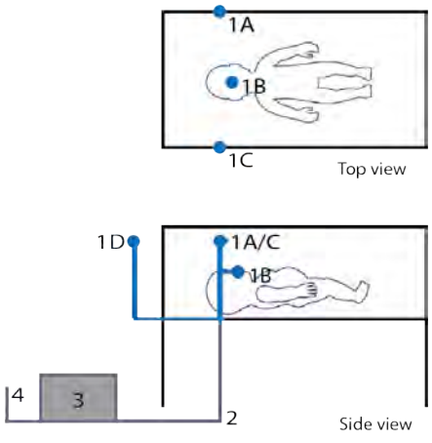

Figure 2. General measurement setup.

RESULTS

The overall results of the measurements relative to the background level are displayed in Figure 3. As can be seen, the values near the mouth position reach the highest concentration when facing a wall, and become lower when facing a more open surface.

CONCLUSION

It was found that the bottom bunk bed with a more closed surrounding led to an average increase of approximatelly 220% relative to the background level, compared to the bedstead where the increase was 160%. In both situations, the increases are significant and even more significant for the measurements at the wall side. Here, the increase for the bottom bunk bed and the bedstead was 270% and 210% respectively. Therefore, it could be concluded that as the surroundings of a crib become more closed, higher CO_2 concentrations should be expected.

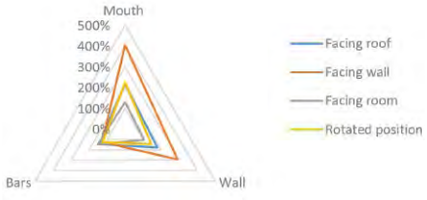

Figure 3. Average CO_2 BBB and BS combined.

The position of the doll had a significant effect on the measurements. For example, when the baby is facing the wall in the bottom bunk bed, the rise in the average CO_2 concentration was around 270%. However, when the baby was facing the room (bars) the CO_2 concentration only rose 30% while facing the roof led to an average increase of around 80%. Therefore, it is concluded that the position of the baby has a significant effect on the measured values. When the mouth of the baby is facing an open surrounding the average CO_2 concentrations of the inhaled air decreased significantly compared to when a baby was facing a more closed surrounding. Therefore, it is concluded that it is not sufficient to only measure the CO_2 concentrations in the sleeping room as the conditions will significantly deviate from those in a crib. ■

[1] B. E. Boor, M. P. Spilak, J. Laverge, A. Novoselac, and Y. Xu, "Human exposure to indoor air pollutants in sleep microenvironments: A literature review," Building and Environment, vol. 125, pp. 528–555, Nov. 2017.

Modeling inhomogeneous irradiance on façades

Supervisors
prof. dr. ir. J.L.M. (Jan) Hensen
dr. ir. R.C.G.M. (Roel) Loonen
Á. (Ádám) Bognár, MSc.

Author
ing. M.D. (Marc) Tavenier

INTRODUCTION

EnergyPlus (E+) is a building simulation engine that is widely used for predicting building energy consumption and the quality of indoor environments. It has algorithms for calculating incident solar irradiance on building façades and is able to take the effect of shading obstructions into account. However, it is currently unknown if this coarse method can predict inhomogeneous irradiance distributions on complex façades. In previous research [1] it was demonstrated that Radiance's raytracing is capable of delivering accurate predictions for such façades.

To this end, a three-way comparison will be made by comparing E+ with Radiance and measurements. The measurements used are that of the ZigZagSolar façade. The resulting research objectives are:

- To analyze the irradiance calculation performance of complex-geometry façades with E+ by comparing it with measurements and Radiance calculations.
- To describe the difference in modeling approaches for making irradiance calculations on complex-geometry façades with E+ compared to the modeling approach in Radiance.

SIMPLE GEOMETRY

As an initial comparison, a cube is modeled, simulated with both engines and compared to measurements where applicable. Figure 1 shows the results of the 'roof' of the cube and the south-facing façade in the shape of a correlation graph.

ZIGZAGSOLAR FAÇADE

This comparison is scaled up for more complexity. The ZigZagSolar façade system is a BIPV (Building Integrated PhotoVoltaic) system where the solar panels are slanted upward. The downward slanted panels are 'reflector' panels that reflect the light of the lower sun onto the solar panels. This way, the energy harvest is up to 26% higher compared to a roof PV-system [2].

A building with a ZigZagSolar façade system is modeled. Since E+ has a limitation where it can only have 4 measurement points per rectangle, the panel is split into two halves for more accuracy. Figure 2 shows the results of the comparison between E+ and measurements for both the front and back panel.

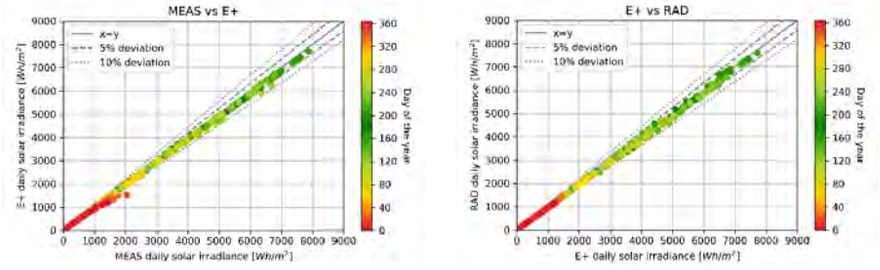

Figure 1. Correlation graphs for horizontal irradiance on flat geometry (left) and for south-facing vertical irradiance (right).

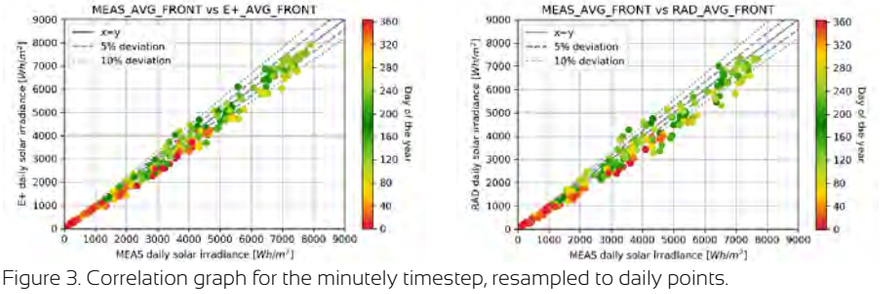

Figure 3. Correlation graph for the minutely timestep, resampled to daily points.

CONCLUSION

The irradiance calculation of E+ performs just as accurate as that of previously validated engine Radiance for both the simple geometry and the complex ZigZagSolar façade. When comparing to measurements, there is an average deviation of about 10% when using hourly data and about 5% when using minutely data.

The difference in modeling approach is that E+ surfaces need to be split up for more accuracy in complex geometries. Also, if the receiving solar panels make use of solar rays more than once off another surface, E+ will not simulate this correctly whereas Radiance is able to simulate this. ■

[1] S. Koenders, "The use of the Radiance-based software Daysim for prediction of the behaviour and performance of the ZigZagSolar facade system," Eindhoven University of Technology, Eindhoven, 2017.

[2] de Architect, "Energie uit ZigZagSolar gevel [NL]," 15 October 2015. [Online]. Available: https://www.dearchitect.nl/architectuur/nieuws/2015/10/energie-uit-zigzag-solar-gevel-10194773. [Accessed 26 November 2018].

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Characterisation of Recycled Concrete

Supervisors
dr.Dipl.-Ing. M.V.A. (Miruna) Florea
prof.dr.ir H.J.H. (Jos) Brouwers

Author
J.L.(Julian) Stapper, BSc.

INTRODUCTION

Demolition waste streams are an inevitable waste stream in the built environment. As buildings reach the end of their functional lifetime, a retrofit or demolition will result in waste materials that could be landfilled or reused in new construction projects. The latter option being obviously preferable, academic and corporate efforts are now made to reuse as many materials as efficiently as possible. An example in this case can be found in the practice of concrete crushing, where concrete waste streams are recycled from demolition sites. The production streams from these crushers contain clean aggregates which might be reused in new concrete mixes [1] or concrete fines which might be reused as a replacement of cement [2].

A coarse stream from the functioning concrete crusher, Mixed Granulates (MG) is under investigation. The company wishes to know its composition, whereas it is also worth investigating whether composition of such streams can be predicted. Quartz content might be a promising measure in determining content of aggregates versus cement. A method is therefore tested to try and estimate the quartz content based on thermogravimetric analysis.

METHODOLOGY

Characterisation is performed in several steps. Moisture content of the original sample is measured through a cycle of weighing, drying and then weighing. Part of the sample is then milled to size fractions of 63µm, 125µm, 250µm, 500µm, 1mm, 2mm, 4mm, 8mm, 11.2mm, 16mm and 22.4mm. A representative sample of each fraction (and the original sample) is then milled to have a PSD lower than 100µm. Milled samples are subjected to X-ray fluorescence (through a wax bead method) and combined thermogravimetric (TGA) and differential scanning calorimetry (DSC) analyses. As the MG sample is a very heterogeneous material it is also divided into material classes manually for the sizes > 2mm. Samples of these classes are also crushed and milled and subjected to the same characterisation methods.

Finally, a quartz calibration is created with DSC using samples containing 20%, 40%, 80% and 100% quartz (the rest being $CaCO_3$). Using this, the quartz content of all other samples can be estimated based on the peak size of the α-quartz to β-quartz transition occurring between 500°C and 600°C on a DSC curve

RESULTS

To compare the quality of characterisation methods, the results of XRF analyses for the material classes are multiplied by their manually determined percentage content in the size fractions > 2mm to attain a cumulative content. This shows very little variation for the smaller fractions, but variations in calcium and silica content occur for fractions 11.6mm and larger, which is likely a result of difficulty in obtaining a representative sample of these fractions due to their grain size.

The calculation of quartz content from DSC analysis based on the calibration curve was compared to silica content values derived from XRF. Logically, the quartz content should be lower since the material might contain other varieties of silica such as flint. Figures 2 and 3 shows the graphs comparing quartz contents determined by DSC to silica contents determined by XRF.

CONCLUSION

Results from predicting quartz content with DSC analysis check out for most samples but there are some incoherences. The method seems not quite right to predict quartz content in small amounts, as is the case for gypsum. Also, there are some cases where quartz content is greater than silica content. Complementary XRD analysis might show presence of any other silica minerals and further verify results. Performing the calculation for a number of subsequent heating and cooling cycles might filter out any interference and lead to a more accurate average result.

As for the characterisation of the MG sample, it was found that it might be too heterogeneous to be applied as a recycled concrete aggregate and is definitely too coarse; more than 40% of the total original sample falls into the size fraction > 22.4mm. Further crushing is required to turn this into a practical material for reuse. ■

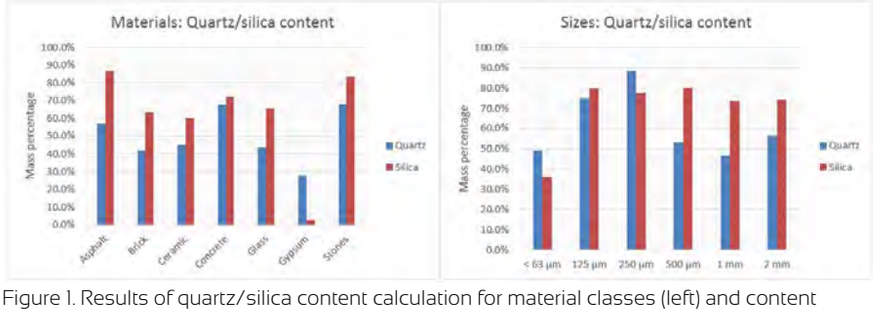

Figure 1. Results of quartz/silica content calculation for material classes (left) and content calculation for size fractions (right).

[1] Florea, M. et al., "Properties of various size fractions of crushed concrete related to process conditions and re-use", Cement and Concrete Research, vol. 52, PP. 11-21, 2013.

[2] Florea, M. et al., "Activation of liberated concrete fines and their application in mortars", Construction and Building Materials, vol. 50, PP. 1-12, 2014.

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Kuijpers & Mollier

Robert Snoeren, trainee Kuijpers
Wouter Flach, recruiter Kuijpers

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Mollier Abroad

Authors
M.D. (Marc) Tavenier
A. (Aleksandra) Zarzycka
D. (Daria) Zendri

At the end of February, we joined the SUPport support trip that occurs every three years from the study association SUPport, which aims to help local communities around the world.
This year's destination was Nepal: a picturesque country between China and India, home of the Mount Everest and birthplace of Buddha. Sixteen students of our faculty joined the trip, five of which BPSers. Two local guides/camp leaders – Mahesh and Nabin – joined us for the entire trip. They have been great advisors and provided us with a ton of information about Nepal and its culture.

Figure 1. Nepali landscape.

The first week of the travel consisted of volunteering work at a community center in Banepa, a city about 30km from the capital Kathmandu. During this week, we stayed in a typical Nepali house made of clay, without any running water or insulation. The daily tasks included carrying the groceries, water and gas up the hill which showed us the struggles of the locals in the village.

Every day, we worked on the community center by building outer walls of the top floor. This, however, did not go with the same speed as we are used to. We had to carry up the bricks, sand, gravel and cement by hand, manually mix the mortar and make sure that every resource we had was used. This meant, for example, cleaning and reusing old bricks. Very labor intensive, but gratifying work. A part of the fee from each participant is used to buy building materials and as a contribution to the local community.
We received a lot of positive feelings from the community, which gave us a welcoming and farewell ceremony and provided us with tea and cookies every day. During this week, we were approached by many villagers who were curious to get to know us, our background, country and culture.

The second week was spent on travelling around the country. The first day, we left Banepa towards Kathmandu and, on the way, we visited a lot of beautiful and magical places: Panauti, Bhaktapur, Patan, Boudhanath Stupa and Swayambhunath Stupa. Our second day in Kathmandu was really special: a major festival in Indian Hinduism was taking place in the capital's major temple. This festival is solemn and marks a remembrance of "overcoming darkness and ignorance" in life and the world. Throughout the day the temple was visited by around one million people, who were queueing for hours in order to access it. This meant enormous chaos and traffic all around the area, but it was still great to be a part of the celebration.

Next destination was Chitwan National Park, the biggest one in Nepal and a UNESCO World Heritage site. The park is home to over 700 wildlife species, including Bengal tigers, leopards, rhinos, crocodiles, sloth bears, elephants, monkeys and many other. During the five-hour jeep safari we were lucky to have spotted several of them wandering around. We also got up before sunrise one morning to watch the birds and witness the jungle waking up.

Our last stop was Pokhara, Nepal's second largest city and base for trekkers undertaking the Annapurna Circuit – one of the most popular trekking paths in the Himalayas and gateway to Mount Everest Base Camp.
From the city, we had amazing views of the beautiful Fewa Lake and of the snowy mountain range, which was truly spectacular.

The best part of the trip was getting to know Nepal in all its aspects: being a part of the local community, as well as seeing the country and getting to know its culture and customs. We shared this experience with a great group, always willing to help each other and giving their best during the construction work.

Even though we are back in the Netherlands, the walls that we built in Banepa will remain; we feel like we left something meaningful and valuable behind, that will serve the people of the community for the years to come. ■

Figure 2. Building the wall.

Building Physics and Services Exhibition

Authors:
R.F. (Ruben) Hetebrij
M.S. (Meghana) Kulhalli

From the 11th March to the 8th of April, for the first time, Mollier organized a Building Physics and Services Exhibition in the Plaza in Vertigo. The exhibition intended to display the different specializations the mastertrack has to offer. It included research currently being conducted by master students, Ph.D. candidates and the faculty, some information and models from student teams related to BPS and also some research by companies.

There are several chairs within the Unit BPS. The research carried out in these chairs contribute towards the improvement of indoor climate, health, performance and innovation in the built environment. The exhibition aimed to show off these different aspects in the Unit.

For the chair of Building Acoustics, the setup for measuring the acoustic properties of a vegetated roof was displayed as an example of environmental acoustics. Tweeting birds could be heard from a unidirectional speaker hanging on the ceiling and one of the acoustic panels used for the room acoustics of the Frits Philips Concert Hall was also brought in.

The chair of Building Lighting had the setup where the effects of different color temperatures can be adjusted using a spectra tune HCL device. The spectral power distribution could be manually changed by the user changing the lighting conditions in the lightbox.

The chair of Building Performance had a model of active insulation, a building envelope system whose insulation function can be switched on and off for which an elaborate computational assessment has been carried out.

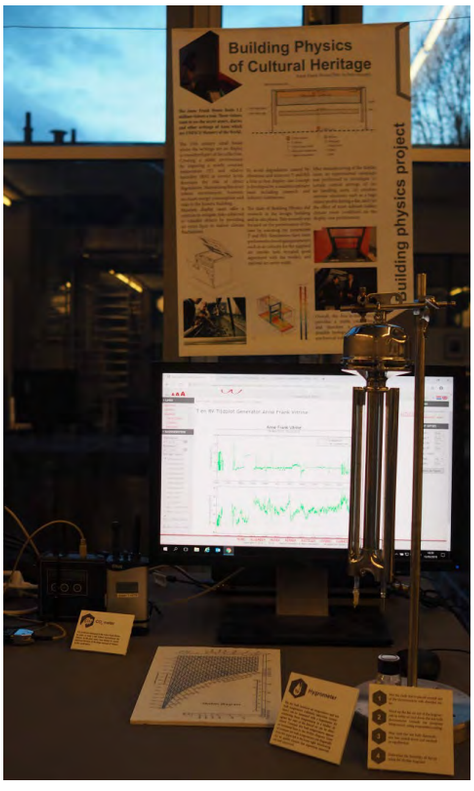
Research within the chair of Building Materials was also presented. Several new material samples such as translucent glass concrete, coconut fiberboard, wood-wool cement board, aerated concrete, aesthetic concrete, hydrophobic concrete and the application of bamboo within an external facade.

For Urban Physics and Environmental Wind Engineering, a huge wind tunnel was displayed, which is a 1:10 model of Ventur, the new wind tunnel of the TU/e. Several wind tunnel models like a skater, cyclist peloton, a TU/e truck and the Bahrain tower were displayed. For Building Physics and Monuments, the measurement setup used in the Anne Frank house was shown, which can be used to assess and improve the indoor environment of historic buildings and objects.

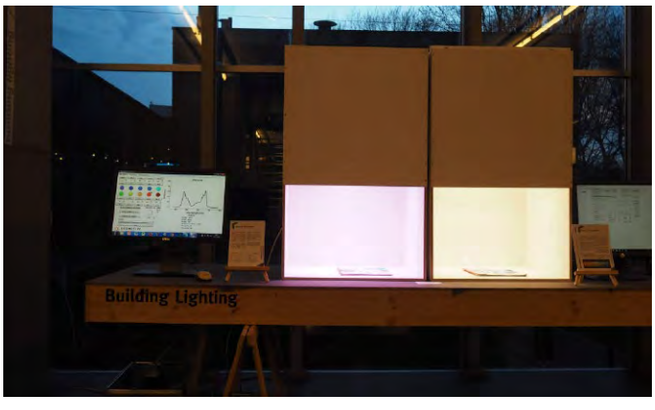
Building Services had an interactive setup of measuring CO_2 levels within baby cots in day care centres. A live measurement device showed how the concentrations varied in real time.

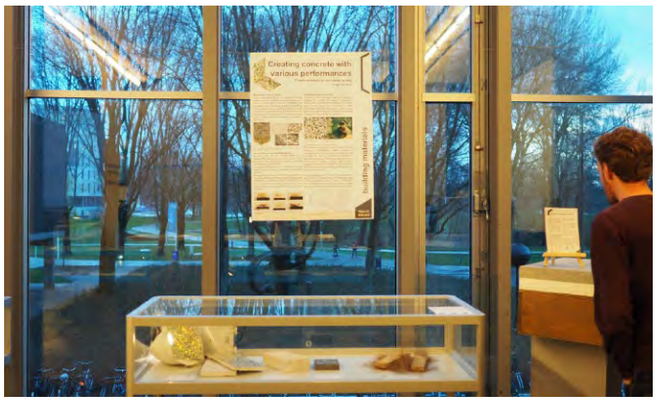
Also, some information about the student teams Team CASA, Team VIRTUe, and Team Ignite were there, with some of the cubes used for GLOW 2018 installation showing nice light effects. These student teams connected the study in Unit BPS to the practical applications the best.

Through this exhibition, we hope that more students are stimulated by the possibilities within building physics or services and apply these principles in their own ideologies and design process to bring forth a healthy and sustainable built environment. Mollier also hopes to put up more such exhibitions in the future!

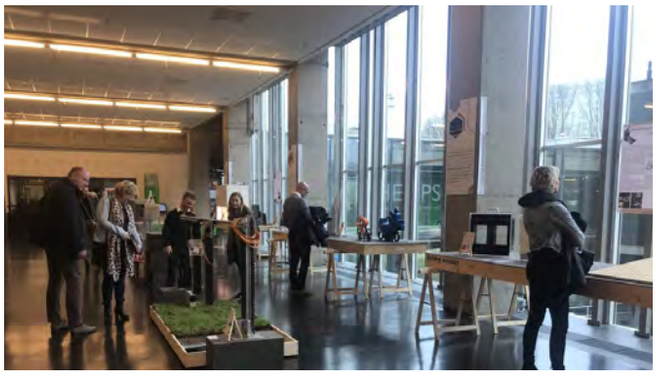

Building Physics
of Cultural Heritage
building physics project


Acoustics of Vegetated
Roofs
building acoustics


Building Lighting


Creating concrete with
various performances
building materials


TU/e
Building Physics
TU/e

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s.v.b.p.s. Mollier
Eindhoven University of Technology
PO Box 513
5600 MB Eindhoven
Secretariaat, BPS, Vertigo, Floor 6
T +31 (0)40 247 4406
E: inside@mollier.nl
www.mollier.nl

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