Academic year 2013 - 2014 #2 | June

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

Background noise in human echolocation

Graduation project Claire Laudij

Study trip 2014

Singapore and Malaysia

A study on turbulent impinging jets

Marina Bay Sands, Singapore, 2014

Foreword

EDITOR-IN-CHIEF

Jelle Loogman

Dear reader,

I am glad to present you the second and last INSide Information of this academic year. We are happy to present you a new article, which pays particular attention to six ongoing student projects and research in the Unit of Building Physics and Services. We hope that these projects give you a better view on the variety of master projects and their content. For the ones who are interested in a more profound article we have selected two outstanding graduation projects about human echolocation and indoor air in long term care facilities. Furthermore, from our Unit we received an interesting article about turbulent impinging jets from one of our PhD students.

Next to that we selected two articles of projects that our sponsors are contributing to. One about the Building Physics and another about the Building Services of two building projects. For those to who reading was not enough, Mollier organized an excursion in collaboration with BAM Techniek to the construction side of the new municipal office: 'Stadskantoor Delft'.

What else? Something we may not forget is our study trip to Singapore and Malaysia. A detailed travel report written by the participants themselves is included in this edition. For the more visual ones, we included some magnificent pictures of what Singapore and Malaysia have got.

Finally, as this is the last INSide Information published under my supervision I would like to thank everyone who contributed to one of the INSide Informations in the last two years. I would like to thank the editorial board in particular for their time and enthusiasm. For next year we are looking for some new editors to complement the Editorial board. So, if you want to participate in any Mollier committee and have some interest in editing, please let us know!

Enjoy reading!

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EDITOR

Marthe Doornbos

EDITOR

Dennis Pennings

EDITOR

You?!

?

COLOPHON

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This INSide


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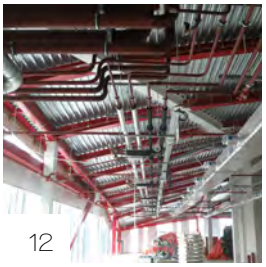
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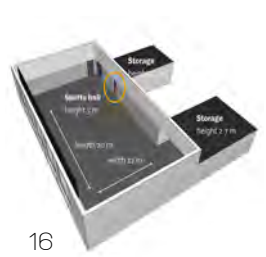

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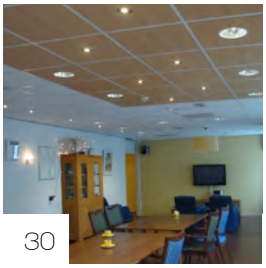
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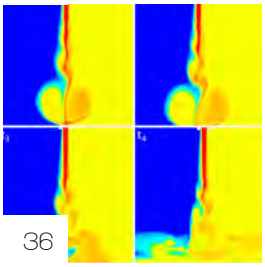
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Student projects

Wind energy potential urban areas

Today the focus is on both adequacy of long term energy supply and also on the environmental implications of particular sources. Due to the negative effect of fossil fuels, more and more attention is paid to the development of sustainable and renewable energy resources. A rather new area is the generation of wind energy in urban areas.

This research focuses on the evaluation of wind conditions in building passages to assess the wind energy potential in urban areas.

The building set-up consists of one single high-rise building positioned without any surrounding. Different opening types and its effect on the wind velocities in the center passage line are investigated.

An amplification of the wind through the passage is expected due to the channeling effect. This amplification represents the important evaluation parameter within this study (figure 1).

It is concluded that (1) constructional obstructions have significant influence; (2) less building structures around the passage are the most advantageous; (3) the surrounding building façade can increase amplification factors for wind

Figure 3 Thermographs of the Zeeuws Museum, The Netherlands

Indoor climate

Museums worldwide try to establish a safe indoor climate suitable for conservation of objects. To achieve optimal conservation for the collection, object deterioration need to be prevent. Therefore, combined to the absence of an absolute guideline for museums in the Netherlands, lead to narrowing of the allowed climatic fluctuations resulting in strict climate specifications.

Predicting the sound field of the LvA transmission rooms with the curvilinear PSTD-method

A diffuse sound field in small reverberant (transmission) rooms is hard to achieve due to modal behaviour of the sound field. Standing waves between the room boundaries cause the sound pressure in the room to vary, resulting in room modes (figure 4). It is important that the sound field is diffuse for measurements performed in this kind of rooms (e.g. determining acoustic properties of materials and constructions or sound power of a sound source). Experience has learned that the transmission rooms in the Acoustics Laboratory on the TU/e campus also show signs of non-diffusivity in low frequency ranges. This project has aimed to obtain an indication of the problem and to propose improvements to decrease the problem, by using the curvilinear PSTD-method to model the sound field of the room.

First, measurements of the current situation have been performed to obtain an indication of the non-diffusivity and to act as a validation for the simulations. Second, simulations have been performed for the original transmission room geometry, for a worst-case situation and for two improved geometries. The comparison between the measurements and the simulations showed good agreement.

Results of the simulations showed little improvement of the diffusivity of the sound field for the improved

velocities within the bounded opening types located at the stagnation point. In addition, the annual energy output is estimated for three opening types with one wind turbine type (figure 2) applied. Considering the electricity power produced by one wind turbine in an idealized full width passage, it can provide electricity for 4.5 households per year.

Yvonne Peters

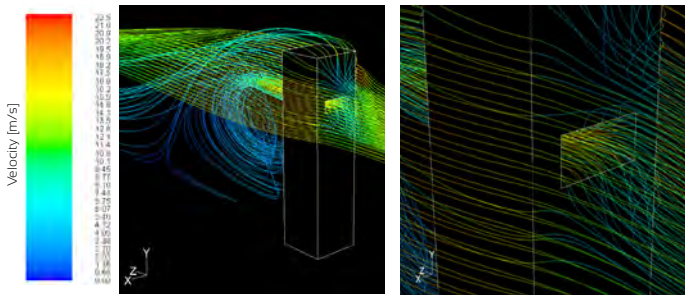


Figure 1 Path lines colored by velocity magnitude [m/s]

Figure 2 Vertical Wind Axis Turbine

suitable for conservation of objects

The project was a case-study for the Zeeuws Museum, this museum has set strict requirements to their climate. The (micro) indoor climate has been measured and compared to the designed climate. The Zeeuws museums wants to achieve an As-climate class, based on measurements and computational tools the climate is not met. Therefore, the risk on the collection have been determined. Also the factors – lighting, building envelope, installation and occupants - which influence the (micro) indoor climate have been studied. Figure 3 provides a thermograph, the influence of supply air on the objects has been shown. The climate conditions near objects which are located nearby the inlet are a risk for mechanical degradation (cracking) for the panel paintings.

Eva van Enk

geometries, and even the worst-case situation did not show a significant decrease of diffusivity. It is expected that traditional measures like panels and diffusers are more efficient alterations to the geometry of the room to improve diffusivity in low frequency ranges.

Niels Hoekstra

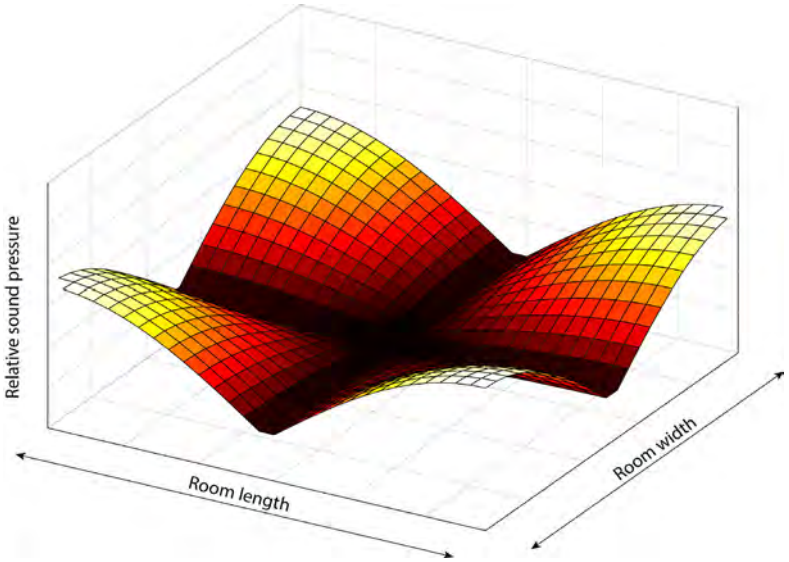


Figure 4 Graphical representation of nodes and anti-nodes of a room mode (sound pressure varying throughout the room)

Student projects

Eco-effective 2020

Sustainability of buildings is increasing, the built environment is shifting from being Eco-Efficient (less-negative) towards being Eco-Effective (positive). New laws and assessment methods (e.g. BREEAM, LEEDS) are developed to stimulate sustainable building; to reduce the waste and pollution and stimulate the use of alternative sources. Nowadays (2014) the main focus is on energy, but in 2020 the energy scarcity needs to be controlled, new buildings have to be energy neutral by law.

This project showed the consequences of this law and the shift toward Eco-Effective building for the assessment method BREEAM. Based on removed and added credits, a shift of focus from energy towards materials was clear for 2020. Nowadays, "what" materials are used is assessed, in the future also "how" materials are used, is important. This way flexibility is stimulated, enabling buildings to adapt to developments and changes. Stimulating buildings to start producing energy, water and materials.

Pieter Wackers

Figure 6 Impression of the measurement setup

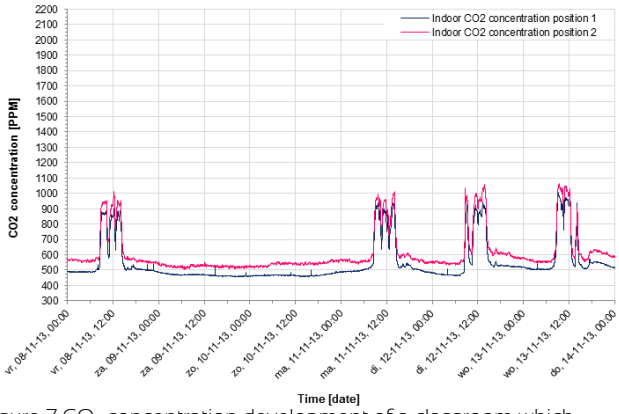


Figure 7 CO_2 concentration development of a classroom which system performs well

Characterizing illuminance fluctuations of daylight in a room under different sky conditions

There are several attempts to mimic the dynamics of daylight for the indoor environment. The most important reason to use this kind of lighting is to increase the comfort and health of the people, but the actual fluctuations of daylight, that are the basis for electric lighting protocols, are not fully understood and properly linked to human requirements. To be able to link this to the human requirements the dynamics of daylight have to be understood. The illuminance fluctuations of the daylight will be measured in this research with the intensity to characterize the fluctuations.

In this research the illuminance of daylight fluctuations was measured in a laboratory room and outdoors for different sky conditions. The intention was to simulate and characterize the light intensity in an office room.

The results showed that the position of the sensors are an important parameter. With a deep room the visibility of the fluctuations further into the room are decaying fast. The large difference of the fluctuations in the

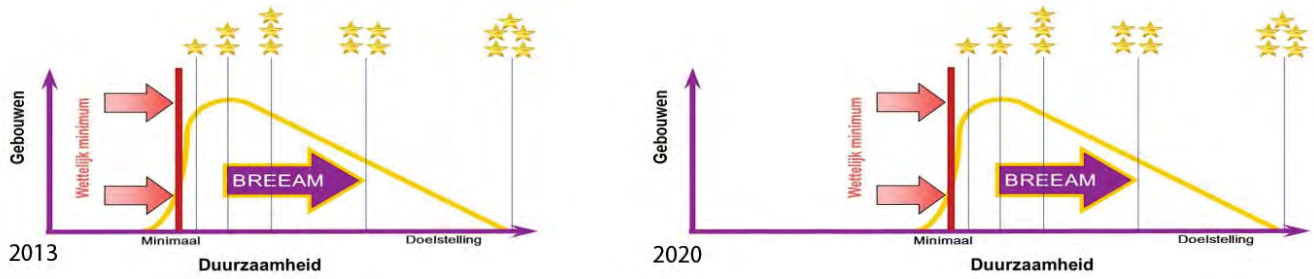


Figure 5 Schematic view of a shift of focus in BREEAM

Indoor air quality

In this research the indoor air quality of schools with a balanced ventilation system was investigated. Indoor air quality is an important topic, because previous research has shown that it influences the health and performances of both students and teachers. Apparently it is difficult to design a school which performs well regarding this topic, as still many new built schools do not meet the given requirements.

The aim of this research was to find a school with a high indoor air quality and to be critical towards the indicators which determine this aspect. For this reason, the CO_2 concentration, temperature and relative humidity in a classroom in four different schools was measured. Besides the air quality measurements the teachers were asked to keep a log and to answer a questionnaire, which could be coupled with the quantitative measurements. Next, it was determined what the performance was of the ventilation system of each school. In the final stage of this research it was analyzed whether the requirements and guidelines give a good representation of the measured and perceived indoor air quality.

The practical approach and the link with human health issues made this project very interesting. It gave me the opportunity to combine the technical aspects with the human aspects, which is in my opinion one of the most motivating facets of building physics.

Simone Teuwen

different sky conditions are visible and request measurements under different sky conditions.

The standard deviation has proven to be an important standard to be able to say something about the fluctuations of the daylight and the difference in standard deviation between the sky conditions is best visible in the ratios inside versus inside window. However, this ratio is not enough to characterize the different sky conditions. Further research is needed to characterize the different sky conditions with one single ratio.

Sigrid Scheijen

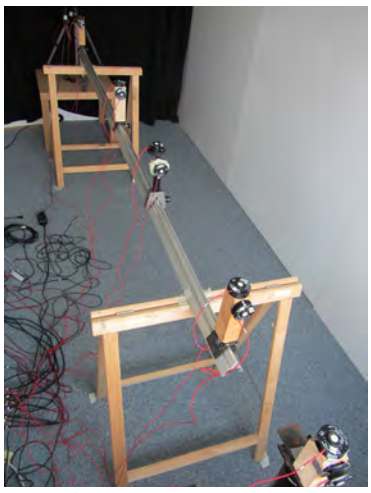
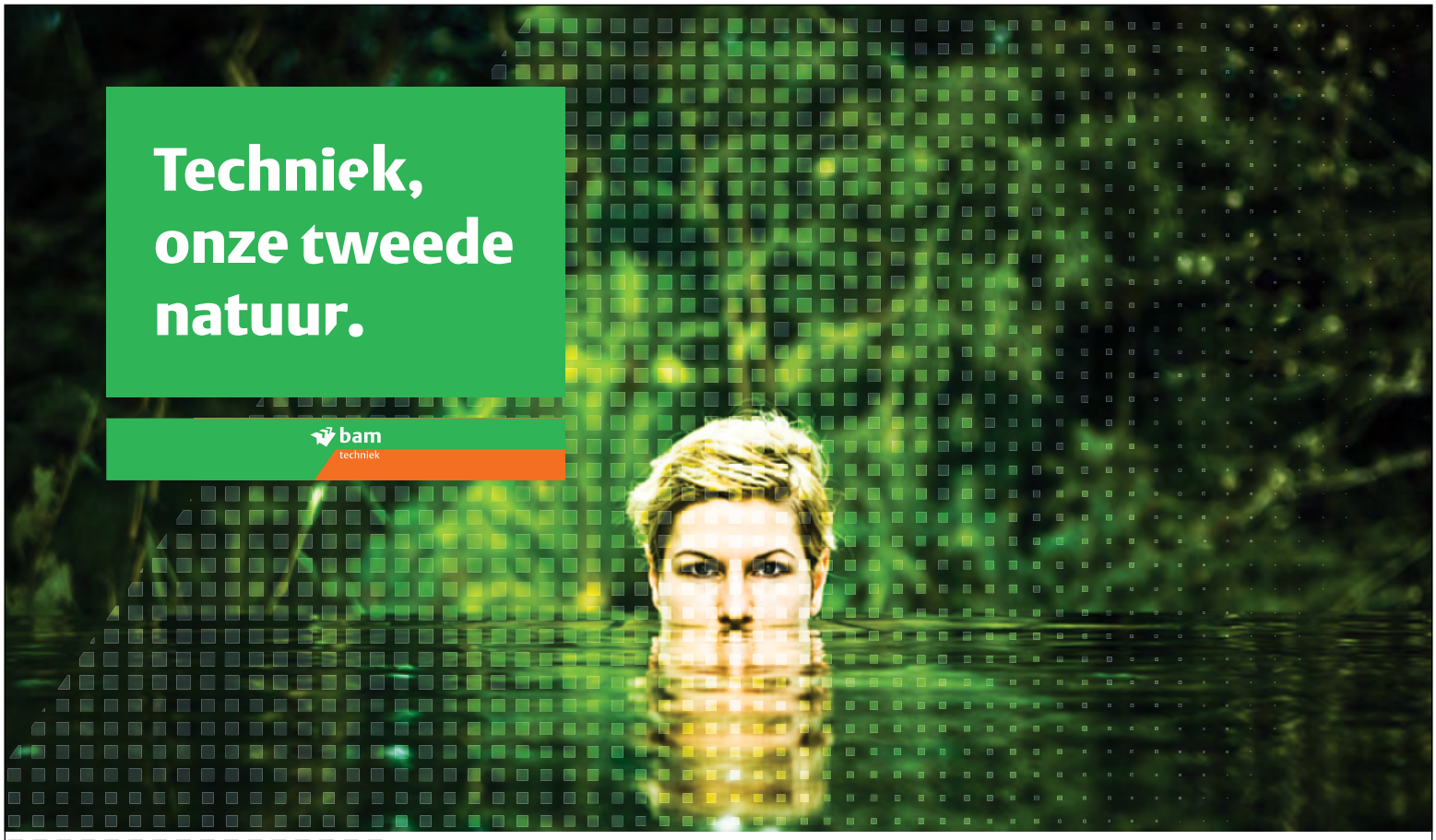


Figure 8 Measurement setup



Techniek zit stevig verankerd in ons DNA. Ontwikkelen, installeren en beheren, daar zijn we goed in. Wij bedenken innovatieve oplossingen die het werk van onze opdrchtgevers gemakkelijker, efficiënter en winstgevender maken. We kunnen elk project aan, hoe complex ook.

Wij kijken onder en boven het oppervlak

Een complex of multidisciplinair project is geen probleem voor BAM Techniek. De integratie van alle technische disciplines stelt ons in staat om met slimme en innovatieve oplossingen te komen. De techniek van morgen opent de deur naar succesvol zaken doen.

Onze grootste kracht is de bundeling van kennis en ervaring binnen ons bedrijf. Alle combinaties van technische disciplines zijn mogelijk: natuurlijk werktuigbouwkunde, elektrotechniek en ICT. Maar ook brandbeveiliging, duurzame energie of technisch beheer.

De bedrijfsfilosofie van BAM Techniek is opdrachtgevers waarde bieden waarbij de kernwaarden samenwerking, respect, kwaliteit en innovatie als uitgangspunt worden genomen.

Interesse in een startersfunctie, stage of afstudeeropdracht bij BAM Techniek?

Ga dan naar www.bamtechniek.nl, laat online je gegevens achter en mogelijk etaleer jij binnenkort jouw ambitie bij BAM Techniek.

www.bamtechniek.nl

FLUX at the TU/e campus

Written by BAM Techniek
Translated by Lisette Draaisma

By a large-scale housing plan all faculties and student facilities of TU Eindhoven are concentrated around a green, pedestrian strip. This housing plan is called 'Campus 2020'. Part of this plan is the new building named Flux, for the departments of Applied Physics and Electrical Engineering. This building of 26,000 m2 including classrooms, offices and laboratories is achieved through a combination of BAM companies. We take a look behind the scenes of a trendsetting project in many ways.

„THERE IS TRANQUILITY ON THE CONSTRUCTION SITE"

„An integrated approach is the common thread in this project", says Dennis van de Wiel, project manager on behalf of 'Major Projects'. From the tender Residential Building and Technical pulled together. ‚Engineering and preparation started from the BAM office in Eindhoven; later the whole team moved to the construction site. BAM Consultancy & Engineering and Fire Protection joined as full partners. „Also all subcontractors involved early in the process". Instead of a detailed, exhausted solution, a wide request is submitted to the contractors. They were challenged to come with clever ideas and better alternatives. Subcontractors took care of the engineering and implementation themselves. They are partakers of the process and partly bear the responsibility".

PRE TACKLED

For BAM Techniek this means a different approach. „We are no longer a problem manager, but we can focus on coordinating, managing and monitoring", said performance manager Ton van Manen. „Especially in the beginning it was an intensive program with weekly consultations between all parties. As the work progressed, it went much easier. There is tranquility on the construction site".

Subcontractors provide their drawings in 3D. The drawings are combined in a model. It is immediately clear where clashes are possible. At each clash an action holder is designated. He will provide a solution. Previously clashes appeared only on the construction site with a lot of discussion, more work and loss of time. This integrated approach ensures that problems are tackled on time. Gradually you even see that subcontractors regulate clashes themselves.

FORMALITY

Where possible, modular and prefabricated elements are used. The modules for the climate ceilings have a 3.6 meters cable tray, heating and cooled water lines included. In total there are 356 standard modules used. All other facilities are prefab delivered, like the technical areas and shafts. Also, the installation is as much as possible integrated into the flooring.

Figure 1 View of the new faculty building of Electrical Engineering and Applied Physics

The extensive integrated and modular approach ensures that planning will be achieved. „The agreed completion date of December 15, we even want to bring out", says Dennis. For the delivery of the building snagR is used, a digital tool developed by Consulting & Engineering. „At an early stage, we perform visual checks. Defects are recorded in snagR with a photo and an explanation. The responsible construction partner receives a message with a period in which the error must be corrected. We check whether this has happened. The entire process is transparent to the client. The final delivery is almost a formality".

Figure 2 Building services installed by BAM Techniek

Excursion 'Stadskantoor Delft'

Written by Tom Thomassen & Karin Conen
Photos by Lisette Draaisma & Marjolijn Benen

April 24th, 2 o'clock: despite a relatively large group was on study trip to Singapore and Malaysia, 22 enthusiastic Mollier members left the TU/e heading to Delft.

This day we were invited by BAM Techniek, one of our main sponsors, to visit their project 'Stadskantoor Delft'. Although the planning was to start at 4 o'clock, everybody arrived at half past three, since the trains were on schedule for once and the traffic was less of a hustle as usual. Due to the early arrival, the presentation and welcome by BAM Techniek started a bit ahead of schedule. On behalf of BAM Techniek, Rob Tollenaar opened the excursion with a word of welcome and a presentation about the company and more specific the project.

Collaborations going on within the project and within the BAM group (between 'BAM Techniek' and 'BAM Utiliteitsbouw') were highlighted. Also the construction, installations, and architectural integration led to project specific challenges, which were discussed in more detail. The project is located in the heart of the city of Delft, right aside the train station which is still in use every day making the challenge even bigger. The monumental train station hall is continuous monitored for displacement to prevent structural damage.

Figure 1 Group photo on top of the building with a nice view over Delft

Figure 2 Site office meeting room where the presentation took place, packed with interested students

Figure 3 Front view of the new train station (ground floor) and municipal office

After the presentation, we were provided with helmets, proper shoes and safety jackets, to start the onsite tour safely. For a lot of students it was the first time visiting a building site this size. The interesting aspect about the current building phase of the project is the fact that most of the installation parts are still visible. Some of the students had no clue about the size of the building systems and the challenge to integrate them into the building in a multidisciplinary manner.

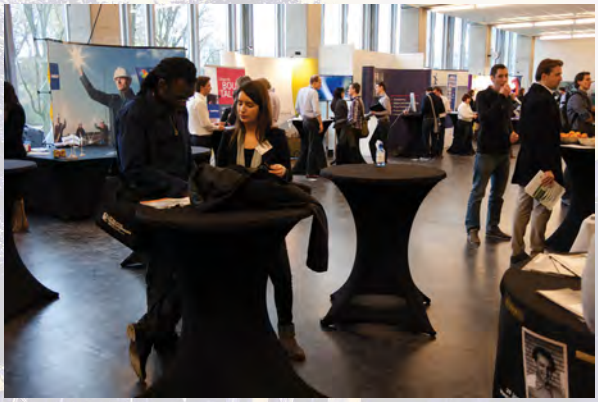
During our tour we were led the buildings heat pump system, the air handling units, fully stacked shafts, air ducts, and standardized piping. We also got a sneak preview of the new train station beneath the building, the city view from the roof tops, and on the floor levels in between; the station hall with stores located, offices, and the most interesting floor: the technical floor. Building safety and especially fire safety measures were shown. All with all, it was a very educational day and with this practical experience we left around 6 o'clock back to smartest region of Europe.

Figure 4 Building systems, piping and ducktwork, still in sight

BOUWKUNDE BEDRIJVENDAGEN

BUILD IDEAS, MEET REALITY

Dinsdag 18 November & Woensdag 19 November 2014



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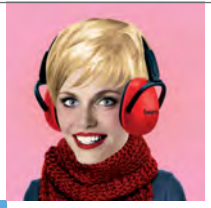

heijmans

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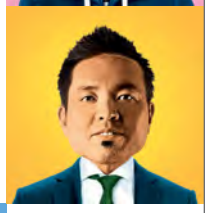

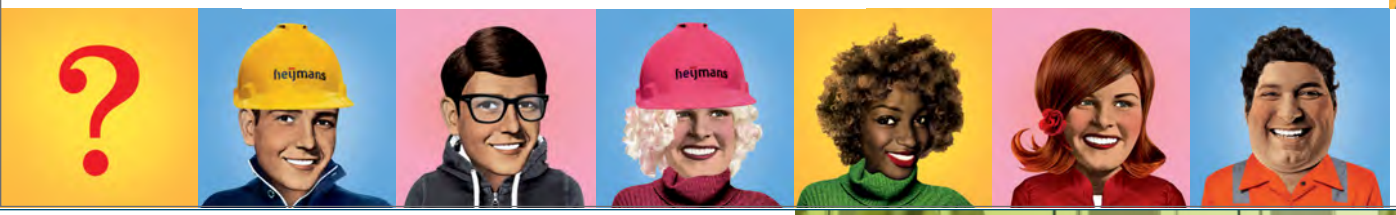

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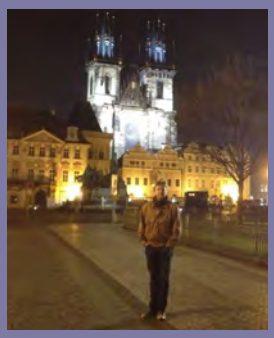
Studying abroad:

Life in Prague

Written by Tom Wijnen



INTRODUCTION

For the people that don't know me, my name is Tom. I'm 23-years-old and I come from Venlo. I did my bachelor at the TU/e and I continued there with my master as well. Even before I started with my bachelor I wanted to live abroad for some time. This was possible with the Erasmus exchange program. But I could not choose a location until a friend told me about her experience in Prague, and I must admit, so far it lived up to my expectations.

Figure 1 Tom in the center of Prague

UNIVERSITY

Because they don't have a master track in Building Physics & Services in Prague, I had to register to three different faculties. If you thought OASE is a mess, I can guarantee you that I like the system here even less. Each faculty has its own site with timetables and mailbox. Furthermore the communication between the faculties is really bad. Therefore, it took some time before I knew where I had to be for my classes. In some cases the teachers did not even know they had to give a class until the second week. But when the classes eventually got started, you could notice that most of them are pretty good and interesting

Figure 2 Holland in Prague

PRAGUE

Now something about Prague and the Czech Republic, the beer is cheap (and big)! And if that is not enough, the city is beautiful, there is a metro system, going out for dinner is not expensive and travelling is cheap... but the language is a pain in the ass. Even after a couple of months it is hard to pronounce most words, if you even remember them. It looks nothing like the English, Dutch, French or German language we were taught in high school. Nevertheless, people do appreciate it when you try. However, the best thing here is.... you make a lot of new friends from all around the world.

And how about the (night) life in Prague? Because most people here live in dorms (which takes getting used to if you are used to having your own room), there is always someone in your building who knows where to find a great party. It doesn't matter what day it is, because it is a big city with a lot of bars and clubs, where most are open every day. But the day that almost every Erasmus student goes out is wednesday. On this day we start the evening with culture presentations organized by the students and end it with a party in the same place.

Figure 3 Erasmus cultural evening

Furthermore, the International Student Office organizes trips and activities each week. So if you plan your own activities as well, you got a pretty busy agenda. Besides activities like karting, paintball, going to ice hockey matches and skydiving, I have been, for example, on a hiking trip to the highest mountain of the Czech Republic to see the sun rise (which is lot higher than our highest mountain, the Vaalserberg... so we didn't see anything because of a snowstorm), or trips to nearby cities like Pilzen, Cesky Krumlov, Karlovy Vary, Kutna Hora (which has a church filled with over 40.000 human bones). But also trips to nearby capitals, like Bratislava and Budapest. I even got a trip planned to Dublin, because the plane ticket from here was ridiculously cheap. Basically, if you like to travel within Europe and you want to do it cheap, Prague is a good place to study. Because of its location in Europe, you can get to most other places pretty easily.

In short, it has been an unforgettable experience so far.

The role of background noise in human echolocation

Claire Laudij

Supervisors:
Dr. Ir. Maarten Hornikx (BPS)
Prof. dr. Armin Kohlrausch (IE&IS)
Prof.dr.ir. Bert Blocken (BPS)
Wim Pierik (Royal Visio)

Eindhoven University of Technology
Department of the Built Environment
Unit Building Physics and Services

Human echolocation is a navigation technique similar to that used by bats and dolphins. Visually impaired people make a sound, of which the reflections are used to understand the surroundings. This technique is only used on a broader scale since the last decade. Therefore not a lot of research has been done so far. For the current project the effect of background noise on the ability to echolocate was investigated.

SENSORY DESIGN

This research was part of a combined master Architecture and Building Physics. The main theme of the graduation project was sensory design. The underlying thought was that buildings and their surroundings are perceived by all senses. We might not realise it, but when we step inside a room we have already touched the door handle, heard the sound of our shoes on the floor and smelled the room. This all contributes to the experience of the room, but not all buildings are made with that realisation in mind. In most buildings visual aspects get more attention than other senses. This is especially problematic for the blind, who rely heavily on acoustics and touch.

The visually impaired mainly use sound to perceive their surroundings (Jordans et al., 2011). Accurately perceiving a building is especially important during orientating. Being able to orientate is one of the most essential competences for human kind and a large part of our happiness depends on the ability of being mobile (Jacobsen, 1998). In buildings there are many signs and orientation points that guide us during this process, but these are mostly based on sight. The visually impaired therefore have to rely more on their obtained knowledge of the floor plan layout (O'Neill, 1991). For the visually impaired it has always been very difficult to estimate for example angles of corners and exact distances that they have walked (Jacobsen, 1998). To overcome this difficulty the visually impaired have started to use active echolocation.

Passive echolocation is probably used by most visually impaired. This occurs when the visually impaired use the present sounds from for example their footsteps or from others around them to understand their surroundings. When using active echolocation the visually impaired actively make a sound, usually with their mouth, to help them orientate. While the technique is not easy to learn, it has several advantages over using passive echolocation. People's ears are adapted very well to their own sound. Furthermore the mouth is positioned exactly in the middle of our ears. These two facts make active echolocation an ideal method for navigating (Rojas, 2009). The most common used sound made with the mouth is the tongue click, since it has among other qualities a good intensity and reproducibility. It has generally a high peak frequency, which makes the sound very directed and a broad spectral content, which makes it ideal to hear over background noise (Schörnich et al., 2012). What the threshold for background noise is was the central question during this research project.

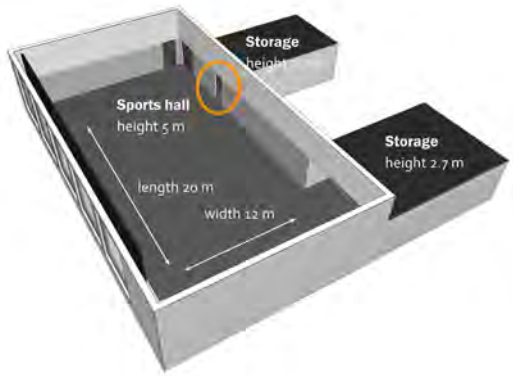


Figure 1 Sports hall, Visio Grave

SETTING UP THE METHOD

An important part of this project was setting up the method for investigation. There is currently too little knowledge on echolocation to correctly model an environment in a simulation model, so the choice was made to set up an experimental test situation. An important task during navigation is hearing whether a passage is free to walk through. The question that was thus investigated during the experimental test was if the visually impaired could hear through active echolocation if a door is open or closed.

The test was performed in the sports hall of Visio Grave (figure 1). This large hall has ideal characteristics for this test. The lower two meters of the floors are clad in a soft material, which avoids excessive reflections. The door that was central in the investigation was placed in the middle of one of the larger walls, avoiding too many reflections from corners. Behind the door was a storage room, which was made dry by placing a sports mat behind the door, so that the door was an isolated acoustic object.

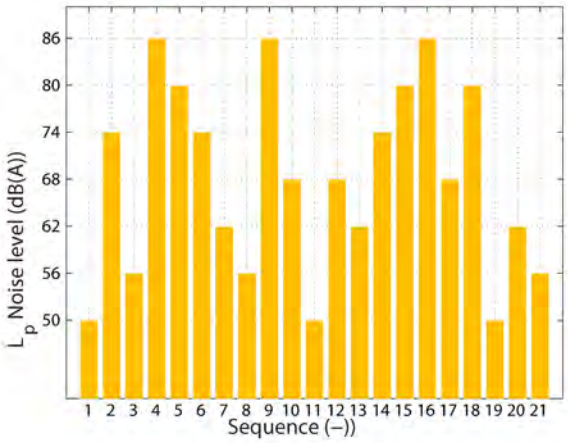


Figure 2 Sequence of background noise levels dB(A)

Figure 3 Characteristics of the respondents

Seven background noise levels were tested: 50, 56, 62, 68, 74, 80 and 86 dB(A) on four positions from the door: 0.63, 1.25, 2.50 and 5.00 meters. The different positions were tested because it was assumed that it can be more difficult to assess whether the door is open or closed with noise depending on how far away from the door you are. The noise levels were played randomly to imitate real life situations and were each repeated twice to get some representative result. The door was either completely open or completely closed during the test. The full sequence of noise levels can be seen in figure 2. The noise was played through two omnidirectional sound sources placed at both sides of the door. It was made sure that the sound from the sources did not help in passive echolocation.

Three respondents took part in the test. Each had a different training level, but they all had a basic skill level in echolocation at the start of the test. All respondents used the tongue click during testing. The respondent answered the question if they thought the door was open or closed through the use of signs, so that their voice did not give feedback about the door. An open hand meant they thought the door was open, a closed hand that the door was closed and the respondents shrugged when they could not tell if the door was open or closed.

RESULTS

In both graphs it can be seen that the amount of correct answers to the question if the door is open or closed decreases. The amount of wrong answers is around twenty percent for both variables and the amount of undecided answers grows for more difficult situations. The invalid answers are when the respondents clicked before or after the noise had stopped.

When the two graphs are compared, a more clear relationship can be seen for the different positions than for the noise levels. It was realised that the respondents did not know exactly what background noise level was played, but they did know at what distance from the door they stood. Maybe this affected the believe of how well they would do, causing these very lineary graphs for the positions.

Furthermore it can be seen that in figure 5 there are already undecided answers at the closest distance, while this was not the case for the three lowest background noise levels in figure 4. Also the amount of wrong answers grows more in figure 5, while this amount stayed more stable in figure 4. The respondents thus seemed to adjust better to background noise than to the different positions. It was also investigated how the respondents could adjust to different situations.

SPECTRAL ANALYSIS

The sessions were recorded in Audacity with in-ear microphones and DPA microphones taped to the door. For the analysis of this project recordings were used from the DPA microphone during a closed door situation. A Fast Fourier Transformation in MATLAB was done to get a mean spectrum of the clicks per noise level/position for each respondent.

In figure 6 respondent A2 shows a low mean and a large standard deviation at 68 dB(A). This is due to the recording method in which the noise was recorded too. For this noise level no clear click could be found. The overall tendency, however, is that the mean peak frequency of the clicks stays stable for each respondent. It can be seen that A2 uses two types of clicks, a low frequency and a high frequency click. In figure 7 it can be seen that the low frequency click is used for the further distances. A2 was the most proficient echolocator

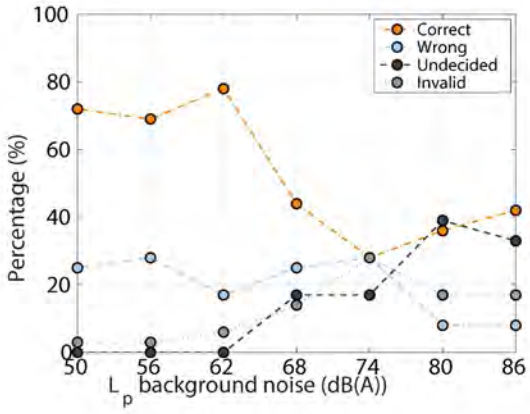


Figure 4 Results for different noise levels (N.B. 86 dB(A) was only tested for A1 and A2)

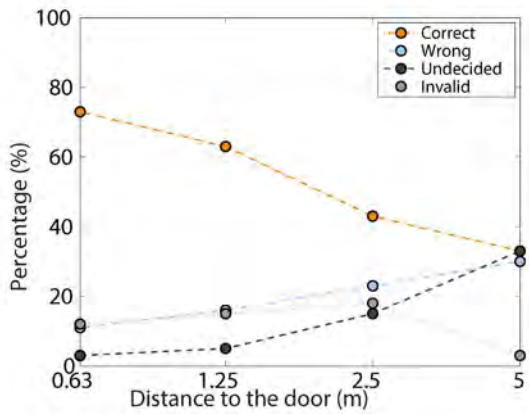


Figure 5 Results for different positions

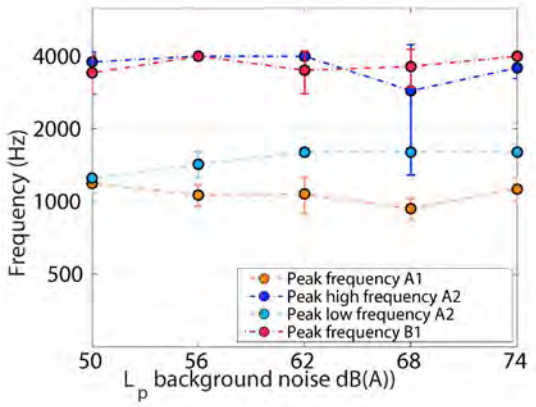


Figure 6 Mean peak frequency clicks per noise level

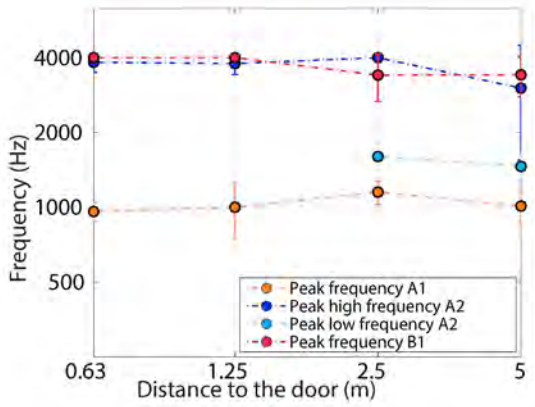


Figure 7 Mean peak frequency clicks per distance

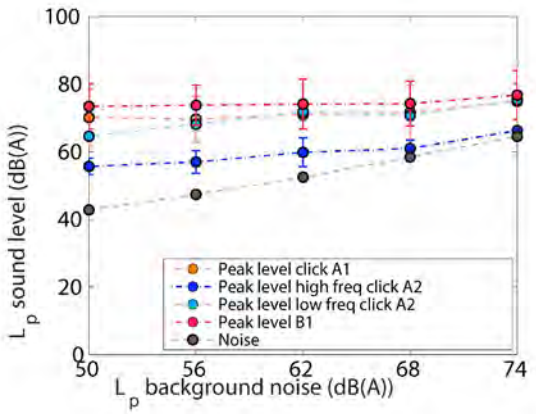


Figure 8 Mean peak level clicks per noise level

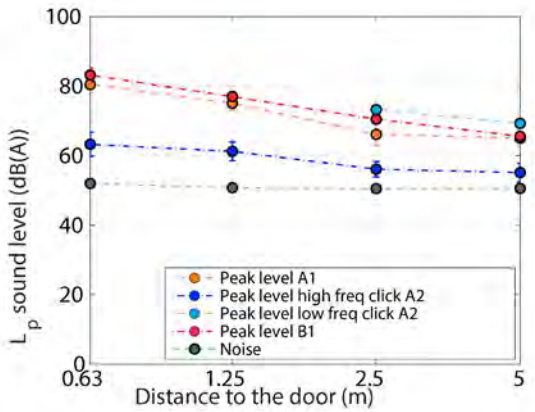


Figure 9 Mean peak level clicks per distance

and presumably learned to use a low frequency click to adapt to the more difficult situation of a far distance.

When the mean peak levels are plotted in figure 8 it can be seen that the low frequency click of A2 is louder than the high peak frequency click. So there seems to be a trade off for A2 between frequency and level of the click. The high frequency click of A2 is soft and very efficient. The mean peak level of the other clicks are louder and closer to each other. All respondents seem to be able to increase the level of their click for louder noise levels.

When the peak level is plotted for each position in figure 9, it has to be realised that the microphone was fixed to the door. So at each further position the respondent stood twice as far away from the earlier position. It is not known exactly what the directivity of the click is, so it is not known what the decrease in level would be. What can be said for sure, however, is that when levels stay the same, for example for A1 and A2 between 2.50 and 5.00 meters, the level of the click must somehow become louder.

With these different characteristics the question arose how the three respondents performed. While the high frequency click is advocated as the most useful, the low frequency click is also used by two respondents. A1 was untrained and used only a low frequency click, but shows very average results. B1, the respondent that uses only high frequency clicks, performed the weakest. So the two respondents that used a low frequency click actually seemed to perform best.

CONCLUSIONS

The answer to the question to what extent background noise plays a role in masking information while using active echolocation is that background noise does play a role. With increased background noise levels the respondents had fewer correct answers. For further distances the amount of correct answers was increasingly less.

The respondents used different clicks that each had a stable peak frequency. A2 used two types of clicks. The use of a low frequency click by A1 and A2 did not make a large difference for the answers of this group and was even used by A2 for more difficult situation.The respondents seemed to be able to increase the level of the click for more difficult situations, both for higher noise levels and further distances.

This research has shown some trends for this group of respondents that are worth investigating further. Research is necessary for example on the directivity of the click. TU/e has already started reasearch on this in cooperation with Royal Visio. Information from this research can be used to improve simulations models, that can increase comfort for the respondents, accuracy of the testing method and usability of recordings.

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Natuurlijke toevoer van ventilatielucht in onderwijsruimten

Aandacht voor tochtrisico

Voor ventilatiesystemen met een natuurlijke toevoer van ventilatielucht vormt het optreden van tocht vaak een aanleiding voor de gebruikers om de ventilatievoorzieningen te sluiten. Een verminderde luchttoevoer is hiervan het gevolg, hetgeen kan resulteren in een ontoereikende luchtkwaliteit. In 2012 zijn de wettelijke eisen voor de minimaal vereiste ventilatiehoeveelheid voor onderwijsruimten verhoogd. De hogere ventilatiehoeveelheid kan resulteren in een toename van het tochtrisico. Betekent dit dat nu alleen nog maar geheel mechanische geventileerde scholen kunnen worden gerealiseerd? In dit artikel wordt een praktijkvoorbeeld gegeven waaruit blijkt dat ook met een natuurlijke toevoer van ventilatielucht aan de comforteisen kan worden voldaan.

Tekst: ir. H. (Henk) Versteeg (bouwfysisch adviseur bij LBP|SIGHT)
Figuren: LBP|SIGHT en WTB-Buro

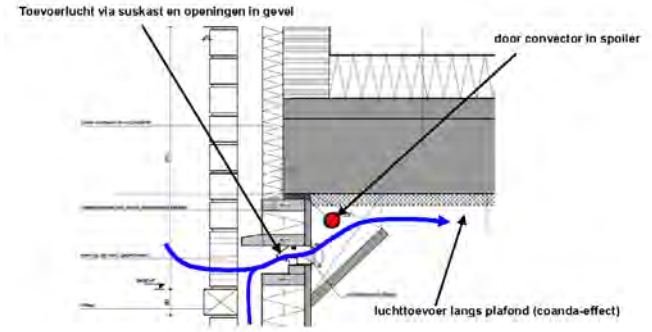
ONDERZOEK BINNENMILIEU BASISSCHOLEN

De luchtverversing van scholen is een onderwerp dat de laatste jaren volop in de belangstelling staat. Op basis van verschillende onderzoeken is duidelijk geworden dat de ventilatie in onderwijsruimten vaak tekortschiet. In 2008 is door LBP|SIGHT in opdracht van de rijksoverheid een landelijk onderzoek verricht naar de kwaliteit van het binnenmilieu (luchtkwaliteit, geluid en klimaat) in 120 klaslokalen van 60 basisscholen. Uit het onderzoek is gebleken dat het binnenmilieu in basisscholen op onderdelen te wensen over laat. Een onvoldoende luchtkwaliteit gedurende het stookseizoen vormde één van de geconstateerde knelpunten. De oorzaak hiervan blijkt in hoofdzaak toegeschreven te kunnen worden aan een onvoldoende ventilatie. De onvoldoende ventilatie blijkt zowel door gedrag als techniek te worden veroorzaakt. In leslokalen met een geheel natuurlijke ventilatie blijkt de ventilatie met name tekort te schieten door een onvoldoende gebruik van de ventilatievoorzieningen (gedrag). Reden van dit onvoldoende gebruik is het tegengaan van tocht- en koudeklachten en het weren van buitengeluid. In leslokalen met mechanische ventilatie blijkt de tekortschietende ventilatie met name het gevolg te zijn van een onvoldoende capaciteit van het mechanisch ventilatiesysteem (techniek).

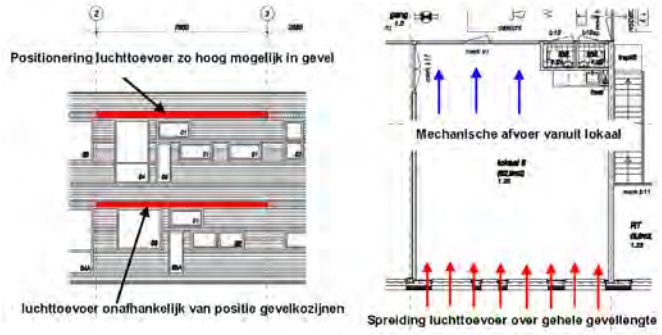
SITUATIE

Bij de nieuw gerealiseerde basisschool 'De Schakel' in Utrecht is in het ontwerpstadium gekozen voor een ventilatiesysteem op basis van een natuurlijke toevoer via de gevel en een mechanische afvoer vanuit het leslokaal. Mogelijke knelpunten bij een natuurlijke toevoer van ventilatielucht zijn de eisen die worden gesteld ten aanzien van de wering van buitengeluid en het thermisch comfort. LBP|SIGHT heeft in samenwerking met de installatie-adviseur WTB-Buro een ventilatieprincipe onderzocht en uitgewerkt waarmee aan deze eisen kan worden voldaan.

Figuur 1 Rapportage onderzoek binnenmilieu basisscholen.



Figuur 2 Weergave detaillering natuurlijke luchttoevoer via de gevel.



Figuur 3 Weergave positionering natuurlijke luchttoevoer via de gevel.

VENTILATIEPRINCIPE

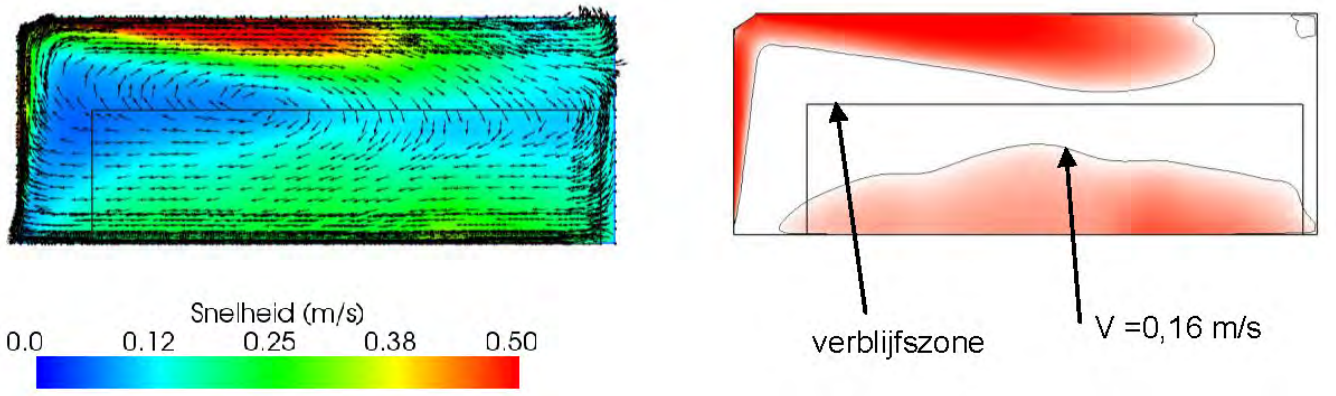
De ventilatie van de basisschool 'De Schakel' geschiedt op basis van een natuurlijke toevoer van ventilatielucht via de gevel en een mechanische afvoer vanuit het leslokaal. Om te kunnen voldoen aan de volgens het Bouwbesluit vereiste geluidwering van de gevel (karakteristieke geluidwering ten minste 20 dB) is uitgegaan van suskasten ten behoeve van de toevoer van ventilatielucht. Aan de binnenzijde van de gevel is een regelbare spoiler opgenomen om de naar binnen toegevoerde lucht over de gehele breedte van het leslokaal door een dunne luchtspleet direct langs het plafond te geleiden. Het effect van het geleiden van de lucht langs een vlak is dat deze luchtstroom door het zogenaamde coanda-effect ('kleefeffect') verder de ruimte wordt ingevoerd en zo verder wordt opgewarmd voordat deze lucht in de leefzone komt. In de spoiler is verder een convectorbuis opgenomen om de toe te voeren lucht gedurende het stookseizoen voor te verwarmen. Een temperatuurvoeler in de spoiler stuurt de waterhoeveelheid door de convectorbuis. Om het risico van bevriezing van deze convectoren tegen te gaan is anti-vries (glycol) aan het water in de convectoren toegevoegd. De convectoren en de suskasten zijn reinigbaar doordat de spoiler kan worden neergelaten. De capaciteit van de mechanische afvoer in het leslokaal wordt geregeld op basis van de heersende CO_2-concentratie en bedraagt maximaal 930 m^3/h, overeenstemmend met een CO_2-concentratie van maximaal 1.000 ppm (30 m^3/h per persoon). Deze hoeveelheid stemt overeen met klasse B van het PVE Frisse scholen 2012 en de wettelijke eisen van het Bouwbesluit 2012.

ONDERZOEK TOCHTRISICO MET CFD-SIMULATIES

Er was voor dit project de eis gesteld dat de optredende luchtsnelheid in de verblijfszone gedurende het winterseizoen maximaal 0,16 m/s mocht bedragen. De genoemde luchtsnelheid stemt overeen met een DR-waarde van maximaal 20%. De DR-waarde (Draught Rating) geeft het gemiddelde percentage ontevredenen over tocht. In samenwerking met Actiflow heeft LBP|SIGHT voor verschillende situaties de comfortrisico's met behulp van CFD-berekeningen onderzocht. Bij deze berekeningen is de invloed van verschillende parameters (verwarmingswijze, inrichting, luchtsnelheid luchttoevoer) op het comfortrisico onderzocht.

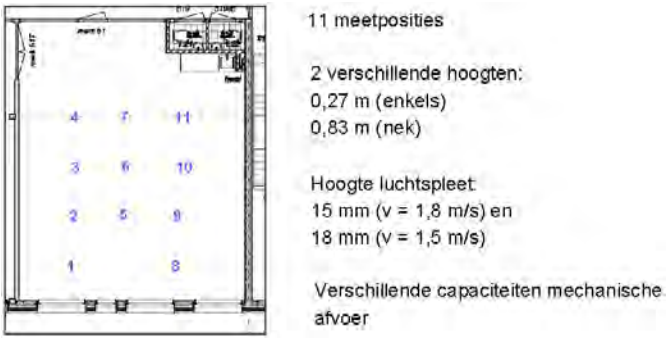
Op basis van de uitkomsten van deze simulaties bleek dat met de geprojecteerde toevoer van ventilatielucht via een spoiler nabij het plafond en met toepassing van radiatorenverwarming naar verwachting een 'tochtvrije' toevoer van ventilatielucht kon worden gerealiseerd. Uitgangspunt hierbij was dat het verwarmingselement ter plaatse van de spoiler gedimensioneerd is voor een opwarming van de buitenlucht met ten minste 10°C en dat de hoogte van de luchtspleet van de spoiler wordt ingesteld op 20 mm (uitgangspunt snelheid luchttoevoer 1,5 m/s).

Op basis van de CFD-berekeningen bleek echter wel sprake van een overschrijding van de comforteis van een maximale luchtsnelheid van 0,16 m/s in de onderste zone van het leslokaal als gevolg van een teruggaande, naar de gevel gerichte luchtstroming. Er bestonden echter onzekerheden in hoeverre er op basis van CFD-berekeningen een realistische inschatting kon worden gegeven van het ontstaan van tochtklachten nabij vloerniveau, omdat deze luchtstroming mede afhankelijk is van variabele factoren als personen en inrichting. In ontwerp is er om deze reden vanuit gegaan om de hoogte van de luchtspleet van de spoiler variabel te maken zodat deze hoogte zonodig naderhand eenvoudig kan worden gewijzigd. Verder is geadviseerd om ten tijde van de oplevering controlemetingen van de optredende luchtsnelheden te laten verrichten, om op basis hiervan na te gaan bij welke instelling van de hoogte van de luchtspleet het laagste tochtrisico kon worden bereikt.



Figuur 4 CFD-onderzoek tochtrisico. Overzicht berekende luchtsnelheden in leslokaal. In de rechter figuur is aangegeven in welk gebied een luchtsnelheid van 0,16 m/s wordt overschreden. De linker figuur toont tevens de richting van de luchtstroming.

Figuur 5 Praktijkonderzoek tochtrisico.
Linksboven: aanzicht suskast en convectorbuis in spoiler.
Linksonder: hoogte luchtspleet is instelbaar.
Rechtsonder: aanzicht interieur leslokaal met weergave spoiler ter plaatse van gevel.



Figuur 6 Meetposities en variabelen bij praktijkonderzoek tochtrisico.

ONDERZOEK TOCHTRISICO PRAKTIJKSITUATIE

De praktijkmetingen hebben gedurende de winterperiode (buitentemperatuur van -2,5 °C) plaatsgevonden. In een representatief leslokaal zijn voor een groot aantal posities metingen verricht van de luchtsnelheid, de luchttemperatuur en de turbulentie-intensiteit. Op basis van deze parameters is vervolgens de DR-waarde berekend. De metingen zijn verricht bij verschillende capaciteitsstanden van het ventilatiesysteem en bij verschillende spleethoogten van de spoiler. Uit de metingen is gebleken dat het risico van het optreden van comfortklachten als gevolg van het optreden van te hoge luchtsnelheden zeer beperkt is. Alleen bij (zeer) lage buitentemperaturen (minder dan 0 °C) en een maximale stand van het mechanisch ventilatiesysteem blijkt op een enkele locatie sprake van een overschrijding van gestelde criterium van een DR-waarde van maximaal 20%. Bij hogere buitentemperaturen en/of een lagere capaciteitsstand van het CO_2-gestuurde ventilatiesysteem zal sprake zijn van aanmerkelijk lagere luchtsnelheden in de verblijfszone.
Op basis van onderzoek met rookpatronen bleek de luchtstroming in het lokaal goed overeen te stemmen met hetgeen vooraf op basis van de CFD-simulaties is vastgesteld. Ook is gebleken dat de opwarming van de buitenlucht door de verwarming achter de 'spoiler' 10-15 °C bedraagt en hiermee voldoet aan het vooraf aangehouden ontwerpuitgangspunt. Uit de controlemetingen is verder gebleken dat het verhogen van de luchtsnelheid in de luchtspleet van 1,5 m/s naar 1,8 m/s een positief effect heeft op de optredende luchtsnelheden in de verblijfszone. Als gevolg hiervan is de ingestelde hoogte van de luchtspleet van de 'spoiler' op basis van de praktijkmetingen nadien aangepast. Het lage tochtrisico wordt door de gebruikers bevestigd: er hebben zich geen tochtklachten voorgedaan.

CONCLUSIES

Ook bij de hogere ventilatiehoeveelheden volgens de eisen van Bouwbesluit 2012 is een natuurlijke tochtvrije toevoer van ventilatielucht in leslokalen realiseerbaar. Om het risico van het optreden van tocht ten gevolge van de natuurlijke toevoer zoveel mogelijk te beperken, kunnen de volgende ontwerpprincipes worden aangehouden:

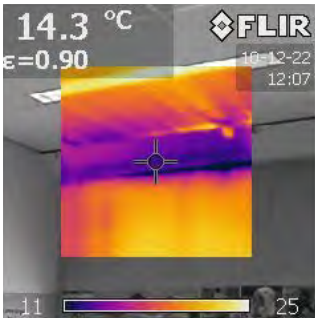
- een gelijkmatige luchttoevoer (verdeeld over gehele gevellengte)
- situering toevoer buiten verblijfszone (zo hoog mogelijk in gevel)
- gebruik maken van coanda-effect (toevoer direct langs plafond via instelbare spoiler)
- voorverwarming temperatuur toevoerlucht (opwarming in spoiler)
- een regeling van de capaciteit van de mechanische afvoer (op basis van CO_2-concentratie)

Verder is het raadzaam om gedurende het ontwerpstadium CFD-onderzoek te verrichten om hiermee inzicht te verkrijgen in de optredende luchtstromingspatronen en de potentiële probleemlocaties. Verder is het zinvol om in het ontwerp mogelijkheden in te bouwen om het systeem op basis van praktijkonderzoek naderhand verder te kunnen optimaliseren.

Voor meer informatie kunt u terecht bij Ir. H. (Henk) Versteeg, bouwfysisch adviseur bij LBP|SIGHT.
Tel: 030-2311377
Email: h.versteeg@lbpsight.nl
Website: www.lbpsight.nl

Dit artikel werd tevens gepubliceerd in het TVVL Magazine (april, 2014, nummer 4).

Figuur 7 Aanzicht gevel basisschool en toevoeropeningen in buitenblad.



DR = Draught Rate = percentage gehinderden ten gevolge van tocht (NEN-EN-ISO 7730)

$$DR = (34 - t_{a,l})(\bar{v}_{a,l} - 0{,}05)^{0{,}62}(0{,}37\,\bar{v}_{a,l}\cdot Tu + 3{,}14)$$

Gemiddelde luchttemperatuur in °C

Gemiddelde luchtsnelheid in m/s

Turbulentie-intensiteit in %

Figuur 8 Praktijkonderzoek tochtrisico – meting temperaturen en luchtsnelheden.

Gegevens en betrokkenen project

Project:	Basisschool De Schakel Utrecht
Opdrachtgever:	PCOU en Willibrord Stichting
Architect:	Meeder Architectenbureau Utrecht
Installatie-adviseur:	WTB-Buro Amersfoort
Adviseur bouwfysica:	LBP|SIGHT Nieuwegein

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Study trip 2014

Singapore Malaysia

Figure 1 Studytrip participants ready for take off at Schiphol Airport

Asia is not uncommon ground for Mollier to explore. After last year's successful trip to Vietnam a decision was made to go east again. Singapore and Malaysia were the destinations and soon after announcing this, all participants' slots were full and a group of twenty students (and one PhD candidate) was formed.

The trip began for most participants in Eindhoven. From here the travel began by train to Schiphol Airport. With a short transfer in Frankfurt we arrived after a long flight in Singapore.

SATURDAY 19 APRIL

Our first impression of Singapore is that it is a clean and green country, with a climate that is comparable to a subtropical swimming pool. After arriving in the hostel we went for our first dinner to a typical Singaporean food court where, among others things, the first frog legs were eaten. The rest of the evening, the nightlife of Singapore was explored by a part of the group, while others went back to the hostel for catching up some sleep.

This next morning the alarm clock was set at seven 'o clock and with a basic breakfast of toast and coffee we went (almost on time) to the city tour. During the city tour we visited the main landmarks of Singapore. Marina Bay Sands was the first stop. Our enthusiastic tour guide, Mr. Foo, told us everything about the new developments of the city, and how this connects to the rich history of this city. The second stop was right in the middle of Chinatown, where we visited the impressive Thian Hock temple. We also went to the city's Botanic garden, with its nice collection of orchid flowers and other tropical flora and fauna. Last stop was Little India, full of small shops, colors and interesting flavors.

After the morning program, we tried to reach our next destination, the City Gallery through Singapore's underground metro jungle. Here, we almost lost our first group member, because the trains here aren't waiting for some "slow" tourists. Fortunately, there are not that many tall people in Singapore, so even when you're lost it's quite easy to find back the group: just look up!

The City Gallery demonstrates and explains Singapore's mission to make the city a great place to live, work and play in. We saw some impressive, large models with the city's master plan and got some insights into the ideas for future developments.

SUNDAY 20 APRIL

After a crazy pub crawl yesterday we headed to Sentosa. With a little hangover we went to this man-made island with its white beaches and Entertainment Park for a day at the beach. With our swimming shorts and bikinis on we took the metro line, some walk and monorail as transportation. The island was facing to more than a hundred large ships waiting to enter the nearby harbor. The harbor is one of the main revenues because of the good accessibility to the main land of south-east Asia. After a swim in the warm water, resting and some ball games we went to harbor port mall.

This mall does feel like a huge American shopping mall with at least 4 levels into the ground with miles of mainly western orientated shops. Here we had dinner and some coffee before we had our night trip to the Southern Ridges walk. The Southern ridges walk is located nearby the harbor city metro station, but since it was a huge mall we couldn't find the exit to the ridges at once. The walk to the ridge of the mountain behind the metro station was through a very dark pathway called Marang Trial. On the ridge we had an amazing view of the skyline of the southern side of Singapore. On this ridge there were more paths which lead us to some beautiful bridges over the hill tops.

MONDAY 21 APRIL

After we had breakfast together, PhD student Clayton Miller joined us at the hostel to guide us through the day. Clayton is from the United States and finished his master at the National University of Singapore (NUS). After some work experience he started his PhD last year on the ETH University of Zurich, where he joined the Architecture and Building department to pursue research on the Future Cities Laboratory (FCL) project which is located in Singapore.

The Universal World College of South East Asia (UWCSEA) is one of the most sustainable buildings in Singapore and was our first stop. After our president Bart gave a short introduction about the TU/e and Mollier, a colleague of Clayton, who monitors the building operations, gave a presentation about the working principles of the building and the installed climate systems.

UWCSEA is designed and built within 36 months by a building team consisting of people with different technical specialization. Because of the warm and humid climate, it is a difficult task to realize comfortable indoor temperatures with acceptable humidity rates. The indoor conditions are

Figure 2 Sentosa Beach - Singapore

treated by a HVAC systems equipped with chillers and dehumidifiers. The temperature settings are kept around 24 degrees Celsius and the humidity level between de 40 and 60%. To realize these settings 36 chillers are needed to cool the whole building. For these chillers the UWCSEA uses solar thermal cooling. The system was designed with a COP of 4.9 (June 2011), but after tweaking by the system it is increased to 6.1. The maintenance engineer even has the entire system on his mobile phone to make adjustments on the spot.

After a great lunch at the campus we headed to the NUS and the Future Cities Lab (FCL) department in Singapore (a 2-hour journey across the whole of Singapore). Singapore has invested in knowledge from all over the world. Research teams from MIT, Berkley, the TU Munich, and the ETH are located in the building. They are funded to perform research for five years by the Singapore government. Over 100 PhD, postdoctoral, and Professional researchers are working on diverse themes varying from room level to urban and state level. All these themes are related to future cities and environmental sustainability. After an exchange of presentation from two PhD-ers on their side, and Bart, Patrick and Roel on our side, there was a small tour set up through the company where several finished projects are displayed. These differed from a solution to the warm 'back ally' air conditioning units to the traffic jams in Singapore. The final destination of the FCL was the BubbelZERO lab. This was built in Zurich to test zero energy heating and ventilation systems in Switzerland, and was moved to Singapore to test the same systems under humid and warm circumstances.

The final stop of today was the Night Safari. It is the world's first safari park with over 2,500 nocturnal animals in their 'natural' nighttime habitats. The highlight was the show whith ended with an educational note: "Remember: Waste should be Reduced, Reused, and RECYCLED!!

TUESDAY 22 APRIL

Today was the First day we would visit a company. At 8am we left the hostel to visit Heinen & Hopman in Singapore. Heinen & Hopman is a company that designs and produces HVAC systems for ships. The company in Singapore is mainly a factory where they make the installations and install them in the ships. We were welcomed by Arthur Klay. In Singapore there are working 37 people from Singapore in the company, and even 155 foreigners. Interesting to know is that the company can employ foreigners but in the ratio of one to five. Most of the people that are working for the company don't work in the factory, but on the shipyards. After the presentation we got a tour around the factory and the office. The lunch was also provided by Heinen & Hopman and after the lunch the group was split up. Sixteen people went to Geylang Serai and four to the Tiger Brewery. To get to our destination we got a lift from Heinen & Hopman. The company had a small pick-up truck that was entirely decorated.

Figure 3 Taxi ride provided by Heinen & Hopman

Figure 4 Bubble Zero Lab at National University of Singapore

The district Geylang was large and we didn't find the part Geylang Serai. We did find (and tried) durian fruit. This is some typical fruit from Asia which is also known as smelly fruit. The fruit indeed does smell and has a fruity flavor mixed with unions. Singapore consists of districts with different cultures. There is the Arabic part, Geylang is the Malay part and there is also for example Little India and Chinatown.

In the evening there was a light show at the Marina Bay Sands with water, lasers and projections. After the show it was scheduled to go to the top of Marina Bay Sands. The skypark was already closed, but the Skybar was still open. At the skybar there was a beautiful view of the skyline of Singapore. After drinking some very expensive cocktails it was time to go home and end the day.

WEDNESDAY 23 APRIL

The morning was free for everybody to pack their bags and get ready, because in the evening we were going to take the night train to Kuala Lumpur. By subway we went to Gardens by the Bay. Carly Lamb, a landscape architect from Grand Associates, gave us a tour. Gardens by the Bay was an international architectural contest, which was won by Grand Associates six years ago. The park contributes to Singapore's goal of a green and sustainable environment.

The two glass and steel green houses in the form of shells close to the river contain each one a specific environment which is threatened by the global warming. One has a cool and dry climate with Mediterranean plants, the other one has a cool and humid climate which can be found in areas with rain forest. For the cooling, organic waste, like grass or part of trees, is used which is collected throughout the whole city. Chilled air is blown in only on the pedestrian level to reduce energy consumption. Furthermore special glass and sunscreens are used to lower the solar radiation. All these features added up to meet the energy requirements

Figure 5 Skyline Singapore by night

which are set up for offices.

The installations to maintain the climate in the cooling houses are hidden underneath a layer of earth which is covered by grass and plants to keep the machinery out of the visitors' sight. Used air needs to be extracted from the buildings. Here the super trees, which are the eye catchers of the park, function as chimneys. Besides that they have other functions like a restaurant/ bar at the top of the tree in the middle or they contain PV panels on top. After the tour we still had some time to discover the green houses ourselves.

After a 45 minutes' walk from our hostel we arrived at the bus stop to Malaysia. At first being afraid of not making it on time due to the huge queue we ended up all together in one bus which was too small for our entire luggage. After a ride of half an hour we arrived at the border of Singapore and Malaysia where our bags and passports had to be checked. After a smooth transition we waited at the platform on our train which supposed to depart at 23:30.

THURSDAY 24 APRIL

The train ride started with a delay of thirty minutes. Everyone was really tired and burned out and was looking for a good night sleep in the bumpy night train. The old train had bunk beds and was (relatively) clean. We soon noticed that the length of the beds was designed for Asian people and definitely not for Europeans. Therefore creative bed poses were invented. After a surprisingly good night of sleep and a delay of two hours, we arrived in Kuala Lumpur.

At the train station we were picked up by the bus of the University of Malaya and within thirty minutes we were brought to the campus. There we received a warm welcome by Raha Sulaiman (a teacher at the University who did her part of her PhD research at the TU/e) and immediately got a breakfast with typical Malaysian food. Then we were brought to the lecture room where twenty Malaysian students were already waiting for us for two hours. We got a short welcome and introduction about the University. The faculty of the Built Environment is a relatively young faculty (since 2000) and entered a new building in 2013. Then three presentations by (PhD) students of each University about their research were held.

After the presentations we got a tour around the campus. Raha and a group of very enthusiastic students could tell us a lot about the campus. The campus is in the middle of the city, but has a large ground surface and is really green. Sixty percent of the students live on the campus and the campus has a big sports center and even a large new stadium.

In the afternoon, the bus took us to the Petronas towers. Here we first went to the 41st floor and walked on the sky bridge which connects the two towers. The bridge is the highest in the world and is used as an escape route in case of emergency in one of the towers. The view over Kuala Lumpur at the sky bridge was amazing, but became even more amazing when we went to the 86st floor (the second highest floor) of the Petronas towers. Here you had a 360oview over the city. When you were standing at the edges of the floor near the windows you could feel the tower swaying.

Our hostel was situated in the middle of Chinatown, next to a Hindu temple. In the evening we went to the Skybar in the Trader's hotel. This Skybar is situated on the 33th floor were we had a view on the Petronas Towers by night.

Overall our first impression of Kuala Lumpur is that the city has more old cultural buildings than Singapore and a lot of natural green areas (in comparison with the man-made green areas in Singapore). However; it has a lot more garbage on the street and is much less structured than Singapore.

FRIDAY 25 APRIL

We visited the ST Diamond building in the new city of Putrajaya, which has specially been founded to house Malayan government buildings. At present, 95% of all government buildings are found here. Imagine the view of a brand new, clean and structured city filled with large buildings, we could not help to think about Singapore. One could say Malaysia is creating its own little Singapore here.

One of the buildings in the city of Putrajaya is the ST Diamond building we visited this morning. It is designed by IEN consultants, a consulting company which specializes in so-called green buildings and strife to keep the building process low carbon. Charles Loo, employee of IEN consultants, was so kind to show us around and give a presentation about the sustainable aspects of the building. The ST Diamond building achieved GBI platinum and GreenMark platinum ratings and has been awarded a second place ASHRAE technology award

Figure 6 University of Malaya - Built Environment department

The presentation gave some insight in the sustainable aspects of the building that contributed to these recognitions. The first aspect is the shape of the building, which of course is a diamond shape (what's in a name) and has many benefits for daylighting. The shape creates natural shading which is very useful in the Malaysian tropical climate. The trees surrounding the building reflect daylight into the offices at the facades. Rooms that are not adjacent to the facade receive daylight from the atrium, where angled panels provide more beneficial reflections into the rooms.

Another remarkable aspect is the cooling which is provided by two systems consisting of a cooled floor slab and air cooling. The air cooling is used during the day and the floor slab at night. The advantage of this system is that the thermal mass is used. It is not very common in Kuala Lumpur to use floor slab cooling because the surface temperature and humidity in the air must be controlled very strictly to prevent condensation. IEN consultants managed to control the air and surface temperatures and the humidity of the air, so no condensation will occur. Further, in contrast with the Netherlands district cooling service is used to provide chilled water. A downside of the system is the supply temperature of 8 °C, which is alright for air cooling but is way too low for the floor slab cooling. Now the chilled water is mixed with return water to increase the inlet temperature of the water to 19 °C, thus destroying the valuable temperature difference. Other green aspects in the building are the rain water harvesting for re-use in toilets and other appliances.

After Charles showed us around the building, we even visited the green roof and had a look at the skylight of the atrium, the photovoltaic panels and all the HVAC systems. After this very interesting and inspiring tour we said goodbye to Charles and the staff of the Diamond building and continued our trip through Putrajaya. Our bus driver picked us up and brought us to the Putra Mosque where we enjoyed a great meal and view at one of the famous buildings of Putrajaya. We continued our journey as the bus drove us through the rest of the city showing us various other government buildings.

We subsequently spent our afternoon traveling to the Kuala Selangor lighthouse on the Bukit Melawati hill. The lighthouse is a reminder of the Dutch presence in Malaysia and is now surrounded by a forest inhabited by monkeys. After hanging around with the monkeys for a while we traveled to the Selangor River to enjoy a nice seafood meal and have a look at one of the world's largest firefly colonies on the mangrove banks of the Selangor River.

Figure 7 Diamond Building. Installations done by IEN consultants

Figure 8 Monkey Business

SATURDAY 26 APRIL

We started with the city tour through Kuala Lumpur, where we have seen all the beautiful places in the city and got to know how Kuala Lumpur has become the city that it is nowadays. The first stop was at the National history museum. After about 40 minutes we went to the next spot, the National mosque. We could enter the mosque, by changing our western clothing for a long robe and in case of the ladies, a head scarf. After this we went to the Kings Palace. We couldn't see a lot of the palace because of the distance, so we enjoyed ourselves by taking pictures of the guards, which were sitting on a horse, which was trying to stand still. We also went to the national monument which is founded to commemorate all the soldiers from Malaysia who fell during the war against Japan for independency.

After the tour we went to the hostel to get prepared for the high tea in the KL tower, which has a height of 421 meters. At a height of 282 meters, there was a large restaurant, with in the middle the high tea buffet. The view at this height was very nice, because the restaurant was turning around. So we could see the whole city. We were impressed by the view, but also by the food that was offered.

Even though we're on the other side of the world we were celebrating King's day. In the evening everyone was dressed up in orange, which took the attention of everyone who has a connection with the Netherlands.

SUNDAY 27 APRIL

After a short night celebrating Kings day and waking up at just the right time we left the guesthouse to take a train trip to Kepong Sentral where the Forest Research Institute Malaysia (FRIM in short) is situated. FRIM is located in the north of Kuala Lumpur and is the largest secondary forest, which means that the forest has had a second life after being destroyed for the tin mining industry. FRIM is nowadays used for research into animals and plants. It is

open for public as a living museum or for taking the climb to the most popular of four routes, the Canopy Walk.

To get there from the train station we have to take some cabs. Some us had the opportunity to meet Michael Schumacher a.k.a. Barack Obama. He was definitely the fastest cabby we've met so far. Arriving safely at FRIM after some near death experiences we were informed by a sweet ticket sales person that we should have made a reservation for a large group. Our leader of the day made it possible to do the Canopy Walk in groups of five people leaving separately.

The first shift left at about 11.45h and started the long walk uphill not knowing what was to come. We learned that Malayan distances are not what they seem to be. Even though the average length of the Malayan population is not that tall, even us Dutchies had some trouble getting up the steep steps. After an hour of climbing and sweating we arrived at the Canopy Walkway. Our hard work was paid off by some amazing views through the treetops. The first group left a message to the others by placing a Mollier sticker on top of the last treetop bridge which was noted by even more Dutch tourists.

At the way down we have seen some of the fauna that the rainforest has to offer. Big red ants and really large centipedes. Some of us were able to cool down beneath a waterfall while the last group was just in time back before the rain started. We are used to rain in the Netherlands but here in the tropics we have really experienced heavy raining.

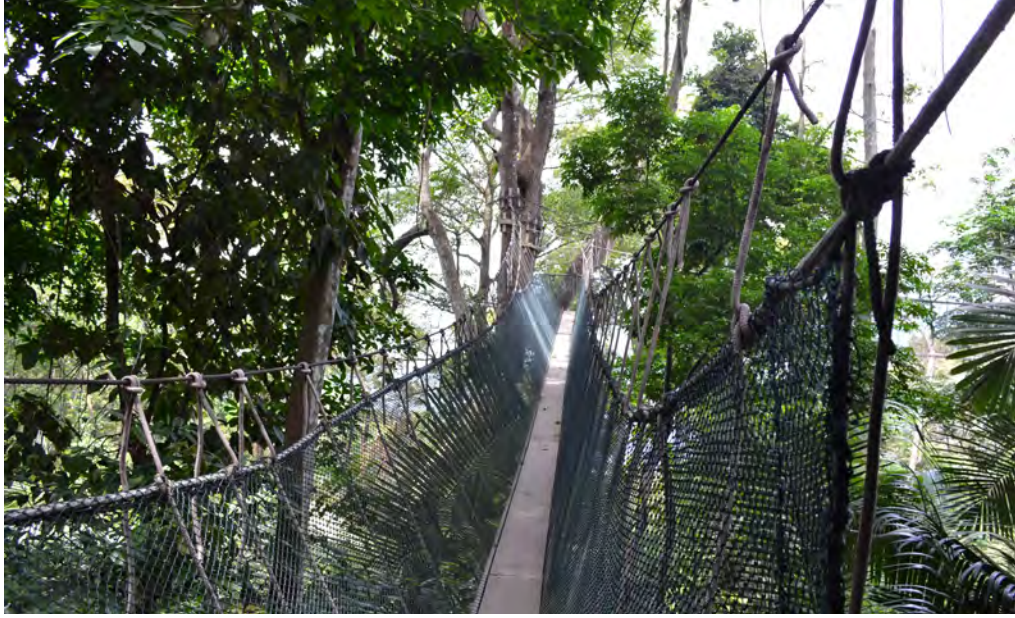

Figure 9 Forest Research Institute of Malaya - Canopy tree walk

The next stop was Batu Caves were we had to climb 272 steps to arrive at a large Hindu temple set in a cave. The temple cave is decorated with large Hindu shrines. After visiting this temple and climbing down the 272 stairs we enjoyed the last full night in Kuala Lumpur.

Figure 10 The 272 steps to the Hindu Temple Batu Caves

MONDAY 28 APRIL

A last visit to a company called ARUP was planned. ARUP is an international company specialized in mechanical, structural, civil and geotechnical engineering. ARUP aims on creating environments that are comfortable for occupants, economic for owners and efficient with resources. With 90 offices in 35 countries and 10000 planners, designers, engineers and consultants they are truly global focused.

A short presentation was given by the Mechanical & Electrical director of the Malaysian department of ARUP focused on the diverse projects ARUP was involved in. The presentation showed that the company is mostly involved with high-rise buildings, especially in Malaysia. Most of the employees of ARUP Malaysia are locals with an exchange of knowledge and expertise with other ARUP departments abroad. In addition, a more detailed presentation in which the involvement of ARUP in the development of the KKR2 high-rise building was presented. Among others ARUP was involved in the development of air conditioning, rain water harvesting, fire protection and mechanical ventilation systems. Afterwards two specialists joined the gathering for some additional information and to answer questions. The visit ended with our last delicious Malaysian lunch.

Due to heavy rain our plan to have a dinner before we went to the airport was cancelled. We took 'Air Force One' (how our cabby called his shuttle bus) to the airport where we had our last dinner. The flight to Amsterdam had again a stop in Frankfurt where we, after a flight with some turbulence, arrived at Tuesday morning.

We can look back on a successful trip with information about studying, working and living in the East!

Indoor air in long term care facilities and spread of infectious diseases

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RESUME

Older adults, especially those who suffer from dementia, are more sensitive to indoor environmental conditions. These people often live at the psychogeriatric department (PG) of long term care facilities (ltcf's). However, no special requirements exist for the indoor air quality of these care facilities, while it has an important influence on comfort and health of building occupants. This study focuses on the relation between indoor air and the spread of airborne infectious diseases in LTCF's. An assessment methodology has been developed to analyse and compare different buildings and to determine the role of indoor air on the spread of airborne infectious diseases.

INTRODUCTION

Not much is known about the favourable indoor air conditions in long term care facilities (ltcf's), where older adults suffering from dementia live. Since the physical environment directly influences health and wellbeing, careful attention to the indoor environment in ltcf's is desirable. However, there are no special requirements for ltcf's (Kort, 2012). The current standards are based on the perception of average people whereas older adults, especially those suffering from dementia, are known to have a different sensitivity to the physical environment (i.a. Andersen et al., 2012; Bea and Park, 2009; Norbäck, 2009). Little is known about the current indoor climate in these ltcf's, although the effect of the physical environment on the health and wellbeing of patients has proved to be important (Huisman et al., 2012). By adjusting the indoor environment to the needs of the residents, it is expected they put less demand on the professionals working in the ltcf's.

A poor indoor air quality can not only cause discomfort and health problems, air can also transfer pathogens of airborne diseases. The study of Li et al (2007) emphasized the need for investigating the impact of indoor air environments on the spread of airborne infectious diseases, as little is known about the impact of airflow patterns on infectious disease propagation. Controlling the complex transmission of infections is hard at the PG department due to several reasons:

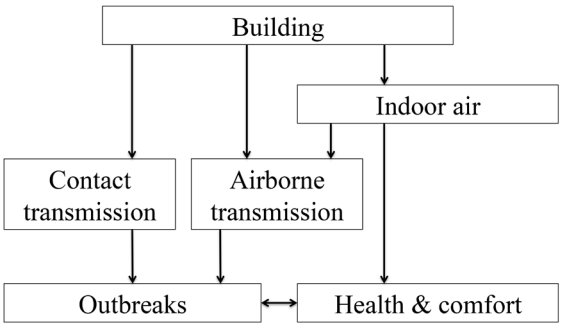

Figure 1 Relation building, indoor air and outbreaks, health and comfort

- Residents live close together and can freely interact (Siegel et al., 2007).
- An advanced age goes together with a declining immune system (Chohan et al., 2001).
- Illness is often recognized after it has already spread (Di, 1999).
- It is hard to apply restrictions to residents because they do not understand the situation (Siegel et al., 2007).

There is not much evidence that ventilation reduces the risk of transmission of infections. However several studies suggest that an insufficient amount of ventilation contributed to the spread airborne diseases (WHO, 2009). Reasons for this little evidence is among others the large number of contributing factors to transmission and so the impact of ventilation is often too difficult to be quantified.The objective of this research is to provide a method to analyse current ltcf's to see if differences in building characteristics, HVAC systems and indoor air influence the spread of airborne infectious diseases. It should assist in the development of design guidelines for the indoor environment in ltcf's.

METHODOLOGY

Based on literature, an assessment method has been developed to analyse ltcf's and to determine if indoor air quality influences the spread of airborne infectious

diseases. It consists of the evaluation of building-, location- and HVAC characteristics, use of the building, the indoor air quality, outbreaks of infectious diseases and health and comfort of staff in long term care facilities (ltcf's). This is done using checklists, interviews, indoor air measurements and questionnaires. The different categories of the evaluation and how they are related, are illustrated in figure 1. This methodology has been carried out at seven ltcf's in the Netherlands.

DATA ANALYSES

The data has been analysed in four steps. First an overview is made of the results of all buildings together to give more insight in the current building quality. For each variable, the results of all buildings together are presented in a boxplot. Then the investigated buildings were ranked from the point of view of infection prevention. This was done as follows: for each building it was determined for each variable whether the value was in the 1st, 2nd, 3rd or 4th quartile of the boxplot. So if the building belongs to the 25% best scoring buildings, 25-50%, 50-75% or to the 25% least scoring buildings for that variable. The corresponding score was assigned as illustrated in figure 2. The score does not imply that a building with a score of "1" is in any case good and a score of "4" is bad. Due

	1st quadrant	2nd quadrant	3rd quadrant	4th quadrant
score	4	3	2	1
	least 25%			best 25%

Figure 2 Assigning scores to buildings

to the lack of guidelines and references no optimum can be defined. The ranking is used to find the effect of differences between buildings and its effect on health and comfort.

After that the different buildings are compared. Radar plots are used to give an overview of the scores of one building. The chart is divided in three parts, as shown in an example in figure 3.

1. Building characteristics & HVAC systems
2. Outbreaks infectious diseases
3. Comfort & health

The chart should give a quick insight in the aspects for which a building has a good or bad score and helps to find possible correlations between the three categories.

DISCUSSION

The aim of this study was to develop a method to analyse ltcf's to investigate how differences in building characteristics, HVAC systems and the use of the building influence the spread of airborne infectious diseases. Application of this method on existing ltcf's provided an overview of its applicability and the expected outcome for existing ltcf's.

It was found that reliable information about the outbreaks of infectious diseases is difficult to obtain. It also appeared to be complicated to find all the desired technical information about the HVAC systems. The radar chart, which gives insight in the scores and possible relations, needs further research to be validated. The parameters on the axes of the radar chart consist of different variables. However, the impact of each of these variables is not yet known. In the current analyses the different variables are divided in categories in which their contribution is assumed to be the same. More research is needed to find out whether weighting factors or a hierarchy should be applied in this analysis. Currently the building evaluation is mostly descriptive based. So more indoor air measurements are needed to support the validation of the model. Quality requirements can be added to the descriptive variables to ensure comparability.

If the model has been validated, relations between on one hand the building characteristics and HVAC systems, and the other hand the spread of infectious diseases and health and comfort of health care professionals can be analysed. When more information is available about the desired conditions and the effect of the building and HVAC characteristics, criteria for the buildings can be integrated in the model as well. Then ltcf's can use the model to structure the buildings and HVAC characteristics and define their positions compared to other ltcf's. Since the type of information required for the analysis is now scattered across many different people, in its current form

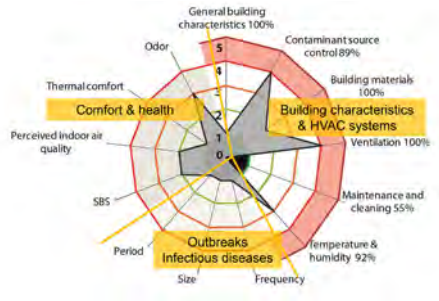

Figure 3 Example of a radar chart

application of the model already has shown to provide the respective stakeholders of ltcf's with a much improved insight of the functioning of their building with respect to its indoor air quality. The model gives information about the ranking of one building compared to other investigated buildings, it shows strength and weaknesses of a building and it shows the effect of the building and HVAC characteristics on infections and the perceived health and comfort. Nevertheless, it is recommended to carry out improvements as discussed to make the method better applicable and thereby serve as a tool to find correlations, determine design guidelines and assist facility managers to improve the building quality of ltcf's.

Figure 4 Impression of one of the assessed healthcare buildings

From this research it can be concluded that this method has potential to evaluate and compare ltcf's and develop design guidelines for these buildings. As discussed, some adjustments to the methodology are necessary to achieve this objective. Therefore the relation between the indoor environment and infection risk is not yet analysed. It is recommended to further develop the method, so it can be applied and thereby serve as a tool to find correlations, determine design guidelines and assist facility managers to improve the building quality of LTCF's.

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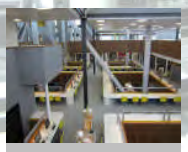

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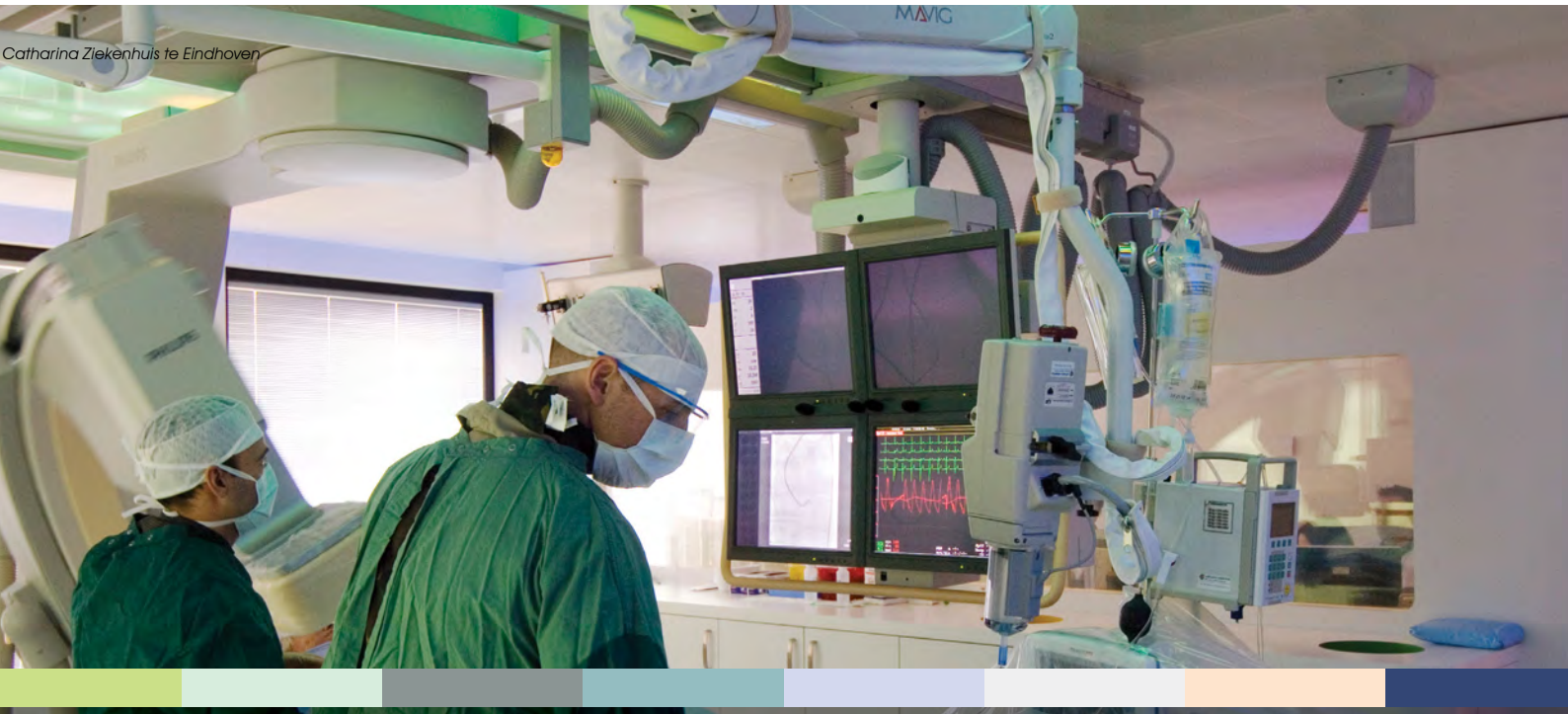

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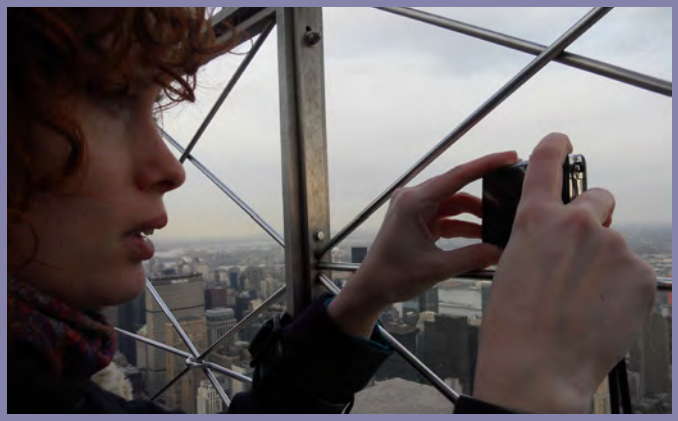
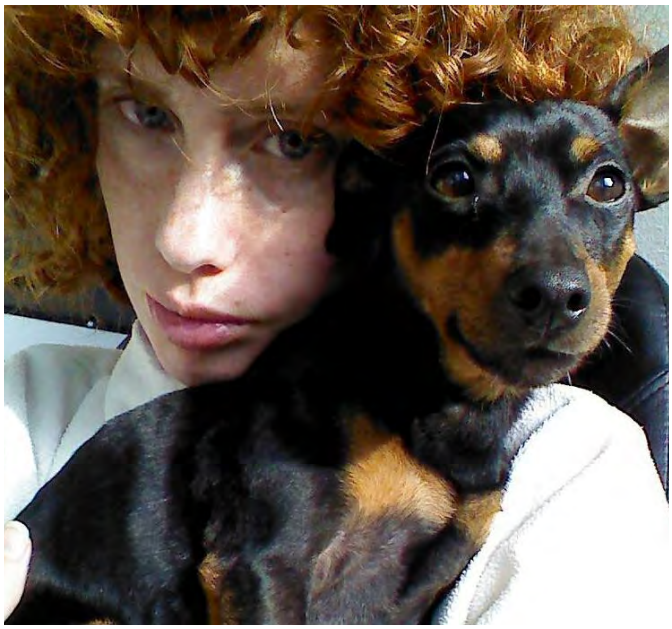
Ice-breaker

Adonia Diakoumis





My name is Adonia Diakoumis, that is pronounced Adonía. I was born in Eindhoven and have lived here the first two years of my life. Then we moved to Boxtel and – when I was 10 – we moved to Analipsi, a small village in Greece. By we, I mean me, my parents, my two younger brothers, my little sister (ok, by now she is 17), our dog and our cat. After finishing my studies and training, and having worked as an officer in the Greek army, I decided that that is not what I wanted to be for the rest of my life. Therefore, at the age of 24 I returned to my roots, Eindhoven.

At this point I am a 4th year student and have completed my bachelor program, Architecture at the TU/e. I started my master program Building Physics and Services this year. I started studying Architecture because I am fascinated by buildings and the impact the have on people. I love sitting in a space and observe how people use it. This highly depends on the culture of the people living or working there. My ambition is not to build new structures, but rather to renovate / refurbish existing buildings. To help give them a new destination and function. To make sure that future users are comfortable in the building. And not only that. I want my buildings to function off the grid, to be autonomous, to not create waste. Which will require a change in the mentality of us as users as well of course. But I remain optimistic!

Other than studying I am working 16-18 hours per week to pay for my study and my lifestyle, which is not that of a typical student I suppose. I live in a studio with my dog and boyfriend. Whenever possible I travel. To my family in Greece of course, but also other places of interest. My last trip was to New York visiting a friend of mine who is studying there. You can imagine that when I returned everything here seemed dull and flat!

My main hobby is ballet. I am dancing since I was 3, but stopped when we moved to Greece because there was no ballet studio nearby. So when I moved back to Eindhoven one of the first things I did was to find a good ballet studio. In April I had my first performance after years! To perform better at ballet I also do a couple of hours yoga a week. I don't know if it helps reducing my stress, but I do know that it improved my flexibility. Although I must confess that I am more zen when I am doing ballet. Believe me, when you are in the first position, elongating your lower back, closing your sternum, creating lines and growing taller taller taller, it is very difficult to think of anything else then being in the moment. It is difficult enough to remember breathing.

For those that do not know me yet and I have to warn you that I do like to talk. A lot. And loud. If you still feel the urge to say hi the next time you see me, you know what to expect. You will find me lingering at floor 4; don't know why I didn't upgrade yet to five or higher.

I will end this rumbling about me, with one of my favorites quotes that has helped me through a lot of not so good moments in my life:

"Everything will be all right in the end. If it's not all right, it is not yet the end". Patel, Hotel Manager, The Best Exotic Marigold Hotel"

Study on turbulent impinging jets – with application to air curtains

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Dear Reader! By this article I would like to describe my PhD research project titled "Dynamics of plane impinging jets at high Reynolds numbers – with application to air curtains". It is quite theoretical, but I hope you will enjoy reading it! The main research objective is to provide fundamental knowledge on plane turbulent impinging jets to support air-curtain applications. The research methodology comprises experimental (Particle Image Velocimetry) and numerical (Computational Fluid Dynamics modelling) techniques. What I find amazing about these tools is that they are not only able to visualise air flows that are invisible in real life, but also to quantify them!

I have also included a few words about a master project that is available on this topic. If you are interested feel free to contact me!

RESEARCH SUBJECT

An air curtain (AC) is a device that provides a certain degree of aerodynamic sealing by a continuous broad stream of air circulated across a doorway of a conditioned space (figure 1). ACs are often used at the open entrances of buildings to reduce heat losses or inside buildings to prevent smoke and pollutant penetration between rooms, while still allowing free access of persons and goods through a doorway.

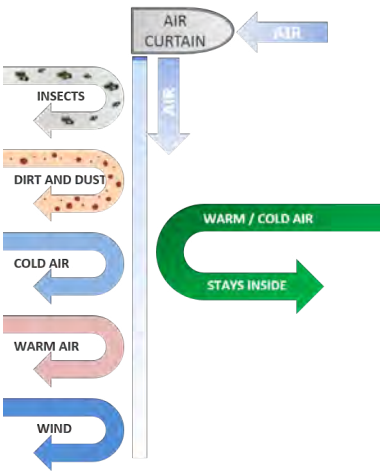

Figure 1 Air curtain

ACs use plane turbulent impinging jets (PTIJ) to separate the two environments in terms of heat and mass transfer. A PTIJ consists of 3 regions (figure 2): the potential core, the intermediate zone and the impingement zone. The centerline velocity within the potential core zone stays equal to the nozzle exit velocity. With increasing distance from the nozzle, the potential core region is consumed by two growing shear layers. Jet momentum diffuses and two-dimensional spanwise vortices occur. The centerline velocity is decreasing in magnitude and jet velocity profile is widening laterally. Within the intermediate zone spanwise vortices become accompanied by streamwise and traverse vortical structures. As the jet approaches the impingement region, it separates in lateral directions into relatively symmetrical flows (wall jets). In the impingement region, three-dimensional counter-rotating vortices exist, which cause intense heat and mass transfer between the jet and the impingement plate.

The jet separation efficiency depends on a wide range of jet parameters (e.g., mean velocity, turbulence intensity, temperature) that influence the vortex structures in the jet and the entrainment processes in which the jet air mixes with the surrounding fluid, and on environmental parameters such as temperature and pressure in the two environments.

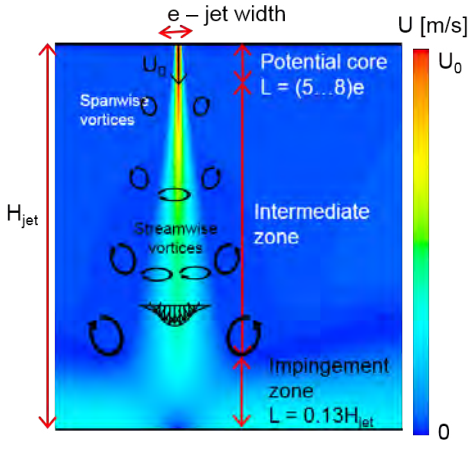

Figure 2 Structure of a plane turbulent impinging jet

This research project focuses on analyzing the relationship between jet separation efficiency on the one hand and the wide range of jet and environmental parameters on the other hand, to support optimal design of air curtain applications. Moreover, this study will provide the evaluation of different turbulence models applied in modeling of impinging jets/ air curtains based on Particle Image Velocimetry (PIV) measurements in an experimental water channel. Finally, guidelines for optimal air curtain settings in different applications will be formulated.

RELEVANCE

PTIJs are used in a wide variety of practical applications:

- to reduce energy losses between indoor and outdoor environments and to improve indoor thermal comfort (at the entrance of stores, shops, hotels, restaurants and bars);
- to improve indoor air quality: by separating smoking and non-smoking areas inside buildings, by reducing contamination hazard in laboratories/ clean rooms and in hospital operating rooms;
- to reduce smoke propagation in tunnels in case of fire;
- to reduce energy losses in appliances, e.g. refrigerated display cabinets in supermarkets.

In all these applications, detailed knowledge about the separation efficiency in case of two environments at different temperatures and/or pressures is required, which is needed for the design and application of air curtains.

RESEARCH METHODS

This research is focused on the fluid dynamics of plane impinging turbulent jets, and flow development for a range of jet and environmental parameters. This basic study will be performed by experiments with PIV measurements and numerical simulations with CFD (Computational Fluid Dynamics). Based on experimental findings proper settings for CFD simulation will be defined and be applied for extended parametric study.

EXPERIMENTS

A dedicated experimental set-up has been designed for studying the performance of an isothermal jet (figure 3). Thanks to Geert-Jan Maas (BPS-lab), this set-up will be installed at the Applied Physics Department this year.

The working principle is as follows: the pressure is created by a water column (1), the water flows through a set of honeycomb and three screens (2). They are applied in order to reduce the turbulence levels and the lateral mean velocity components. After that, the water goes through the bell-shaped contraction (3) and is issued from the nozzle. The

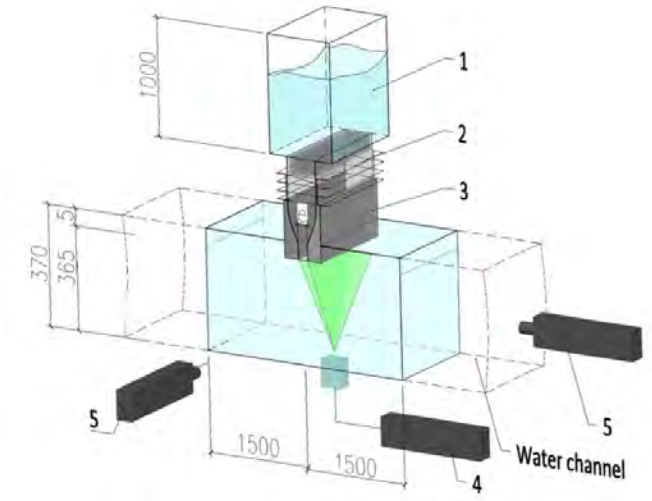

Figure 3 Overview of experimental set-up (dimensions are in mm): 1 – water column; 2 – conditioning section; 3 – contraction; 4 – laser; 5 – cameras

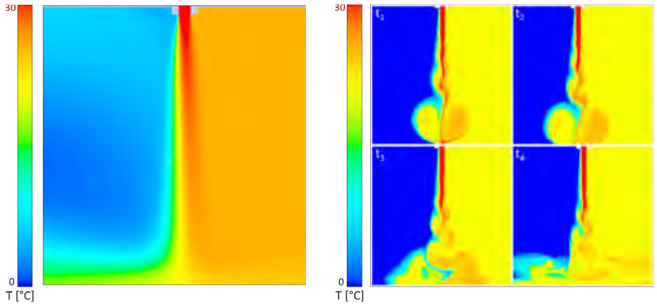

Figure 4 Temperature contours predicted by CFD: a) mean flow obtained with RANS; b) instantaneous flow obtained with LES

height of the water column and the nozzle width determine the Reynolds number of the jet, which can be varied within the range of 7000 to 32000. Particle-Image Velocimetry is applied for the measurements. Particles seeded in the water follow the flow, and are illuminated by laser pulses (4), the flow is visualized and monitored by the cameras (5). The pictures are digitally transformed to to obtain velocities and turbulent quantities in three dimensions.

CFD

CFD simulations will include two techniques: Reynolds-Averaged Navier-Stokes (RANS) for time-averaged solution and Large Eddy Simulations (LES) for average and instantaneous solutions (figure 4). The advantage of RANS is that it is less computationally expensive. However, it is unable to predict turbulent vortical structures in the jet flow, which are relevant to consider in this research. LES consumes much more computational power, but provides detailed time-dependent information, and is therefore able to provide information on the formation of vortices in the flow. This research will also provide an evaluation of turbulence models and computational settings for predicting the performance of impinging jets and air curtains.

MASTER PROJECT

The purpose of this study is to look into the sealing efficiency of an air curtain in cold and warm conditions (winter and summer). The influence of four air-curtain parameters on the sealing efficiency will be investigated: initial velocity U_0, temperature T, jet angle α, and jet width e (figure 5). A set of these parameters with the optimal sealing efficiency will be defined for each case. This study will be performed using 3D steady RANS simulations with ANSYS Fluent.

If you are interested in this topic – please feel free to contact Adelya Khayrullina, a.khayrullina@tue.nl, VRT 6.36

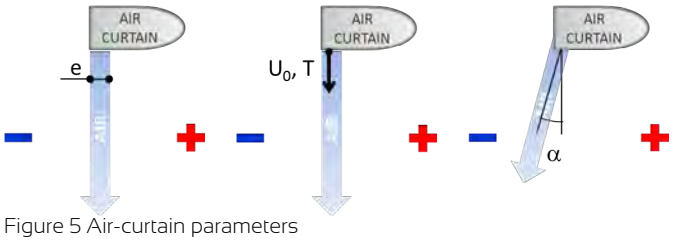

Figure 5 Air-curtain parameters

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