Academic year 2014 - 2015 #1 | December

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

Numerical analysis on the energy performance of the Strata Tower

Graduation project Karin Kompatscher

Column Modern Scientists

Maarten Hornikx

Constitution 19th board

Muziekgebouw Frits Philips, Eindhoven, 2014

Foreword

Lisan Crommentuijn

President 19th board of s.v.b.p.s. Mollier

Dear Mollier member, Alumnus and other interested,

First of all, I want to thank you, as a reader, for making some time to open and read the new release of the INSide Information. We proudly present this magazine again with a lot of information, and I hope also inspiring motivation from all our sponsoring companies, professors, PhD students and students within the field of Building Physics and Services. We, as the 19th board will continue to represent the link between students, companies and university for our study association this academic year. On the next pages we will introduce ourselves.

Because a couple of old members of the INSide commission left, some new, fresh and enthusiastic members took part. On behalf of the entire 19th board, I want to thank every one of you for your energy and input to create this new version. Besides the commission which is responsible for this magazine, s.v.b.p.s. Mollier has a lot of other commissions where students and members make themselves hard to organize activities during the year. The end activity to the Ardennes in June, the lunch lectures and also the first activity of the new study year last November became a success because of you.

When you are looking through the magazine later on, maybe some of you will notice that new companies became sponsor of s.v.b.p.s Mollier. Of course we are very glad that these companies notice how important their investment is in our study association. I am convinced we can show the profits and gains for them, as a company, too.

I already mentioned several past activities but for sure also in this academic year we have already new upcoming events. Activities for fun, but also excursions to our sponsors or the Meet&Greet and the lunch lectures can be noticed in your calendars.

Last but not least I want to ask some attention for the fourth Lustrum that will be organized in this academic year. Do not hesitate if you have some tips or tricks for this event! More information will follow later this year.

Well, I hope you enjoy reading and on behalf of the entire 19th board and the editors of this INSide Information, I wish you Happy Holidays and an inspiring 2015!

EDITOR IN CHIEF	Marthe Doornbos
EDITORS	Annelous Bossers Bareld Nicolai Charlotte Rosenkotter Dennis Pennings Karin Kompatscher Koop-Pieter Ziel Marjolijn Benen Yvonne Peters

COLOPHON

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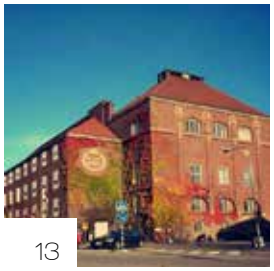
This INSide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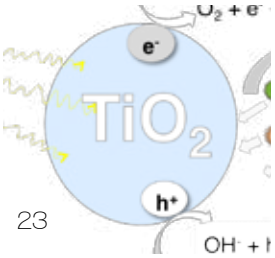

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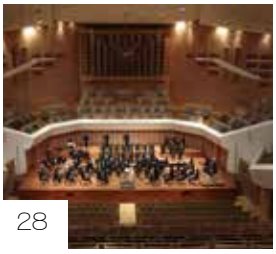
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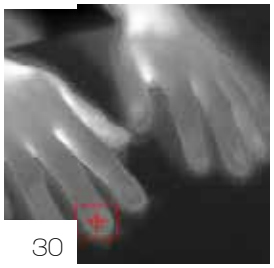
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33


40


41

The 19th board of Mollier

LISAN CROMMENTUIJN
CHAIRMAN

Yes it's a girl! As most of you know, in the history of Mollier as a study association, it hasn't happened before that there was a female president. Well, here I am! And I am proud to present myself as the 19th president of s.v.b.p.s Mollier. Let me introduce myself.

My name is Lisan Crommentuijn, a 23 year old girl born in Weert and raised in Ell. This is a very small village in the middle of the province Limburg, in the south of the Netherlands.

After high school I saw my chance to move to a city when I started with my bachelor of the Built Environment at the Avans University for Applied Sciences in Tilburg. My ambition was to become an architect so I chose this specialization and did my graduation project at Ector Hoogstad Architecten. With a delay of half a year I graduated in January 2013. In the months before I started with a further study at the TU Eindhoven, my doubts about doing also my master in Architecture became stronger and through visiting the master event and reading more about building physics, I chose to switch. After 4,5 years I left my student house in Tilburg and in September 2013 I started with the pre-master Building Physics and Services which I completed in February this year. Then I started my first master project about relative humidity and temperature in a monumental building in Amsterdam. During that period I also moved to Eindhoven where I live in my own studio apartment now. At this moment I'm working on my second project, which is about echolocation performance of human beings. Upcoming February I hope to start with my graduation project.

Together with my background as an architect and personal interests, I really like to focus on the influences of physical aspects of buildings on their users. Also transforming or renovating churches or old utility buildings into a new destination have my attention. In my spare time I like to go on city trips and look around for these kind of buildings. Therefor my friends always tell me that I'm not looking were I'm walking but just walk around with my noise pointed into the sky. When I'm not that lucky to go on holiday, I work part time in a DIY (Do It Yourself) shop in Eindhoven after school and in the weekends. Also I like to visit the sport centre at the TU/e campus or go for a drink with (Mollier) friends. Together with being a member of this years' board, my weeks are pretty full but I hope that my chairmanship will be an experience that I can use in the future and helps to develop my personal skills further. I hope that Mollier, as a study association, also can help other students to achieve this goal!

MARJOLIJN BENEN
SECRETARY

My name is Marjolijn and I am 22 years old. I started my life in a small village of Wijnandsrade, somewhere in the very, very south of The Netherlands (in between Heerlen and Maastricht). But I grew up in Vilt (a small village on the top of the Cauberg, Valkenburg) and Maastricht. I am the oldest of four kids and am the only girl in the family.

I went to primary school in Maastricht, the school play in the last grade where in a hall of a high school. I liked this hall so much that I knew very early on where I wanted to go for my high school. In 2010 I finished my high school education at Sint-Maartens College in Maastricht. I started in Eindhoven and traveled for two years. I can tell you, I don't recommend it... And as my friends told me, I am 'living in The Netherlands instead of Germany' at last. In Eindhoven I started the Bachelor Bouwkunde, which I hope to finish this February. Then I can finally start my Master Building Physics and Services.

I love reading, drawing and doing stuff with friends and family. But the thing a like the most is dancing. I also love to have people around me and have a good time. This year as member of the board, and especially as the secretary of the board, I hope that I will see you all at our activities!

BABETTE MATTHËUS
COMMISSIONER ACTIVTIES

Hello, my name is Babette Mattheüs, I am 23 years old and born and raised to the innocent girl I am today in Mijnsheerenland, a small town nearby Rotterdam. After the HAVO I went to the Rotterdam University of Applied Sciences to study 'Bouwkunde'. Part of that study was a semester abroad in Helsinki, Finland where I learned to speak fluent Finnish, Not! And two years ago I moved to Eindhoven where after finishing the premaster I started the master Building Physics and Services, which I hope to finish in 2016.

In my spare time I spent 6 days a week horse-riding because I have my own horse in a stable in Best. I also play the piano and in the weekends I work at the Primark in Eindhoven and after a year of working there I can give you one piece of advice: Never go on weekends to the Primark, Never.

Last year, I was part of the study trip commission which made me decide to become a member of the 19th board of s.v.b.p.s. Mollier. Since the constitution I fulfil the new role as commissioner of activities. I hope we can continue the good work of the previous board in professionalizing the association. Another goals of our board is to organize more activities, both sponsor-related and non-study related member activities.

JELLE REIJNDERS
TREASURER

My name is Jelle Reinders, 24 years old and I was born and raised in Zutphen, a nice Hanzestad in Gelderland. I am the new treasurer of Mollier.

I started my career in high school with "VMBO" and went on with "HAVO". After high school I went to the HAN university of applied science. I thought of becoming an architect but after the first few weeks at the HAN, I wanted to do something meaningful with my life and dropt that idea. So I specialized in building technology instead. During the study I found out that the building physics really interested me. So I did my internships at DGMR and Peutz and I saw myself doing that kind of work when I am mature.

After my graduation in 2012 from the HAN I wanted to specialize in the building physics so I went to the TU/e to study Building Physics and Services. The trip to Eindhoven and back to Zutphen bored very quickly so I moved to the south.

In my spare time I like to go to the gym and going out for a run if my ankle isn't broken. I also joined a great group of elite students "Bierfysica" which motto is "Why drink beer if you can study". So all my other spare time goes to studying and research and there is very little, to no time, left for craziness.

BAS PETERS
COMMISSIONER PUBLIC RELATIONS

My name is Bas Peeters, I was born and raised in Horst, the most beautiful village in the Netherlands. After primary school I went to high school where I studied 'HAVO' for six years. During my time in high school it was clear to me that I want to do a technical study, this became building engineering on the Avans University of Applied Sciences in Den Bosch. During my minor period, I did the transition program for HBO intake at the Eindhoven University of Technology. So after my Bachelor I could immediately start in the Master program Building Physics and Services.

Since September 2013 I'm studying in Eindhoven and after almost a year of traveling, I live in Eindhoven since June this year. Within a few weeks I will start with the last part of the study: my graduation project. This will be in cooperation with Wolter&Dros. In my spare time I like to play soccer and hang out with friends. Furthermore, I play the (bass) guitar and I love to listen to music and visit festivals and concerts.

ROBIN VAN DER SANDE
COMMISSIONER EDUCATION

Every life has certain events that place a mirror in front of you, a self-reflecting moment realizing your life is chaotic and makes no sense. Writing this introduction is exactly a kind of event, where one is expected to mention his flourishing list of exciting hobbies and epic life events. Like most life stories, it started with my birth in the picturesque little town Sint-Michielsgestel. Accompanied by a loving family with an older brother and sister, I quickly gained street credibility as I aged in my home-town. To unleash my full potential, I left the picturesque village and got out of my comfort zone by attending high school in the city of 's-Hertogenbosch.

Cycling the 5k to school was no easy task as Mother Nature tested my endurance with new challenges every season. Nevertheless I was able to acquire my degree (HAVO) and chose to pursuit happiness in the building environment. The bachelor in the building environments taught me two things: The economic crisis was going to last a little longer and there is a lot more to learn. Counting my blessings I decided to continue my educational career in Eindhoven.

Unfortunately due to all the highlights of my life, the flourishing list of hobbies can only be described briefly. I once thought a side-career in the music industry could bring me both material and emotional wealth. Turns out I wasn't fit for the music industry, however I did end up with DJ-equipment, which is nice. Recently the joy of reading was brought upon me, and every now and then I pick up a self-development book (no shame). Most books I read relate closely to my own belief that you got to have fun before you can actually do proper work. There are times I put this philosophy too enthusiastically to practice which can result in deadlines creating stress. So I pick up another self-development book and the cycle continues. Has my little introduction sparkled your interest in me, feel free to approach me so we can talk about philosophy and street credibility.

Kuijpers

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

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

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

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Unit projects

CFD study of the effect of staggered floors

The construction of a building has a big influence on the microclimate in its vicinity. In particular near high-rise buildings high wind velocities are often introduced at pedestrian level, which can be uncomfortable or even dangerous. Therefore the architect of the A-tower of the WTC in Amsterdam came up with a remarkable design solution. He designed a building with staggered floors to increase the buildings surface roughness so that it will lead to a more comfortable wind environment at pedestrian level. His statements were the reason to start the investigation of the effect of the buildings surface roughness on pedestrian wind comfort.

To be able to show the influence of the buildings surface roughness, CFD studies of three building geometries were performed. Model A is the model without staggered floors, model B with staggered floors of 1.1 m overhang (original design of the building) and model C with an extreme overhang of 4.4 m.

Figure 1 shows contour plots of the wind speed ratios (= U/Uref) at pedestrian level (=1.75 m) for the models A, B and C. The plots show the results for the wind directions 30°, 60° and 90°. Uref is the wind speed at pedestrian level, undisturbed by the building.

Decreasing wind velocities at pedestrian by increasing the surface roughness is possible, but it remains to be seen whether this results in a better wind comfort quality class, which will be investigated in further research on this topic.

Joep Bischoff

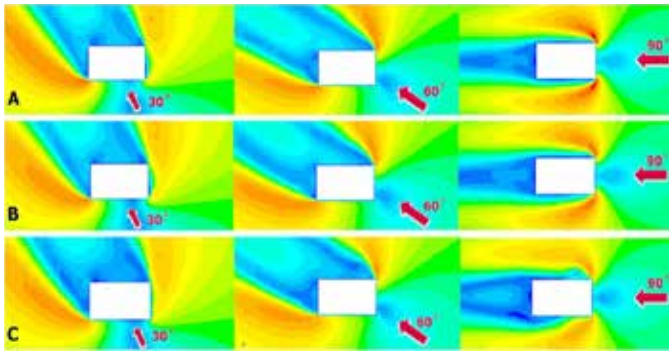

Figure 1 | Studied building geometries: A, B and C

The operation of BaOpt

BaOpt, Bauer Optimierung, is a climate system that intends to provide an optimal indoor climate with a homogeneity of 100%. It is a German patented system that uses software (PLC) and takes over the control of the Air Handling Unit. It is a big success on the market, but the theoretical foundation is unknown.

Therefore, a research has been performed with the goal: getting insight in the operation of BaOpt. BaOpt formulated several claims on their website, which were tested in this research, i.e. constant temperature, relative humidity and air quality (CO2), optimal comfort and no draught or convection. These claims were investigated by carrying out measurements on the BaOpt system in theater Speelhuis, located in a church in Helmond. Measurements took place during three performances.

A literature study shows that there is no obvious insight in the operation of BaOpt. From the measurement results, it can be concluded that the stratification is limited. Furthermore, draught has been measured in some situations. The performance of BaOpt is tolerable, but not exceptional. Further research is needed in other applications / buildings and at other circumstances, i.e. during the winter.

Silke Seuren

Figure 1 | View of the foyer

Natural ventilation through openings in separation walls

When openings in separation constructions are partly above and partly beneath the neutral pressure plane, natural supply and natural exhaust of air occur simultaneously. This creates a shortcut between supplied air and exhausted air. Only a small part of the supplied air will mix with the entire volume of the room. The ventilation efficiency characterizes the mixing behaviour of air within a space and the removal of pollution from a source within that space and is described with a value from zero to one. To investigate the possible shortcomings in zone models regarding ventilation efficiency, the mass flow in zone models (CFAST) is compared to FDS (Fire Dynamics Simulator) calculations in which better resemblances of real world physics are expected.

It is anticipated that FDS will take the air flow shortcut into account, in contrast to the zone model. For both the 1 and 2 zone model, it can be concluded that the ventilation efficiency of openings in separation walls is underestimated. However, FDS and CFAST gain significantly different results based on the same input. It is highly unlikely that this is only caused by the possibility of the shortcut effect. There might be other existing parameters or settings which influence the results.

Annelous Bossers and Thijs van Druenen

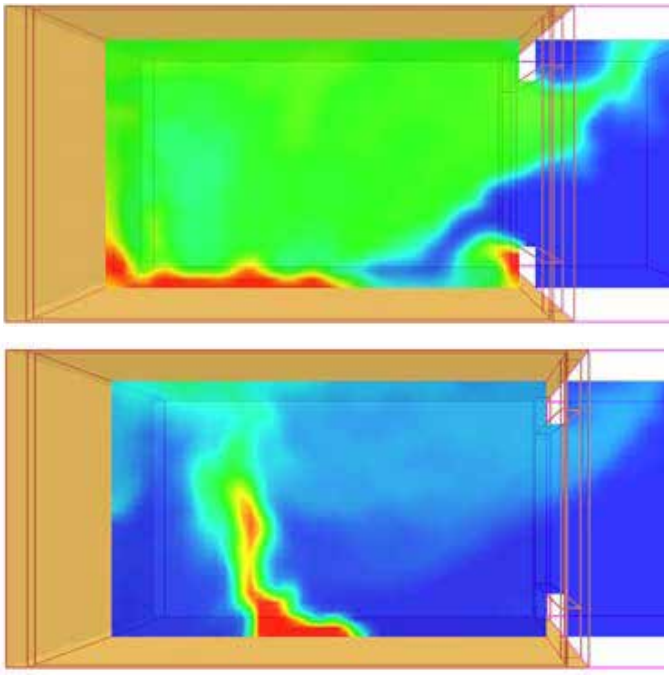

Figure 1 | Temperature (1-ZM)
Figure 2 | Temperature (2-ZM)w

Towards adaptive climate guidelines for museums

Recent research showed that the degradation of the collection in museums with a dynamic indoor climate does not differ much compared to museums with a strict indoor climate. After this conclusion, thermal comfort for the visitors got more important. Assuming that the thermal comfort for visitors only has to be present at opening hours, energy can be saved during opening hours. The problem is that there is still only a set of Adaptive Temperature Guidelines (ATG) for office buildings. The aim of this project is to create a new set of ATG for museum buildings.

In this project a new set of Adaptive Temperature Guidelines is created from the PMV (Predicted Mean Vote) formula. First, this PMV formula of Fanger is analysed critically. The parameters clothing insulation and air velocity are made dependent on the outdoor climate by applying formulas from different studies. There are three acceptance levels; 90%, 80% and 65%. For these levels the corresponding PMV values are respectively between -0.5 and 0.5, -0.84 and 0.84 and between -1.19 and 1.19. The new sets of guidelines are calculated in Matlab. The guidelines are created for Beta buildings with a Quality of Envelope of 1 and 4. The simulations were performed in HAMBase and gave energy uses as results. The final energy uses for the new sets of ATG are compared to the energy uses when the original set of ATG of Van der Linden were used.

It is possible to create new ATG from the PMV formula. The new guidelines have a wider ranger compared to the original sets and the lower and upper limit lines are not parallel. A final energy profit can be reached, regarding different acceptance levels of 25% to 46% for the Quality of Envelope 1 museum buildings and for the Quality of Envelope 4 buildings even from 2% to 73%.

Juliëtte van Duijnhoven

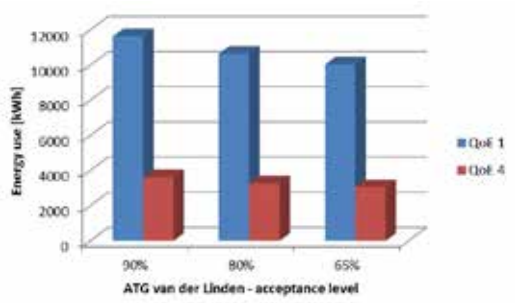

Figure 1 | Energy uses for the original sets of ATG for QoE 1 and QoE 4 buildings
Figure 2 | Method Overview

Visual experience of a virtual window

The presence of daylight through windows in buildings is beneficial for its users. This appearance is a result of qualities like view, changing daylight with the time of day and spaciousness. Those aspects are critical for the appreciation of a window, so will therefore also be important for the experience of a virtual window. Virtual Natural Lighting Solutions (VNLS) are systems that can artificially provide lighting and a view, with properties comparable to those of real windows and skylights. This research only focusses on one of the many aspect, the visual experience. It describes the performance indicators of the VNLS that will be used for a perception study.

As stated in the introduction the goal of this research is to see whether the VNLS is able to depict various weather types and if this is also experienced by its users. Three weather types are created at the VNLS; sunny, intermediatie and cloudy. In order to validate the user experiences for the weather types, a small pilot is done.

Due to the technic struggles of the VNLS the glare component could play a more important role. If the window can view a higher contrast between the weather types, started with more luminance, the window can give the viewer more glare expose for each weather type. Also, because of the technic struggle the pilot only involves the sunny sky, due to the changing experience of the colour white at the VNLS.

Marthe Doornbos

Figure 1 | view of the weather type sunny at the virtual window
Figure 2 | view of the weather type intermediate at the virtual window

Modern scientists

Written by:

dr. ir. M.C.J. Hornikx

At this moment, I am seated in an airplane that takes me to the Internoise conference. I skip to share my opinion of the indoor climate in this particular airplane, which could easily cover a column.

The conference is held every year and the 2014 venue is Melbourne. The flight gives me the opportunity to reflect, to ponder, about science. And about scientists. According to the Apple dictionary, this is a person who is studying or has expert knowledge of one or more of the natural or physical sciences. This definition does not please me too much.

Many people have studied a natural or physical science, as a student or of own interest. When I think of scientists of the past, I think of academics who were immersed by books, who heavily experimented and tried to explain the unexplained. Scientist who had lively discussions with other scientists about their experiments, theories and about their results. Scientists orating to students about their research field and their discoveries.

At this point in time, I consider myself being a scientist. My agenda is filled with administrative and project meetings, supervision of (PhD) students, writing of research proposals, networking with partners from universities, companies and public bodies for research collaboration -preferably interdisciplinary, with societal relevance and with a potential for valorization -, designing, improving and implementing courses for Bachelor, Master and PhD students, carrying out research, reading, writing and reviewing scientific papers and visiting conferences. The agenda of my fellow colleague scientists looks fairly similar. For sure, it is a more diverse and denser agenda than the 'old day' scientists had, with less time for research. According to me, a reason for this difference is that modern scientists are assessed based on citations and the number of publications: this mostly is a quantity-based evaluation rather than a quality-based evaluation.

In Melbourne I will meet acousticians from all over the world, we will discuss about experiments, theories and results and we try to explain the unexplained. After all, we are scientists!

The renewed INSide editorial

A brief introduction

Who will you secretly meet in person?
Annelous Bossers. Not for a date if you thought that, but for an interview or any other interesting story Annelous is there. Her first articles are placed in this edition.

Who likes to party?
Koop-Pieter Ziel. No further explanation needed, besides writing articles I organize the release parties of this great magazine. Like many others I'm new in the editorial.

Who is the graphic boy?
Bareld Nicolai. He has the skills and knowledge to give our magazine the look it deserves. He is new in this editorial and this is his first release of the INSide.

Who is the chef?
Dennis Pennings. At this very moment when I´m writing this I don´t know if his cooking is heaven or hell, since we will have dinner at his place. Nevertheless, he is an appreciated member of the editorial and working on his fourth release.

Who is in charge?
Marthe Doornbos. She is definitely the boss as chief editor. At least we let her believe... She is participating in her third release of the INSide.

Who is the longest sitting editor?
Karin Kompatscher. Her knowledge and experience about the INSide takes it to the next level. She is participating in her sixth and last release.

Who is club hopper?
Marjolijn Benen. From AnArchi to Mollier. Do we need to say more. The new secretary of the 19th board and new in the editorial.

Excuse me?
Yvonne Peters. She tends to say sorry, but knows how to grab the bull by the horns. A new impulse within the editorial.

Who is the sugar butt?
Charlotte Rosenkotter. Working hard at layout day costs us a lot. The bag of chocolate pepper nuts was gone in minutes. Nevertheless her efforts as new editor are well appreciated.

Op zoek naar een internationale uitdaging?

Abu Dhabi International Airport

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Deerns is het grootste onafhankelijke ingenieursbureau in Nederland als het gaat om het ontwerpen van installatietechniek, energieconcepten en bouwfysica in en rondom de gebouwde omgeving. Met projecten over de hele wereld en vestigingen in Europa, Dubai en de Verenigde Staten is Deerns bovendien een toonaangevend internationaal bureau.

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ICE BREAKER

Iris Moonen

Hi, my name is Iris Moonen. Unlike most people studying here, I have lived in Eindhoven my entire life. I'm 21 years old. I lived, and still live, with my mom, dad and brother. My brother is three years older than me. My school career wasn't really special until now. When I graduated from high school, I doubted between studying Architecture, Building & Planning and studying Food & Health, but in the end I decided to go for ABP. After three years I finished my bachelor this summer and started studying for my master Building Physics.

I've always been fascinated by buildings, but when I started here I wasn't sure if this was the right place for me. When I found out about Building Physics, I knew this track was what I was looking for. I think it's really fascinating how much work and thought (and money) goes into something that barely gets noticed by people, unless it's done wrong. And when it is done wrong, all of a sudden nothing is good about the building anymore.

I've done a lot of sports over the years like trampolining, volleyball and aikido. However, these days I usually do a combination of running, going to the gym and Youtube workouts. I'm still very interested in food & health, so lately I've started to learn more about it. Besides working out, you can find me in the kitchen, baking. I LOVE to bake! I think it's incredible how you can put some ingredients together and form something new with them, just by using some kitchen tools and equipment, like the oven. For me it's very similar to architecture and building in some way. In my opinion, focusing on one department alone won't make a good building. But when you take just the right amount of every department and develop it into one building, you get a great one!

I also play a little bit of guitar, but I'm planning on playing more in the future than I do now. My boyfriend is obsessed with playing guitar so once in a while I grab my guitar (a Taylor Big Baby for those familiar with guitars) and try to learn some songs. Music plays a big role in my life and if you see me walking around Vertigo or anywhere else, chances are, I am listening to music. No worries, if you want to talk to me I will turn it off and I'll be all ears, so feel free to say hi! I usually listen to country-pop music, however lately I've been getting into 'mainstream' pop more and more. I am a huge fan of Taylor Swift so if you are a fan too and/or want to talk about her, let me know! I warn you though, I can get a little over-excited when talking about her.

I love to travel. Actually, while I am writing this, I am on my way back from Venice, Italy. It's such a beautiful city, so please visit it if you get a chance! I usually try to combine my love for buildings, food and music during these trips! I also love to take pictures during special moments, especially polaroids. I am absolutely in love with taking polaroids. I love how you can capture the whole vibe of such moments in a single picture.

As I said, feel free to say hi next time you see me and I'll probably take off my headphones and talk to you!

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Study Abroad

Franziska in Stockholm, Sweden

HEJ HEJ!

Going abroad during my study was something I always wanted to do. Though, I must add that I'm from Germany and studying in the Netherlands is already similar to studying abroad. After the first years of my Bachelor in Den Bosch, the Netherlands felt too much like home to me already to still view it as studying abroad. When I was in my Bachelor I tried to do an internship outside the Netherlands, but unfortunately that did not work out. So I stayed, still keeping the thought in mind.

When I started my master at the TU/e I knew that this was my last chance. Thus, I looked at the possible partner Universities and the choice to go to Kungliga Tekniska Högskolan (KTH) was made pretty fast. The main reason for my decision to go to Sweden was that my mother was born in Stockholm and lived there the first years of her life, so I wanted to connect to the country were part of my family came from. I was attracted to the country and I wanted to experience how it is to live there for a while. Therefore, I made the decision to go to Stockholm, Sweden, and I got a spot at the KTH for the winter semester 2014.

One month before the official classes started I left home to take a summer course Swedish. It included a few weeks of impossible pronunciations and funny situations when the whole class tried to 'sing' Swedish sentences. Yes, Swedish is like singing, your voice just goes up and down and you never know where you have to put the stress on words or even in the whole sentence. During that time I've got to know many other exchange students who were all up to discover everything of Stockholm and who all wanted to get to know other people. During the first weeks there were also many activities organized by a student association at KTH. You could take part in games with other international students, go for city tours, game nights, pub crawls etc. There were plenty of things to do and I did not have the time to get bored or think about home, also I met a lot of other exchange students. Everyone's group of newly gained friends was growing from day to day.

The year at KTH is structured the same way as at TU/e, 8 weeks of classes and 2 weeks of exams. During my first quartiles I had 2 courses. I know that does not sound like much, but I had almost 30 hours of lectures a week plus additional assignments. Many lectures were practical orientated with exercises for calculations and examples. Mostly I spend lunch time with friends. There is one thing about lunch I consider as pretty funny; hundreds of students standing in line with their Tupperware boxes waiting for their turn at one of the many microwaves to heat up their food. These microwave 'walls' you can find in every building at the campus.

Free time during the weekends and in the evenings were used to enjoy Stockholm and its beauty. The first two months were still very warm and sunny. So going to one of the uncountable bathing spots at Stockholm's lakes was a very common thing for us to do. Every exchange student I met was a bit afraid of the dark months that were to com, which now are here. The clock turned back already and it is getting dark very early. At the end of this semester I had the opportunity of experiencing one of Stockholm's greatest summers, so let's hope for a good winter as well. I wish for lots of snow! If the winter will be just half as great as the summer, I will be able to look back at this semester with great joy and no regrets.

VERBIND JEZELF AAN DE GROOTSTE TECHNISCH DIENSTVERLENER VAN NEDERLAND.

Het binnenklimaat van een kantoorgebouw. Een ijskoud biertje van de tap. Wat voor veel mensen vanzelfsprekend is, bevat vaak de bijzondere techniek van Cofely. Dagelijks werken wij aan mooie projecten voor opdrachtgevers als Heineken, Shell en Rijkswaterstaat. Als technicus kun je bij ons bovendien rekenen op goede arbeidsvoorwaarden, een prettige werkomgeving en veel aandacht voor jouw ontwikkeling. Wil jij dicht bij huis werken voor mooie klanten en op je eigen manier kunnen groeien in de techniek? Ontdek dan je mogelijkheden op **werkenbijcofely.nl**.

verbind jezelf aan COFELY GDF SUEZ

Building Physics

Alessendro Pizzoferrato

Vertical Axis Wind Turbine aerodynamic optimization for the urban environment

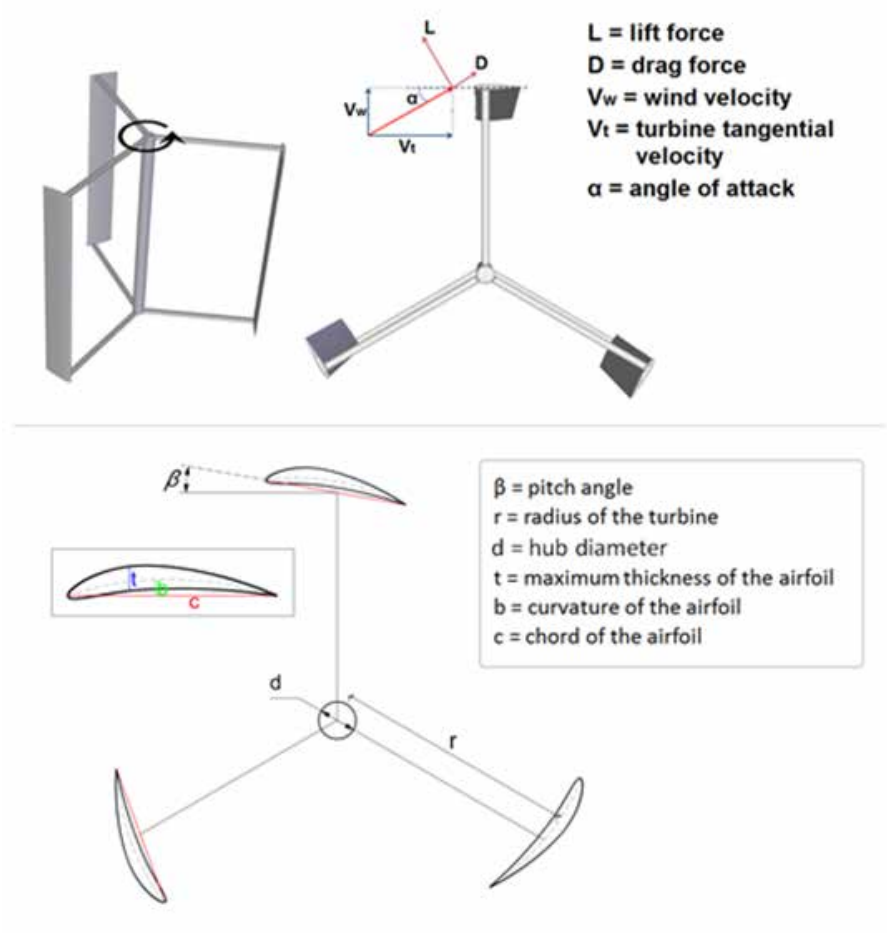

Figure 1 Schematic representation of a straight bladed VAWT and the forces acting on a blade. The lift force is responsible for the turbine motion. The angle of attack is the angle between the relative wind velocity and the chord of the blade section. The 2-dimensional sketch highlights some parameters which are important for the performance of the turbine.

INTRODUCTION

In this article I will describe my PhD research project titled "Vertical Axis Wind Turbine aerodynamic optimization for the urban environment". I have started my PhD study at the unit BPS in the past year. My supervisors are prof. dr.ir. Bert Blocken and dr. Ivo Kalkman.

From now on, I would like to refer to Vertical Axis Wind Turbine with the acronym VAWT. The possibility to harvest wind energy from the urban environment is a topic that is gaining importance. Efforts from several research groups are dedicated to this purpose and surely TU/e is not lagging behind!

Turbines suitable to harvest energy from the urban environment are smaller compared to the conventional ones and they are mostly grouped as "small wind turbines". Some of the most promising methods to assess the performance of a wind turbine are Computational Fluid Dynamics (CFD) and wind tunnel experiments. In the first period of my research activity I will use CFD as my main tool and, at the later stages, I am planning to validate my studies with wind tunnel experiments.

RELEVANCE OF THE RESEARCH

The worldwide installed capacity for small wind turbines is predicted to grow rapidly, reaching a cumulative installed capacity of close to 3 GW by 2020. The majority of vertical axis models were developed in the last 6 to 8 years, attesting that the VAWT market is still in an early stage with plenty of room for improvement.

RESEARCH METHOD

CFD simulations will be used to predict the performance of rotors. For most of the research phase, two approaches will be used: Reynolds Averaged Navier-Stokes (RANS) for a statistical solution of the turbulence properties and Large Eddy Simulations

(LES) for an instantaneous solution. RANS methods are able to produce an accurate prediction of attached or weakly separated flows. LES will be employed for strongly separated flows as a statistical approach might not produce satisfactory results for this kind of flows. At the later stages of the PhD, wind tunnel experiments will be conducted to validate the CFD results.

A BRIEF INTRODUCTION TO VAWTs

VAWTs can be defined as wind turbines with a vertical shaft. Fig. 1 shows a drawing of a lift-driven VAWT, which is a turbine propelled by means of lift force. Compared to the Horizontal Axis Wind Turbines (HAWTs), they offer several advantages, such as having good capabilities for handling turbulent and gusty wind flows which are typical of urban areas and providing similar levels of performance, independent of the wind direction. A disadvantage of the VAWTs is their limited energy harvesting capabilities compared to the HAWTs and one of the major drawbacks of many VAWTs is their difficulty in self-starting, which means an external force is required to initiate the rotation of the turbine.

Fig. 1 shows also a 2-dimensional drawing of a straight bladed VAWT with some of the geometric parameters which are important for its performance. Introducing asymmetry in the geometry, such as curved blade sections and non-null pitch angle, can help the turbine to self-start, but its performance at the working condition can be negatively affected. A similar result might be obtained by increasing the chord of the profile. All in all, an optimal design should be obtained by balancing opposite tendencies.

RESEARCH SUBJECT

My PhD will focus on the development of a new rotor optimized for urban areas.

Historically, the aerodynamics discipline was devoted to the aeronautic sector and a large number of airfoils for airplanes have been developed starting from the beginning of the 20th century. The aerodynamic conditions of a small VAWT are different from those experienced by the wing of an airplane. Therefore, when used for wind energy applications, the traditional airfoils might produce a sub-optimal performance.

The prediction of the performance of small VAWTs is a hard task because the blades will work in a wide range of angles of attack, including strongly stalled conditions, which are difficult to predict even with modern techniques. I am now trying to understand how to simulate such conditions in the most effective and efficient way using CFD. To achieve such an understanding, I am validating my CFD simulations with the experimental data produced by wind tunnel experiments of an airfoil. Once I am able predict the performance of an airfoil and a rotor accurately with CFD, then I will start to develop my own rotor!

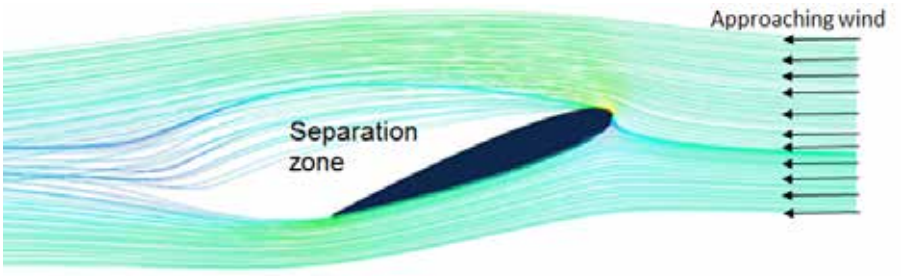

Figure 2 Flow separation on a NACA 0018 airfoil. Result of a CFD simulation that I performed at TU/e

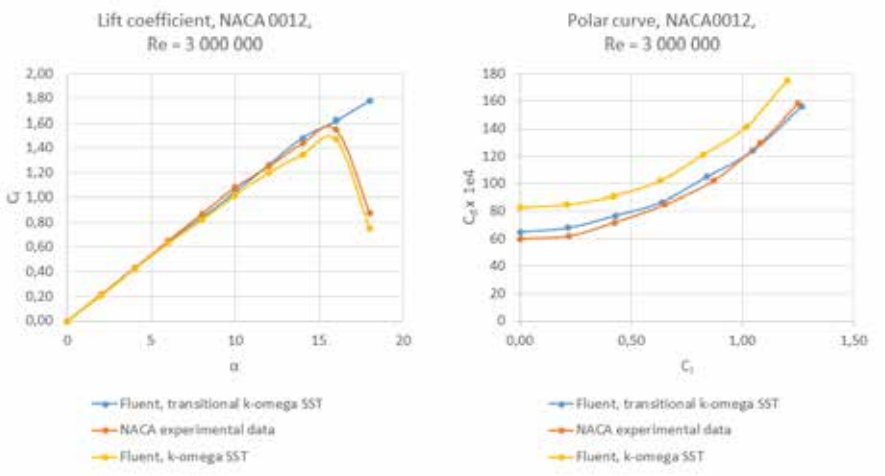

Figure 3 NACA 0012 characteristic curves. The lift and drag coefficient are a non-dimensional expression of the lift and the drag forces. The Reynolds number (Re) is a similarity parameter determined by wind velocity, air density, dynamic air viscosity and the chord length of the airfoil.

VALIDATION OF THE CHARACTERISTIC CURVES OF AN AIRFOIL

While preparing this short article, my work was concentrated on the validation of the CFD methods that I will use for this research. Firstly, I focused my attention on Reynolds-averaged Navier Stokes (RANS) methods and on some turbulence models suitable for this type of aerodynamic flow problems: the k-ω SST and the transitional k-ω SST.

Based on the CFD simulations performed, the results from my current work show that the transitional k-ω SST model is able to predict the transition from laminar to turbulent flow, producing accurate predictions of the drag coefficient. However, the standard k-ω SST model is more accurate in predicting the separation of the flow, which occurs at high angles of attack.

If you are interested in this topic, please feel free to contact me, Alessandro Pizzoferrato, via e-mail: a.pizzoferrato@tue.nl; Room: VRT 6.36

Building Lighting

Parisa Khademagha

Nature inspired healthy light in the built environment

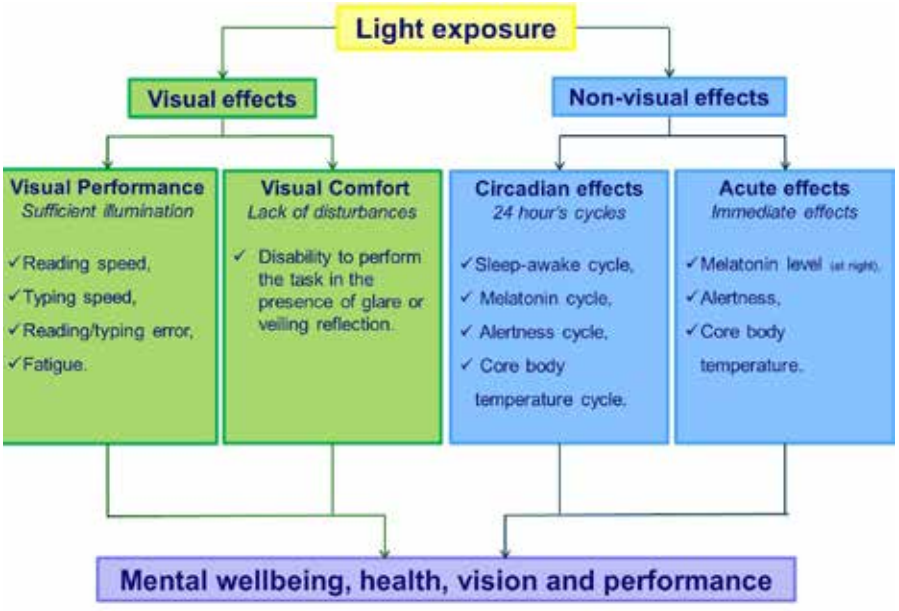

Figure 1: Visual and non-visual effects of light, the performance indicators from which the effects are evaluated, and the light parameters with which the magnitude of effects are quantified.

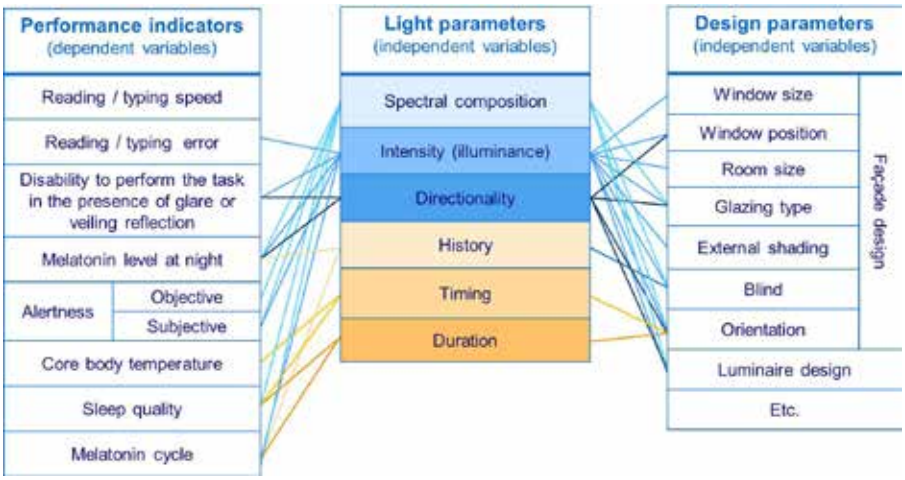

Figure 3: Relations between performance indicators, light and design parameters which will be studied and implemented in the model.

BACKGROUND

Human beings have evolved under the influence of daylight benefitting from its dynamic pattern. (Day)light entering the eyes influences human visual and non-visual responses in two ways:

1) via visual photoreceptors in the retina called "rods and cones" which enable us to see, ex-perience and interact with the visual environment, and
2) via non-visual photoreceptor in the retina called "intrinsically photosensitive Retinal Gan-glion cells" (ipRGC) which through the regulation of long term (circadian) and short term (acute) effects influences human health and well-being.

For many years scientists considered rods and cones as the only photoreceptor cells in the human eyes. The discovery of the third photoreceptor has proven that not only is (day)light exposure es-sential for vision, but also for health through stimulation of the both visual and non-visual effects. Figure 1 shows visual and non-visual effects of light, the performance indicators from which the effects are evaluated, and the light parameters with which the magnitude of effects are quantified.

The sensitivity of the human eyes varies enormously within the visible range of electromagnetic radiation (between 380nm and 780nm), depending on the wavelengths. Whereas rods and cones are more sensitive to the green light, ipRGCs are more sensitive to the blue light. Figure 2 shows the relative spectral sensitivity curves of the human eye. Daylight is rich in the blue part of the visible spectrum and might therefore play a large role in new lighting recommendations for health. Hence, it is to be studied and be considered as the primary source of healthy light and inspiration for artificial light solutions.

Exposure to (day)light stimulates a nerve pathway from the ipRGc to the Supra-Chiasmatic Nu-clei (SCN) in the brain. The SCN, as the internal clock entrains a set of daily cycles of human bodies, so-called circadian rhythms, with the external clock (light/ dark cycle) and consequently influences health, well-being and performances of people 1-6. Circadian rhythms define vital signs in body such as sleep-awake, core body temperature, hormone production, and alertness cycles. Disruption in entrainment of circadian rhythms can have negative effects e.g. poor performance, depression, sleep problem, heart disease, weight gain, and even cancer 7. In addition to the circa-dian effects, light has acute (immediate) effects 8-16. For instance, light suppresses melatonin pro-duction, constricts the pupil, stimulates subjective and objective alertness, etc.

Awareness of the impact of the non-visual effects of (day)light next to the visual effects, in de-signing healthy (day)lighting, is gradually increasing. However, the current recommendations of (day)lighting are based mainly on visual effects of light such as illuminance, contrast, glare, etc. The light parameters influencing the visual effects of light are well-known amongst lighting de-signers and the required threshold value for each parameter is specified in building norms and standards. Although this approach is sufficient to provide visual comfort and performance in spaces, it does not necessarily ensure an adequate level of non-visual effects for health benefits. In this context, healthy light is defined as the light which meets both visual and non-visual de-mands. Despite the valuable efforts in quantification of non-visual effect of light, the challenge remains to identify and measure the necessary light parameters for the stimulation of non-visual effects of light.

PROBLEM DEFINITION

According to literature, non-visual effects are triggered by spectral composition, quantity, direc-tionality, timing, duration, and history of (day) light 8-16. To date, neither the required threshold of these parameters are standardized nor are their interrelations in stimulation of non-visual effects defined. Moreover, there is yet no model for design of an indoor environment with healthy light in its inner space. Therefore, in this project the main research question is what is the model by which the visual and non-visual effects of (day)light can be evaluated in order to provide a healthy indoor environment?

AIM

The aim of this study is to develop and validate a new model for building design that includes healthy light conditions. Design guidelines will be developed to provide recommendations on the consideration of visual and non-visual effects of light within the design process.

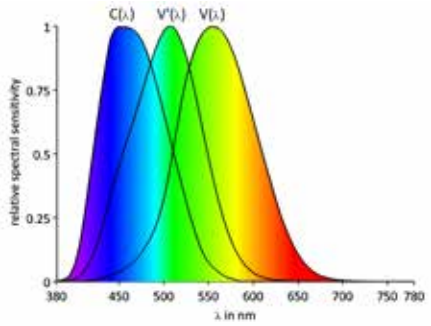

Figure 2, V(⊠), V'(⊠) and C(⊠) represent the relative spectral sensitivity of the cone-based (photopic), the rode-based (scotopic), and the ipRGC-based (circadian) photoreceptors.

METHODOLOY

In the first phase of the project, an extensive literature review has been done in order to define a suitable approach for tackling the given challenge of developing a new model capable of taking current (and emerging) knowledge on the non-visual effects of light into account. During the pro-cess, properties of healthy light will be identified and methods will be developed to quantify these properties. In parallel, the relation between light properties/environmental cues and the performance indica-tors on one hand and the light properties/ environmental cues and building design parameters on the other hand will be studied. Demonstrated relationships in Figure 2 are intended to be taken into account in the model. To validate the model, controlled laboratory studies for selected con-texts will be performed. Finally, the validated model will be applied in a case study.

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Building Materials

Stepan Lorencik

Photocatalysis Research

INTRODUCTION

My name is Stepan Lorencik, I come from the Czech Republic and I'm a fourth year PhD at the building materials group of Prof.dr.ir H.J.H. (Jos) Brouwers. After my master study focusing on building materials at Brno University Technology (in the Czech Republic) and a trainee program in one of the world largest cement producers (GCC) located in Switzerland, I got a chance to broaden my knowledge of building materials by doing a PhD here in Eindhoven.

My project titled "Indoor Air Purification Using Functional Wall Covering" is dealing with application of photocatalytic oxidation in building materials. As the title says, the main aim is to use it in wall covering, but numerous applications are studied by me, or by my colleagues at the moment, with very promising results. I will briefly talk about the past and present photocatalysis research in our group, but first I will speak briefly something about this technology.

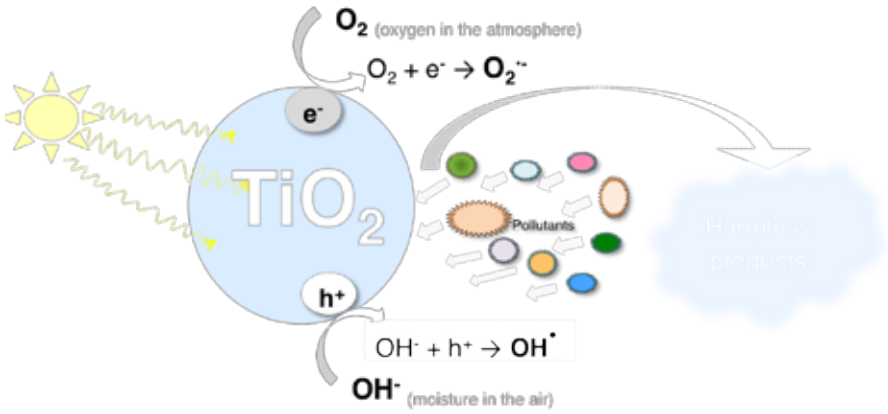

Figure 1: Photocatalysis scheme

PHOTOCATALYTIC OXIDATION

Photocatalytic oxidation (PCO) technology is considered as one of the potentially very efficient advanced oxidation processes for the improvement of the air quality by degrading inorganic and organic air pollutants without any energy or maintenance needs. Photocatalytic oxidation is not only studied for the air improvement, but also for the water purification or for self-cleaning applications.

The most commonly used photocatalyst, titanium dioxide (TiO2), has received considerable attention in the past decade due to its high PCO activity, high chemical stability, low toxicity and low cost. Under the appropriate irradiation of photon energy, electron-hole (e-/h+) pairs are generated on the TiO2. The photo-generated holes in the valence band and the electrons in the conduction band diffuse to the TiO2 surface and they produce highly energetic hydroxyl radicals (OH•) and super-oxide radical anions (O2•-), by the reaction with H2O and O2 from the environment, which can oxidise the adsorbed pollutants on the TiO2 surface.

PHOTOCATALYTIC RESEARCH IN OUR GROUP

Our building materials group, under the supervision of Prof.dr.ir. Jos Brouwers, is working on many projects linked between each other and in close cooperation with industry. I will only introduce those, which dealt, or are dealing with photocatalysis. Let me start with two former PhDs and one postdoctoral researcher who laid the foundations of PCO application in our group. Dr. Götz Hüzken and Dr. Martin Hunger started with an application of photocatalytic TiO2 as an additive in concrete and Dr. Milagros Ballari focused her postdoctoral research on the preparation and application of photocatalytic pavement, resulting in real outdoor measurements in Hengelo (The Netherlands).

Their research was followed by Dr. Qingliang Yu (currently assistant professor in our group) by application of photocatalysis in gypsum-cement boards and together with Dr. Przemek Spiesz by application in a light-weight and translucent concrete. One of the ongoing research projects, handled by PhD candidate Ir. Guillaume Doudart de la Grée, is looking into the application of photocatalysis in wood-cement boards.

Our group dealt with the application of photocatalytic TiO2 as an additive in concrete, light-weight concrete, translucent concrete, in pavement, gypsum-cement boards and wood-cement boards. All these were tested under the laboratory conditions, and some under the real outdoor conditions, for the degradation of very common outdoor air pollutant - Nitric oxide (NO).

In addition to the material development research, our group is also dealing with the modelling (kinetic and numerical) of the photocatalytic processes in order to better explain and predict possible benefits coming from the application of the developed photocatalytic materials under various lightning or air flow conditions. This can lead to better utilisation lighting or reduction of ventilation needs (also studied at our unit: Building Lighting and Building Services). Modelling research was done in the past by Dr. Milagros Ballari, Dr. Qingliang Yu and by two former master students Hector Cubillos Sanabria M.Sc. and Ir. Ruben Pelzers.

What was left for me? (One might ask).

MY PROJECT

My work is aiming at the improvement of indoor air quality. The goal of my project is to apply photocatalytic TiO2 into water-based coating for the indoor wallpaper application and to evaluate it for the degradation of nitric oxide, but also for the degradation of volatile organic compounds (VOCs) on the laboratory scale.

The application of photocatalytic materials in organic materials have, however, several issues to be solved. One of the main challenges is that the photocatalytic materials are degrading the organic binder of the coating, resulting in the loss of durability and reduction of the products lifetime.

My approach is the application of nano-silica, coated under various ratios onto the TiO2. This results in protection of the organic binder and at the same time maintaining certain photocatalytic activity.

How do I test the photocatalytic activity towards the degradation of air pollutants? I have available complex photocatalytic experimental set-up in our laboratory (see the scheme in Figure 1). With this set-up I'm able to measure real time concentration of NO by NOx analyser and I can very precisely measure extremely low (ppt) concentrations of VOCs by gas chromatograph/mass spectrometer couple with automated thermal desorption system (ATD-GC/MS). The final "mineralisation" product of a photocatalytic degradation of VOCs - CO2 - is measured by gas chromatograph coupled with photo-ionisation detector (GC-PDHID). Two type of reactors are used: plug flow and continuously stirred batch/flow reactor.

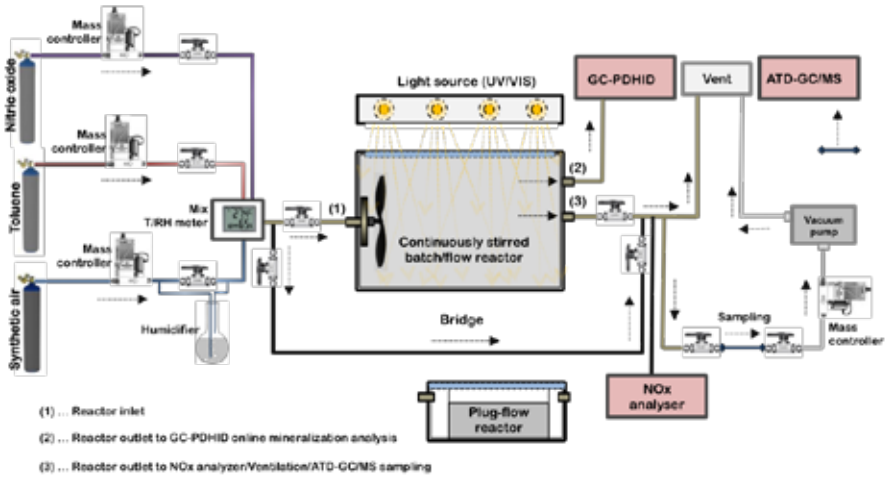

Figure 3: RPhotocatalytic experimental setup

The current results of my work show that the PCO efficiency of the coating indeed depends on the nano-silica modification, on the dosage of the applied coating, on the pollutant concentration, light intensity and the applied flow rate of the gas mixture. The preliminary NOx degradation results of relatively durable water-based coating protected against the photocatalytic influence of the incorporated carbon-doped titanium dioxide (visible light responsive), show around 15% of NOx degradation under plug-flow experimental conditions. This work will continue with the testing of the developed coating under mixed conditions and hopefully it will be tested under real indoor conditions with even better results.

ir. S.(Stepan) Lorencik
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Unit Building Physics and Services
Department of the Built Environment
Eindhoven University of Technology

Stichting
Promotie
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(PIT)

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

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

Building Performance

Pieter-Jan Hoes

Performance prediction of lightweight low-energy houses with hybrid adaptable thermal storage

INTRODUCTION

This article gives an overview of my PhD research and describes some of the results. The main objective of this research is to identify if the so-called hybrid adaptable thermal energy storage (HATS) approach shows potential to reduce the energy demand of new lightweight residential buildings in the Netherlands and maintain or improve thermal comfort. This HATS approach combines the thermophysical benefits of low and high thermal mass buildings by adapting (on demand) to the most optimal thermal capacity. This research is based on computational building performance simulation, i.e. using 'virtual buildings'. A significant part of this research consists of defining an assessment methodology and developing a virtual test environment which can be used to study the performance of HATS concepts.

HYBRID ADAPTABLE THERMAL STORAGE CONCEPTS

A literature review is performed to get an overview of existing thermal energy storage methods that can be used in HATS concepts. Furthermore, it discusses how thermal energy storage methods can be used adaptable or made adaptable. Various adaptation approaches are identified and an overview of adaptation mechanisms is presented. Based on these findings, various promising HATS concepts are defined. The performance of the following concepts is investigated in detail using simulation models:

- Concept 1: Lightweight wall and ceiling constructions with PCMs (passive).
- Concept 2: High thermal storage wall with variable emissivity and absorptivity coating (passive).
- Concept 3: High thermal storage wall with dynamic insulation or movable insulation (active).

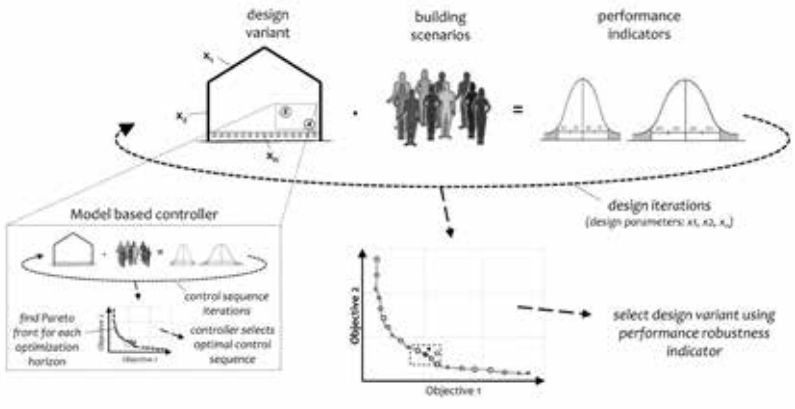

Figure 1 Schematic overview of the performance assessment methodology for HATS concepts. The design optimization process consists of multiple design iterations (variations on the design parameters x1, x2, xn) taking into account various building scenarios; after the Pareto front is found, the decision maker can select a design variant using a performance robustness indicator. During the design optimization process, the active HATS concepts are operated by a model based controller; the controller uses sensors (S) and actuators (A). For each optimization horizon, the controller searches for the Pareto front taking into account disturbances, e.g. caused by occupant behavior and weather predictions. The controller selects the most robust performing control sequence based on predefined goals (minimize energy demand, minimize discomfort or use a trade-off solution).

PERFORMANCE ASSESSMENT METHODOLOGY

A performance assessment methodology is proposed to assess the performance of the promising HATS concepts. Since the predicted performance of each concept depends on the values of certain design parameters, it is necessary to include a design optimization method in the performance assessment methodology. Therefore a design optimization method is proposed which assesses the robustness of the design solutions to variations in building scenarios. The method selects the most robust performing design solution in a certain region of the Pareto front (curve with trade-off solutions). Since the performance of active operated HATS concepts depends on their control strategy, it is necessary to include appropriate control strategies in the design optimization method. Based on literature review it is found that model based control is the appropriate strategy for the HATS concepts. The robustness assessment method for design optimization is also used in the model based controller to search for robust performing control sequences. Based on the performance assessment methodology, a virtual test environment for design and operation of HATS concepts is developed. The virtual test environment is based on the coupling of existing building simulation software (ESP-r) with software that can be used for design optimization and operation (Matlab). The coupling of both programs is facilitated by the middleware BCVTB. For this purpose, new subroutines are developed for ESP-r. Although the performance assessment methodology and the virtual test environment are developed for HATS concepts, both can be used for a wide range of other building concepts.

PREDICTED PERFORMANCE OF PROMISING HATS CONCEPTS

The virtual test environment is used to assess the performance of the three HATS concepts. The performance of each concept is compared to the performance of a lightweight (low thermal mass) and a heavyweight (high thermal mass) variant of the same reference building; both variants are identical except for the wall, floor and ceiling constructions. The three HATS concepts are all applied to the lightweight reference building. Below follows a short description of the three investigated concepts:

- Concept 1: PCM is used to increase the storage capacity of the wall and ceiling constructions. Three PCM design approaches are studied: one melting temperature for both zones, unique melting temperatures per zone and two melting temperatures per zone. Figure 2 shows the results; the dots represent unique (Pareto optimal) PCM designs with variations in the melting temperatures.

- Concept 2: The storage capacity of the walls is increased by replacing the gypsum board constructions with heavyweight wall constructions (concrete or water walls). Two (fictive) coatings are studied: a coating that changes its solar absorptivity (near-infrared radiation with wavelengths of 0.75 to 1.4 μm), and a coating that changes its long-wave emissivity (infrared radiation with wavelengths of 8 to 15 μm). Figure 2 shows the results; the dots represent unique designs with variations in the switching temperatures.

- Concept 3: Three walls in each room are replaced with a storage wall (concrete or water wall) coupled to an interface construction of dynamic thermal insulation and a coated metal sheet. The dynamic insulation can be an adaptation mechanisms based on conduction, e.g. thermodiodes, smart insulation or switchable insulation. Figure 2 shows the results; the dots represent different optimized controller strategies.

The results show that the third concept is Pareto dominant over the other concepts regarding the investigated performance indicators. Compared to the heavyweight reference case, the heating energy demand is reduced by 28%, while the total number of discomfort hours is increased by 13 wPPDh. These discomfort hours are distributed differently over the year; the heavyweight reference case shows discomfort mainly during the winter period, while the HATS concept shows discomfort during the summer period. Compared to the lightweight reference case, the heating energy demand is reduced with 26% and the weighted discomfort hours are reduced by 241 wPPDh; the heating energy demand reduction compared to the reference case is caused by the lower effective thermal capacity of the zones when the wall is decoupled (only the thermal capacity of the metal sheets is available when decoupled). In general, the three HATS concepts show potential to reduce the heating energy demand and increase thermal comfort.

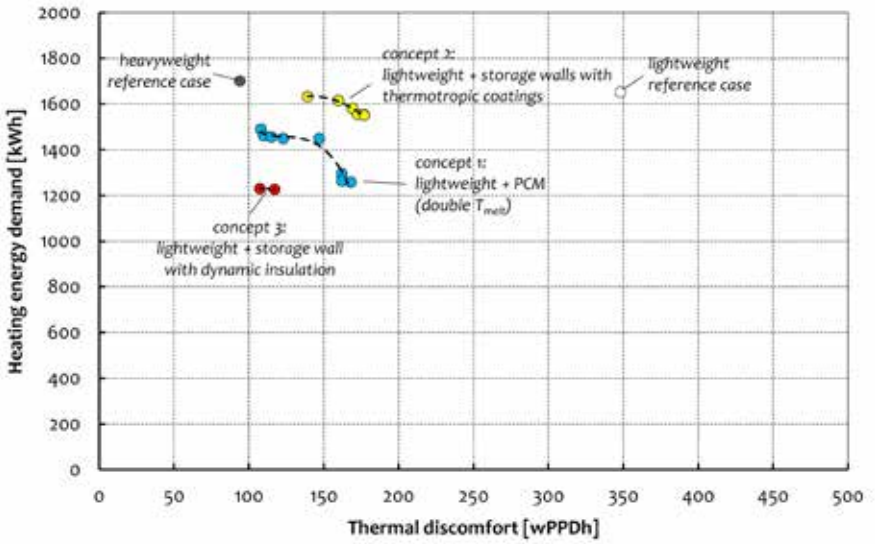

Figure 2 Pareto front of optimized HATS concepts (1 and 2) and of optimized HATS control strategy (concept 3) compared to the reference cases. Scenario: evening occupancy, internal gains 4 W/m², ventilation rate 1.2 ACH.

CONCLUSIONS AND FUTURE RESEARCH

This research shows that the HATS approach is able to reduce the heating energy demand, while improving thermal comfort compared to the lightweight reference case. However, the potential energy demand reduction of the HATS approach depends on the building scenario (occupant scenario and climate). For example, the occupancy pattern has a strong influence on the potential of adaptable thermal storage. In general, buildings which are used intermittently or during short periods benefit from adaptable thermal storage. Examples of such buildings are residential houses with people working during the day or hotel rooms. However, buildings which are used during long and constant periods benefit less from adaptable thermal storage. The potential energy demand reduction depends on the possibility of charging and discharging the storage material during the day, which is strongly influenced by the climate; the HATS concepts are more effective in climates with moderate or large temperature differences during the day (like the Dutch climate), than in climates with small temperature differences.

This research also shows that the HATS approach is able to reduce the heating energy demand compared to the heavyweight reference case, while showing almost the same level of thermal comfort.

In the future, the combination of HATS concepts with climate adaptive building shells (CABS) will be investigated. CABS are facades that are able to adapt to their environment. Combining HATS and CABS might improve building performance significantly. Furthermore, the possibilities of using active HATS concepts in demand side management (DSM) strategies will be investigated. DSM strategies are used to change the shape of the load on the electricity grid in order to optimize the whole electricity system. This becomes important in order to avoid grid instability when more non-dispatchable energy sources (wind, solar) are used to generate electricity and supply electricity to the grid.

Building Acoustics

Remy Wenmaekers

Stage Acoustics for Dummy's

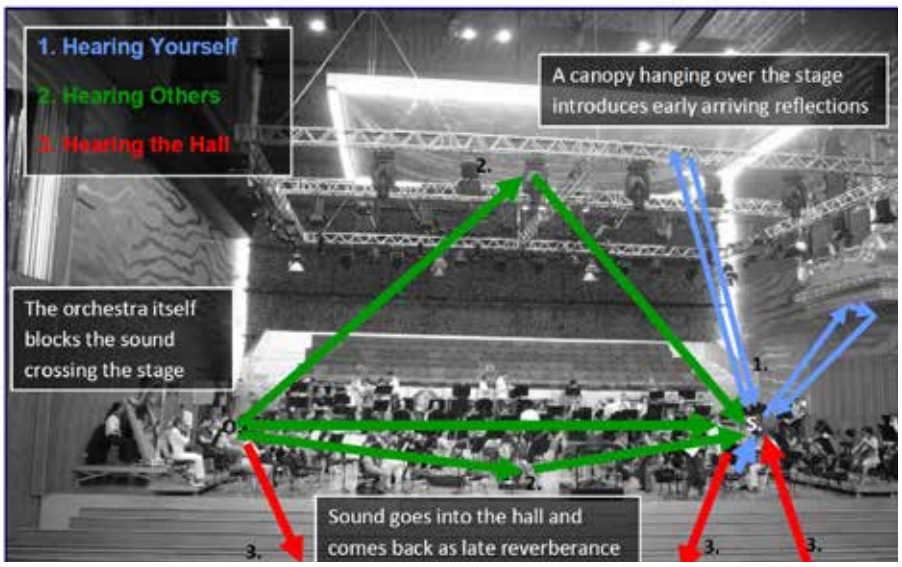

Figure 1 Sound paths on stage

Figure 2 Stage acoustics measurements

STAGE ACOUSTICS FOR DUMMY'S

Eighty dressed up mannequins act as musicians in a research on acoustics. Normally, in concert hall acoustics, the audience is in the centre of attention. This time, the experience of the musicians themselves is investigated. This is important for playing ensemble, and moreover, for the musicians' health; many professional musicians suffer hearing damage. The researchers of Eindhoven University of Technology and Level Acoustics have already taken their dummy orchestra to the Muziekgebouw Eindhoven and the Parktheater Eindhoven will also be visiting the Nationale Opera & Ballet Amsterdam. The aim of the study is to find new guidelines and methods to design concert stages.

STAGE ACOUSTICS

Designing excellent stage environments in concert halls and theatres is an acoustic challenge. For centuries, acousticians have been focusing on the acoustics in the concert hall from an audience point of view. The past three decades, also the importance of acoustic comfort for musicians on the stage is recognized. This subject is referred to as stage acoustics. For musicians three auditory factors are important on stage: (1) the hearing of yourself, (2) the hearing of fellow musicians, and (3) the hearing of the hall. An example of important sound paths on a concert hall stage concerned with these three factors is illustrated in figure 1. The musician 'S' sitting on the right side of the stage, is hearing himself directly by the sound path from the instrument to his ears. And, sound is send upwards towards the canopy and organ to be reflected back to him. All these sound paths help musician 'S' to hear himself. Another musician 'O' is sitting on the left side of the stage. His sound is also travelling directly to his colleague 'S', but the sound has to pass through the orchestra, that itself blocks the sound..

To compensate for this blocking, sound is also send over the orchestra via a canopy reflection. The reflection helps musician 'S' to hear musician 'O'. The musicians' sound is not only reflected via the stage boundaries, but is also send into the audience area of the hall. Some sound will arrive back to the stage as reverberant sound, see the red arrows in the figure.

MUSIC AND HEALTH

Good stage acoustics is not only important for the orchestra to easily play together. It might also contribute to avoid hearing damage caused by excessively high sound pressure levels. To reduce the noise exposure, measures have been proposed like the introduction of screens and risers within the orchestra or even ear plugs. One of our studies (Wenmaekers et al. 2012a) showed the importance of the stage environment on the occurring noise exposure. In this study, differences up to 3 dB (a doubling of the sound energy) were found between two different stage acoustic environments. This shows that good stage acoustics is important from a musical as well as a health point of view.

DESIGNING THE STAGE

The early reflections that arrive within a short time delay will contribute to hearing yourself and others on stage to be able to play together properly. Late reflected sound is important for a sense of reverberation and to control what the audience is hearing. For achieving a proper stage acoustics, it is the challenge to design architectural elements that provide a good balance between direct sound and reflected sound. But how do we know when this balance it optimal? How can we judge the acoustics on stage? Asking musicians about their opinion is one approach. But, to be able to design a concert hall stage, we need physical measures that can predict the quality of the acoustics. In our studies at TU/e, we are focusing on improving the available physical measures and optimizing measurement methods (see figure 2).

DUMMY ORCHESTRA

The transfer of sound can be measured by recording impulse responses, providing detailed information about the direct and reflected sound that arrives as a function of time (see Wenmaekers et al. 2012b for lots of background info). However, during such a measurement, the stage is usually either empty or only occupied by empty chairs. The musicians themselves might be having a large influence on the measured acoustics and, for the first time, this effect is being investigated. Because the measurements take many days, we cannot ask real people to sit still and be quiet, while we do measurements. The solution is to use an orchestra of eighty dummy's to substitute the musicians. Last summer, we have performed measurements on stage of the Muziekgebouw Eindhoven (figure 3) and the Parktheater Eindhoven (figure 4). Later this year, we will also be visiting the Nationale Opera & Ballet Amsterdam to investigate the orchestra pit. After that, a tedious job awaits us: almost 10.000 impulse responses to analyze!

Figure 3 Dummy orchestra on the stage of Muziekgebouw Eindhoven

Figure 4 Dummy orchestra on the stage of Parktheater Eindhoven

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more info on:
www.acoustics-built-environment.nl

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Michal Vesely

Fingertip temperature as a control signal for personalized heating

INTRODUCTION

The building industry nowadays is facing two major challenges – an increased concern for energy consumption and a need for comfort improvement. These challenges led many researchers to develop a personalized conditioning system. Personalized conditioning climatizes only a small space around a single person. This makes it possible to satisfy different needs of every individual and to reduce energy consumption due to higher effectiveness. Different personalized conditioning systems have been introduced, including personalized ventilation [1], local floor heating [2], or a combination of personalized ventilation with local convective and radiant heating [3,4]. However, these systems are still controlled only by user interaction, which can lead to problems such as lower thermal comfort due to rebound or overshoot or loss of effectiveness due to incorrect use of the system. Therefore, it is needed to seek for methods that can help to automate the control process of personalized conditioning.

An effective automatic control of personalized conditioning first requires a parameter, which is related to comfort and convenient to measure in an office environment. Wang et al. [5] showed that the fingertip temperature is related to a risk of cold discomfort. They identified a clear threshold of fingertip temperature of 30 °C, above which no risk of cold discomfort occurred. This implies a possible use of fingertip temperature as a control signal for personalized heating. Wang et al. measured in their experiments the skin temperature by thermocouples attached directly to the body. However, for practical application it is necessary to measure the skin temperature in a way that does not hinder an overall comfort of the users. Since the hands are in an office usually directly exposed to the environment, it is possible to measure the fingertip temperature by an infrared thermography.

This paper presents a correlation of thermal comfort with fingertip temperature as measured by infrared thermography. Furthermore, the possibilities of using fingertip temperature as a control signal for personalized heating are discussed.

METHODS

In order to test a feasibility of using a remotely sensed fingertip temperature as control signal for personalized heating a human subject experiment was set up in the climate chamber at TU/e.

Six subjects (five male and one female) performed a normal office work. The workplace was equipped with a laptop with external monitor, keyboard and mouse. The subjects were exposed for two hours to a uniform thermal environment with operative temperature of 18 °C. The conditions were designed as slightly cool to cool (predicted mean vote of -2 to -1).

Every fifteen minutes the test subjects were filling a questionnaire regarding their overall and local thermal comfort and sensation. Beside of that their fingertip temperature was remotely measured by a thermocamera Flir ThermaCAM S65HS placed above the desk.

For the finger tracking we developed an algorithm based on pattern matching in LabVIEW [6]. Figure 1 shows an example of pattern matching in a static image – after a pattern is taken the algorithm finds similar areas in the whole image.

The pattern matching algorithm for real time finger tracking works in following steps:
1. The finger templates are searched for.
2. The matched patterns are sorted by maximum temperature in each match.
3. The matched pattern with the highest maximum temperature is chosen as the correct match of fingertip and the algorithm returns this temperature. This step is based on assumption that the background of an infrared image is colder than the fingertip.

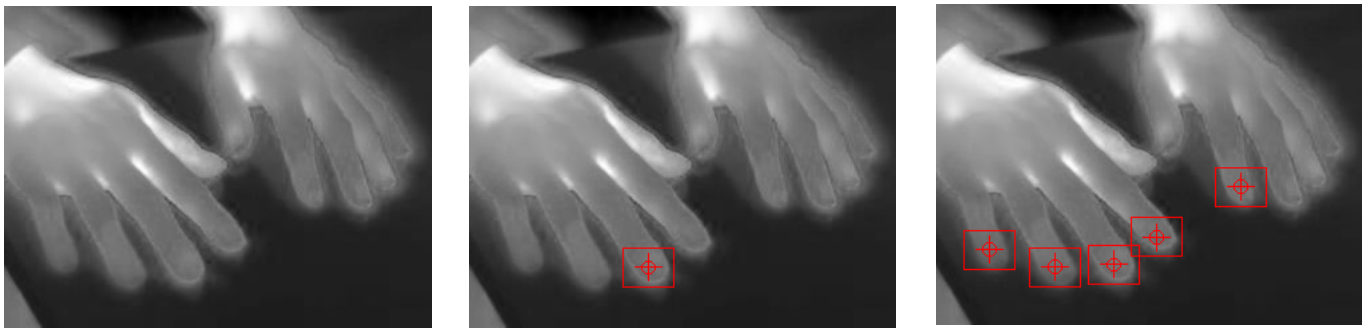

Figure 1 Pattern matching in a static image (from left: source image, marked pattern, matched patterns)

4. In case of no matched pattern the algorithm returns default temperature of 30 °C.
5. The fingertip temperature is averaged of last 12 values (moving average). This is done to lower the fluctuations of measured value in case of false detections.

The infrared images were also post processed in order to check the reliability of the tracking algorithm. The post processed values were carefully read from the infrared images with 15 minutes interval (same as the questionnaire interval).

RESULTS & DISCUSSION

Figure 2 presents a comparison of the fingertip temperature as measured by the tracking algorithm and post processed for one test subject. The fingertip temperature as measured by the tracking follows the post processed temperature within ± 2 °C until the fingertip drops under 30 °C. Similar trend was observed for all the test subjects. It was also observed that, when the temperature continues dropping, the number of false or no detection greatly increases and the tracking algorithm cannot reasonably follow the fingers anymore. This is caused by the loss of contrast in the image because the fingertip temperature is getting closer to the temperature of background. Since the tracking algorithm is not reliable in the whole range of measured temperatures, we used the post processed temperature values for the following analysis.

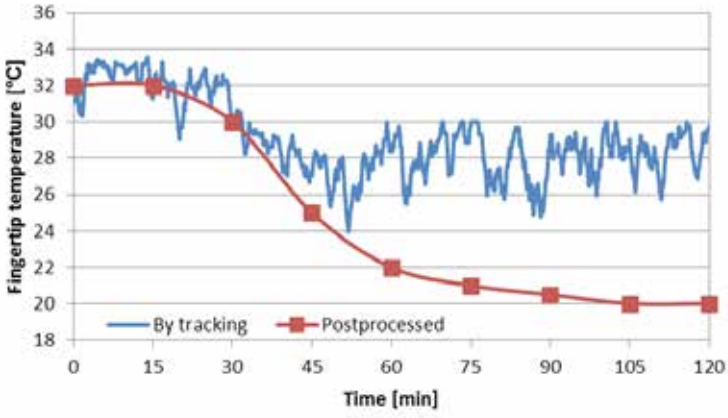

Figure 2 Fingertip temperature as measured by tracking algorithm and post processed (one test subject)

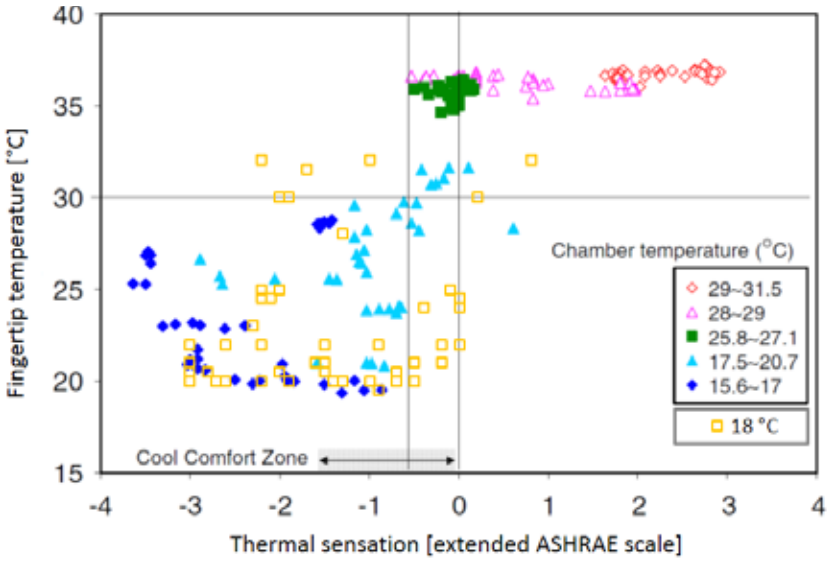

Figure 3 Comparison of our study with the study of Wang et al. [5], our data are represented by yellow empty squares

Thermal sensation correlates with fingertip temperature with R2 value of 0.93. Thermal sensation can thus be reasonably predicted by fingertip temperature under assumptions of our study (mild cool thermal conditions). This is in a line with the study of Wang et al. [5]. A comparison of our results with this study is shown in Figure 3. Although Wang et al. used a slightly different thermal sensation scale (ASHRAE scale extended to 9-point scale) and different measuring technic, the data of both studies show a good agreement. The data points that represent a risk of cold discomfort cluster mostly under the fingertip temperature of 30 °C and thermal sensation under neutral.

CONCLUSIONS

The results presented in this paper show that there is a good correlation of fingertip temperature and thermal comfort under mild cool conditions. Since it is possible to measure the fingertip temperature remotely by infrared thermography, it can become a good control signal for personalized heating.

LIMITATIONS AND FUTURE RESEARCH

The number of test subjects in our experiments was generally low and one test subject was a female. In order to have a stronger basis of results it is planned to involve more test subjects in further. It is particularly important to involve more female since the women are generally more critical about thermal comfort, especially in cool conditions [7].

For practical application of the fingertip temperature as a control signal for personalized heating it is necessary to track the fingers in real time. The finger tracking algorithm as presented in this paper was able to track the fingers as long as the fingertip temperature was above 30 °C and the background has a normal indoor temperature. This might be often not the case, for instance, when using a hand heating mat. Further research on reliable tracking method of the fingers is thus needed.

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A graduation project in a wind tunnel in Switzerland

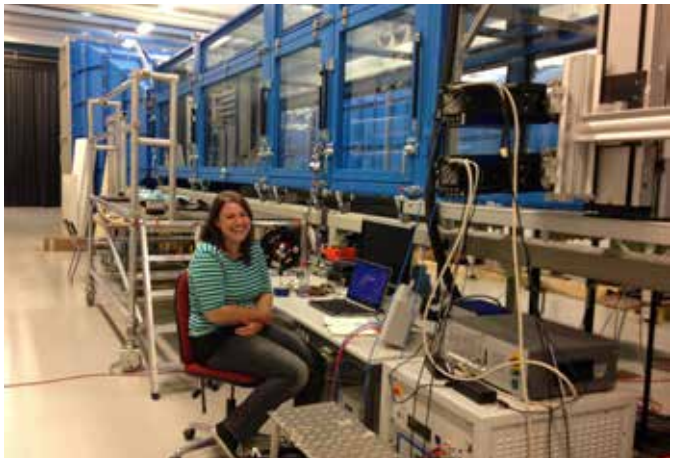
Sigrid Scheijen

When I started the bachelor Bouwkunde at the TU/e, I knew I wanted to graduate at Building Physics and Services in the chair Building Acoustics. During the bachelor and master I learned about wind flows and wind tunnels. For my graduation project I wanted to combine acoustics and wind flows. So when my supervisor asked me in December 2013 if I wanted to do a graduation project at Empa in Dübendorf (Zürich, Switzerland) in a wind tunnel, of course I said yes. The project is about the wind effect on the shielding of traffic noise by buildings.

Preparations for my stay in Switzerland are mainly taken care of by Empa (like an accommodation, compensation for my stay (there is no scholarship between the TU/e and the ETH)). The accommodation where I stayed are apartments of Empa itself. Those apartments consist of four bedrooms (you are sharing the apartment with three/four other people), a kitchen and two bathrooms and a cleaning room. The apartment is cleaned once a week and the rooms are furnished. Some matters that I still had to arrange myself where signing-up at the local authority and arranging a bank account. Also a health care insurance is in Switzerland very important. Switzerland is an expensive, but beautiful country and Zürich is a nice place to visit.

On May 5th, 2014 I went to Zürich. The first part of my stay mainly consisted of doing tests to see if everything was possible and feasible. I've done some test measurements in a semi-anechoic room and also some measurements in the wind tunnel. Soon it became clear the research had to be adapted. Of course there were some other problems, like defect and not good working equipment. The final part of the experiments consisted of acoustical measurements in the wind tunnel and Particle Image Velocimetry (PIV) measurements (measurements to determine the flow field). I came back to the Netherlands on September 30th. It was a great experience to work in a research facility and to be able to do experiments in a wind tunnel.

At the moment I am busy analyzing the measurement data and writing my thesis. The planning is to finish my graduation project in January 2015.



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NUMERICAL STUDY ON THE ENERGY PERFORMANCE OF THE STRATA TOWER IN LONDON.

Karin Kompatscher

Supervisors
Prof. dr. ir. B.J.E. Blocken
Dr. ir. T.A.J. van Hooff
Ir. A. Khayrullina
Ir. A. Pizzoferrato

"The first building in the world with cladding-enclosed wind turbines, it sets a new benchmark in terms of environmental strategy."

Robert Torday, BFLS

INTRODUCTION

The European Commission (2010) has set three targets for reducing greenhouse gas emissions, raising the share of EU energy consumption produced from renewable energy sources and improving the EU's energy efficiency. These targets have all been set at 20% by 2020.

- 20% greenhouse gas emission reduction.
- 20% share of renewable energy sources.
- 20% improvement in energy efficiency.

The European Renewable Energy Council (2011) provides a renewable energy sources roadmap available for every European country. According to this roadmap the National Renewable Energy National Plans (NREAPs) has an electricity share of one third generated by renewable energy sources. A large part will be contributed by wind energy. Around 14% will be generated by onshore and offshore wind energy by 2020 (Figure 1).

This research focuses in particular on wind energy production in high-rise buildings. Yuen et al. (2004) performed a study on the efficiency of a vertical wind farm in the built environment. They concluded that renewable energy can be generated in every city and every building. Wind turbines integrated in high-rise buildings are able to give a promising energy yield.

Aside from the benefits mentioned in the study of Yuen et al. (2004), a few remarks need to be made. Integrating the wind turbines into the building or mounting them on top of the building results in critical conditions such as resonance occurring due to the structure and forces on the wind turbine. Aside from this, mechanical and electrical integration is often costly and difficult.

The geometry of a building plays a significant role in the energy yield. For instance, the roof shape has a large impact on the wind flow around and over the roof. Abohela et al. (2013) provides an overview of different roof types of high-rise buildings and their advantages and disadvantages for wind turbines installed on the roof. They conclude that different roof shapes can lead to an increase in energy yield of 56.1%.

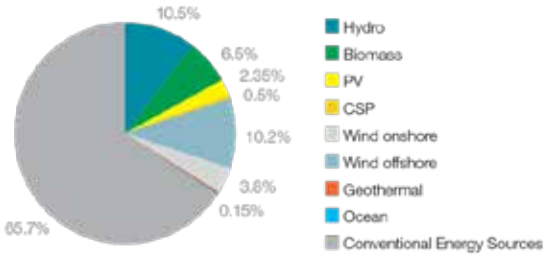

Figure 1. Renewable energy sources in the electricity mix in 2020 (European renewable energy council, 2011)

Campbell and Stankovic (2001) integrated wind turbines in basic high-rise building designs and performed wind tunnel tests with models of these designs. Their research shows an increase in energy yield if a wind turbine is mounted between two buildings at a certain height.

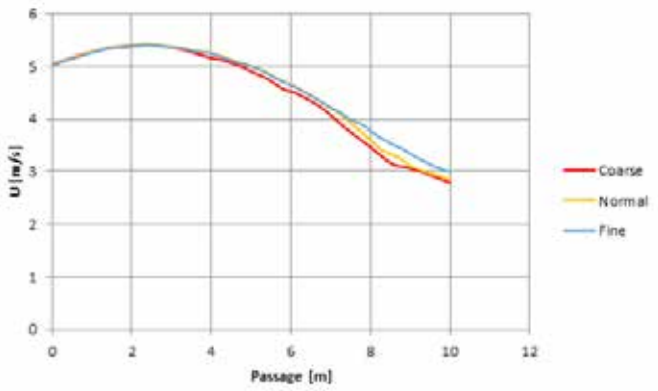

Figure 2. Wind speed through center passage along wind turbine axis for coarse, normal and fine grid.

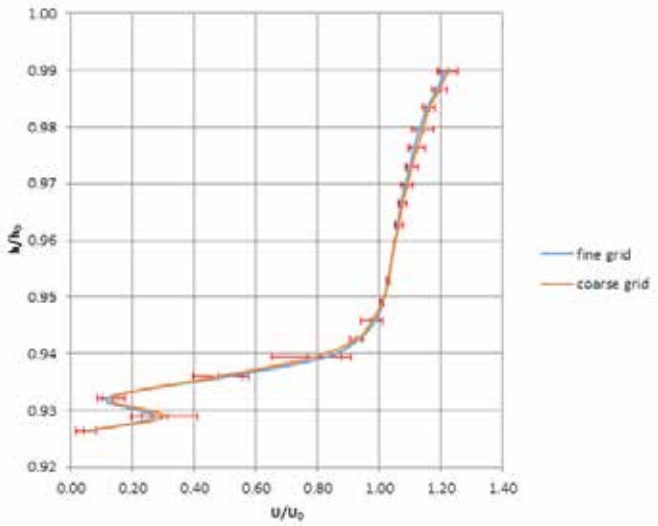

Figure 3. Wind speed amplification factors along vertical center line h in center passage. Error bars indicate Grid Convergence Index.

Case

BFLS architects accepted the challenge to design a high-rise building with integrated wind turbines. The Strata tower is the first residential tower with three integrated wind turbines. The 148 meters tall building provides 408 residential apartments suitable for one thousand residents. The energy harvesting from the three wind turbines installed in the roof should be able to provide 8% of the total energy consumption of the Strata tower.

The building was completed in 2010 after three years of construction. Aside from the designing and construction, several pre-planning assessments were done on the wind turbines and the geometry of the building. The studies (BDSP Partnership, 2005; Rambøll, 2006; RWDI Consulting Engineers, 2007) have been performed prior to the construction of the residence.

Although the earlier conducted researches (Rambøll Danmark A/S (2006), RWDI Consulting Engineers (2007)) conclude that it is feasible to integrate three wind turbines in the roof shape of the Strata tower, it is stated that the wind turbines are not operating. This triggered this research on possible design solutions for the Strata tower improving the wind turbines performance.

Method

During this research Computational Fluid Dynamics (CFD) was used as a method to investigate the amplification of wind speed and the behavior of the wind flows in the vicinity of the wind turbines. Information from previous research was used to validate the model. The information provided by BDSP Partnership (2005), Rambøll Danmark A/S (2006), and RWDI Consulting Engineers (2007) was limited and little data could be used for the model set-up. A validation study was performed with the available information in the previous mentioned research. After the validation of the model different design improvements were made on the shape of the cladding enclosing of the wind turbines.

Table 1. Wind speed amplification factor at the center of wind turbine from Danmark A/S (2006) and CFD model applied in this research.

Rambøll (2006)	Hole 1	Hole 2	Hole 3
	1.14	1.25	1.14
Basic 1:180 SST k - ω	Hole 1	Hole 2	Hole 3
centre U_{rel} [-]	1.09	1.00	1.10

Figure 4. Configurations (from left to right): basic, nozzle, diffuser.

VALIDATION STUDY

The boundary conditions of the model are described in Table 2. The calculation grid of the model needs to be analyzed in a grid-sensitivity analysis. A complex geometry requires a large amount of calculation cells that results in a long computational calculation time. If the grid-sensitivity analysis concludes that a coarser grid is as accurate as a fine grid, the coarse grid can be used to decrease the calculation time. During this research three grids –coarse, normal, and fine (4.3 million, 3 million and 2.3 million cells respectively) - were used and compared to each other. The normal grid showed a large similarity to the fine grid and was chosen to continue with (Figure 2, Figure 3).

Table 2. Boundary conditions and computational setting used in CFD model

Characteristics and settings			
	Coarse	Normal	Fine
Computational domain			
Model scale	1:180		
H [m]	5		
W [m]	8.3		
D [m]	16.7		
Mesh domain	structured		
# cells (* million)	2.3	3	4.3
Building geometry			
H [m]	0.822		
W [m]	0.172		
D [m]	0.2		
Mesh building	unstructured		
Turbulence model			
Model	SST k-ω		
Near-wall treatment	Standard wall functions		

Characteristics and settings			
	Coarse	Normal	Fine
Boundary conditions			
Wall functions			
Type	Symmetry		
Inlet and outlet			
Type inlet	Velocity inlet		
Type outlet	Pressure outlet		
Ground surface			
Type	Wall		
Roughness height K_s [m]	0.00556		
Roughness constant C_s	5.5		
First cell height Y_p [m]	0.01111		
Solution methods			
Scheme	Simple		
Pressure	Second order		
Density	Sec. Order upwind		
Momentum	Sec. Order upwind		
Turb. Kin. Energy	Sec. Order upwind		
Turb. Dissip. Rate	Sec. Order upwind		

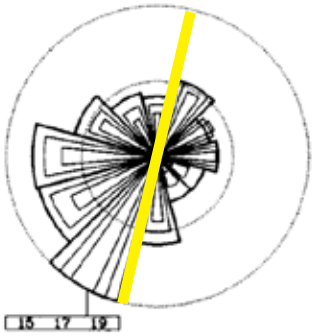

Figure 5. Building orientation (yellow line) and prevailing wind direction (Rambøll Danmark A/S, 2006)

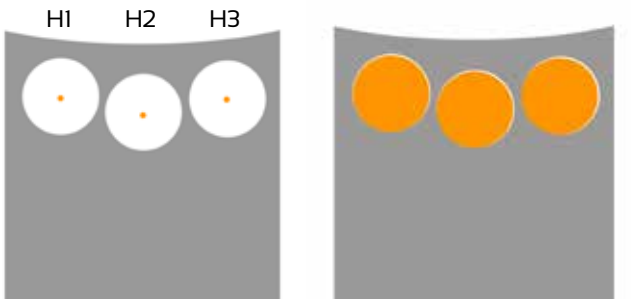

Figure 6. Schematic measurement grids (center point and average on plane).

The SST k-ω turbulence model was applied in ANSYS Fluent with boundary conditions and computational settings described in Table 2. The results of Rambøll Danmark A/S (2006) were described by the wind speed amplification factor in several points in the wind turbine enclosure provided by a wind tunnel test. Table 1 shows the comparison between the results obtained by the Rambøll Danmark A/S (2006) model and the current model. As can be seen there are some significant differences. These differences can be explained by the fact that the wind tunnel, in which the Rambøll Danmark A/S (2006) measurements are performed, has a high blockage ratio. This could cause excessive turbulence in flows around the sides of the Strata tower model.

DESIGN IMPROVEMENTS

The design improvements that have been analyzed are shown in Figure 4. Shrouded wind turbines form the base of these improvements. Kosasih and Tondelli (2012) showed in their research that adding a shroud improves the performance of that particular wind turbine by 60%. Their research also described the optimalization of the length and height of such a shroud that shows multiple solutions. To limit the many possibilities for design improvements, the new configurations need to meet certain requirements. The radius of the current wind turbines is the radius used for the new configurations, the inlet area should remain the same, and the angle $\alpha = 12°$ suggested by Kosasih and Tondelli (2012) should be used.

Besides the changes to the geometry, this research also looked into the orientation of the building. The wind turbines are almost facing north-south orientation. The prevailing wind direction is south-southwest which differs 15° from the centerline of the building (Figure 5).

RESULTS

Figures 7 - 12 show some interesting results. Adding a shrouded wind turbine shows little to no improvement for a wind direction of 0° (perpendicular to the rotor blades) and 15° (parallel to the prevailing wind direction). Changing the direction of the building with 180° shows a significant improvement in the wind speed amplification factor.

A distinction was made between the amplification factor in the center point and over the entire plane (Figure 6). The amplification factor measured as an average over the plane shows more extreme differences in values for the different wind turbine enclosures

CONCLUSIONS

Though it is an ongoing investigation, it is already possible to conclude that the building should be oriented the other way around to gain the highest wind speed amplification in the center passage. To increase the wind speed amplification even further, a nozzle and diffuser can be added. Note that when adding such a diffuser its structure will influence the wind flow in the passages, especially in the central passage, and thus wind turbine performance.

In the upcoming months the influence of the surroundings and location (height) of the wind turbines will be investigated that might deliver more interesting results.

Figure 7. Wind amplification factors for basic configuration of duct for three wind directions (0, 15, and 180 degrees), H1–H3 – see Fig.6

Figure 8. Wind amplification factors for basic configuration of duct for three wind directions (0, 15, and 180 degrees), H1–H3 – see Fig.6

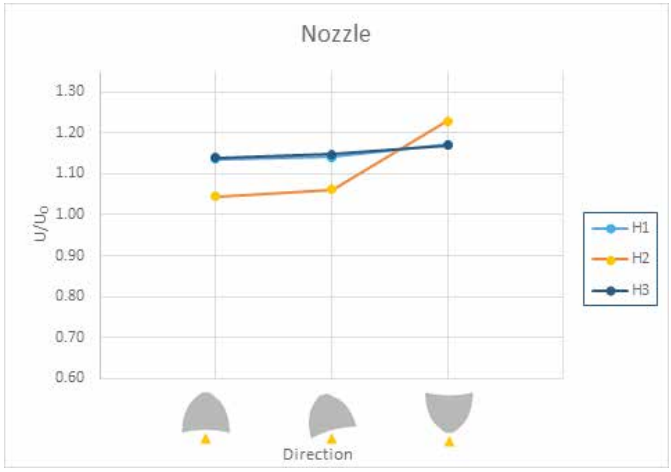

Figure 9. Wind amplification factors for nozzle configuration of duct for three wind directions (0, 15, and 180 degrees), H1—H3 – see Fig.6

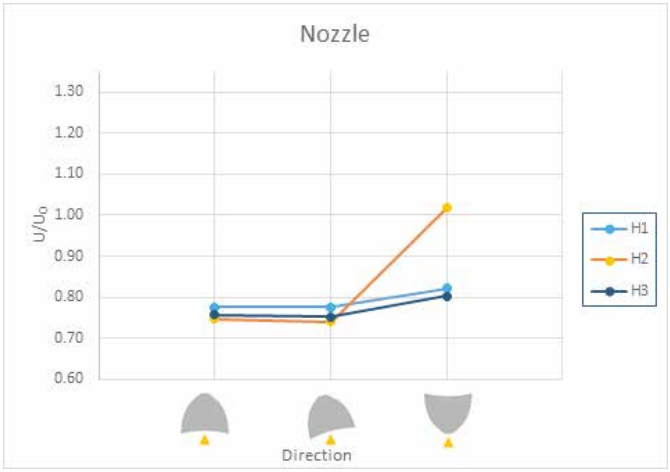

Figure 10. Wind amplification factors for nozzle configuration of duct for three wind directions (0, 15, and 180 degrees), H1—H3 – see Fig.6

Figure 11. Wind amplification factors for diffuser configuration of duct for three wind directions (0, 15, and 180 degrees), H1—H3 – see Fig.6

Figure 12. Wind amplification factors for diffuser configuration of duct for three wind directions (0, 15, and 180 degrees), H1—H3 – see Fig.6

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FOAMGLAS
Building

End Activity

Written by Paul Molenaar

In june a group of 24 Mollier members went on the yearly endactivity. This year's destination was Brûly de Pesche in the Belgian Ardennes. The group arrived around dinner time in a big accommodation were there was room for more than 30 people. After arrival some students started to prepare dinner and some were setting up a large beamer for the football game Holland vs. Spain later that evening. In the evening all students enjoyed the football match, that had an end score of 5-1 for Holland! This was reason enough to party till late in the night.

The next morning, after a slow start the group went water-skiing at a lake nearby. There was a strong wind, which made skiing too cold for some of the students. They preferred sitting at the lake side and laughing at the countless failing attempts of the others. For beginners it was possible to start with a knee-board (instead of a pair of skis). This was easier to learn.

That evening dinner was a huge BBQ, that was provided by our sponsor Foamglas! After the BBQ, with a full stomach, the group started with a quiz. The quiz was made to learn some more about each other. There was one question about every student that joined the end-activity. Rick van Pruissen had won the quiz, therefore he received several fantastic prices.

At night the group was told that we would go to a local pub to get some drinks. However, instead of a warm and cozy pub, a dropping in the forest was planned. Not everyone was happy when they arrived at their drop-of location, when they were told: 'Get out, and walk back home'. During the dropping the group was split up in two separate groups. They both received a hand drawn map with some directions. The shortest way to get home was to go directly straight through the forest. Both groups were back home in around one and a half hour. The night ended with a campfire next to the accommodation.

The next morning it was already time to pack our stuff and drive back home. On our way home we made a stop at the same lake as the day before, however this time to do some laser gaming. Four teams were formed to fight against each other. At the end, the best strategy was to focus on shooting the hidden crocodiles in the game, because they were worth a lot more points than shooting the other students.

After a final drink in the sun the different cars separated and drove back to Eindhoven. It was a successful and fun weekend, in which we all got to know each other a little better.

Career speed date with Wolter&Dros

Written by Bas Peters

In the second week of this academic year members of Mollier were invited by Wolter & Dros to participate in their career speed dates. This event was organized for students who want to do a project, internship of graduation study in cooperation with Wolter & Dros.

After a cup of coffee the students got a tour through 'het Belevingscentrum' where the speed dates are held. On this floor, state-of-the-art techniques in the field of indoor comfort are demonstrated. At some places the technique that is normally invisible was made visible by use of transparent ceiling panels or floor elements.

Everyone had the opportunity to speak to four employees of Wolter & Dros. Every person had its own topics to talk about, in general there were two technical subjects and two subjects focused on your personal motivation and skills.

A cameraman filmed the whole day and a professional promotion video, which can be seen at the Mollier website, was made. After the speed dates, both the students and Wolter & Dros were very enthusiastic and some student decided to do a (graduation) project in collaboration with Wolter & Dros.

FOAMGLAS

Written by Lisette Draaisma

FOAMGLAS® BUILDING

On Thursday the 9th of October we went with a small group of Mollier to FOAMGLAS® Building. At 7:45 AM we were picked up by a coach and brought to the factory of FOAMGLAS® in Tessenderlo, Belgium. First, Peter Verheij, who is Sales Manager of the Dutch department, gave a presentation about the company and the manufacture process. Meanwhile, we were served with coffee, tea, and Belgium treats. After the presentation, we were guided through the factory by Peter Verheij and his Belgium colleague. The tour started at the large oven where glass was melted for the production of FOAMGLAS®. After we went to the part were FOAMGLAS® actually was made. A mixture of carbon and glass went in a mold, this was then heated to a certain temperature. At the end of the assembly line FOAMGLAS® came out as bread shaped blocks. After the baking process, the blocks were assimilated in different shapes and sizes and were packed for transport.

Next stop was the test space for different glue materials. It was shown how to insulate a roof with FOAMGLAS®. The last part of the guided tour was the laboratory where the properties of the insulation material are tested. We were shown tests of the permeability, the compressive strength and fire safety of the insulation, which was quite impressive. Finally, it was time for the bespoken lunch! It exceeded our expectations; champagne as a welcome drink, a neatly covered table, and a three course dinner. As entree we had homemade soup with bread, the main course was a buffet with meat, vegetables and potatoes, and dessert was apple crumble with cream. With our bellies stuffed and goodie bag full of merchandise, we were brought back to Eindhoven. If you feel sad about missing this excursion, don't be; there will be an excursion to FOAMGLAS® building again!

BPS Reunion BBQ

Written by Bart Kok

What started with an idea of the university and s.v.b.p.s. Mollier, became reality on the 4th of October. A barbecue was organized at Scala (Kanaalstraat 6 in Eindhoven) to reunite all the (former) employees, alumni, and students of the master programme Building Physics and Services. Organizing this barbecue was quite a big challenge, mainly because we did not have contact information of all invited people. Therefore, we started searching for their contact information or current job positions. We even called those companies to receive the contact information we required. As a result, 125 persons were present at the barbecue to enjoy the food, drinks and atmosphere.

It was nice to see people meeting againt after so many years. That is also why the most used opening phrase of this evening was: 'you still look the same'. Most of the alumni attendees where graduated in the past 20 years and a smaller number of attendees graduated in the 70's and 80's. We hope, if there will be a next time, that we could welcome more of this latter group as well. At the end of the evening, some people (including alumni and former employees) went to Stratumseind for a few more drinks to end a successful evening. After all, they are still students in their hearts.

Start Activity

Written by Koop-Pieter Ziel

For months the members of Mollier knew when the start activity would take place, but where was the big question. As the date of departure got closer and closer the tension and excitement rise. Finally on the 7th of November 33 enthusiastic members took off for the – until then unknown – destination. With 8 cars the biggest participating group ever in Molliers history took off to... Belgium! The city of Westouter got pleasantly surprised and slightly terrorized by our visit. A small village in the south-west of Belgium close to the French border and between the cities Poperinge and Ieper.

After a 2,5 hour drive the majority of the group arrived around five. Once there the boys got pleasantly surprised as the girls had started cooking diner. After a scrumptious diner the group went out for a scavenger hunt. During this hunt we looked for the treasure of Pierre – the mould ghost – throughout the woods and fields of Heuvellland. The hunt was cold and muddy so many were grateful to return back safely in the monastery. Our accommodation for the weekend or as some quoted "Hotel Mollier".

Finally the party could get started. Although one problem occurred. None of the members thought about the Belgium sockets, which turned out to be slightly different than those in the Netherlands. We all thought... why? So a second hunt started. One for a socket without a big grounding pin in the middle. Luckily there was one in het monastery located at the second floor. This meant that the party could actually start, but at the second floor corridor. Packed together it turned out to be a great party which went on late into the night.

Saturday morning. Some had felt better, but all were present for breakfast. Scrambled eggs with bacon... yummy. With the music still going on in our minds and with a beat box in our heads we went off to the next activity. An activity for which nerves of steel were necessary. Hanging on a lifeline and daring to let go were essential aspects during the activities called high ropes and death ride. If that was not defiant enough for the daredevils among us a swing off the pamper pole was possible as well.

The evening started with dinner. Wraps were on the menu. After diner the majority of the group went off to the city called Ieper. Ieper was just a few kilometres away from the frontline during the first World War and got completely destroyed. At this frontline the first weapons of mass destruction were used. Here the horror of chlorine gas, the flamethrower and mustard gas – also known as Ieperiet – took place. Ieper had become an experimental battle field. Ever since the first World War ended Ieper has held a daily memorial for the fallen. Members of the group attended this memorial, but also walked around through the impressive city centre.

When the people returned from Ieper the long-expected game of Stratego between the boys and girls could take place. Some may have called it a tie, but of course the boys won. Previous to the first night a party ended the day. The music blew the roof off, drinks flowed richly, people got carried out, and some may have had regrets the next day. Ultimately, a great night out with Mollier.

Sunday morning. After breakfast we all cleaned the monastery and went back home to Eindhoven. On the way we stopped for our last activity. A laid back game of miniature golf. We ended with a group picture and thanked the committee for a great weekend.

Kuijpers meeting knowledge-management

Written by Bas Peters

On September 25th, a group of 14 Mollier members went to Zeist for a meeting organized by 'Kuijpers Installaties'. Kuijpers ambition is to build installations from 2018 energy neutral and healthy. First their 'strategy plan' was introduced by an animated video. Then Marjan Minnesma gave an interesting and inspiring presentation about the agenda of her foundation, Urgenda. The title of this agenda is: 'The Netherlands: 100% renewable energy in 2030. It's possible if you want it!'

After these inspiring words a brainstorm session was held about Kuijpers ambition in the foyer. During these sessions the students were appointed as moderators for the discussion groups. After a 45 minute discussion everyone went back to the conference room and the students presented a short quote/one-liner which covered the outcome of the brainstorm session. The day ended with a buffet where the day could be reviewed in an informal setting.

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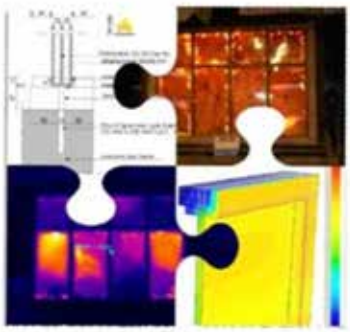

Examples of student research projects:

- Experimental research on fire and response of structures and separation constructions under fire conditions
- Mathematical simulation of fire and response of gasmass, building occupants and constructions
- Probabilistic approach of fire safety objectives in relation to rules and regulations

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THE USE OF COMPUTER SIMULATION MODELS TO EVALUATE THE RISKS OF DAMAGE TO OBJECTS EXPOSED TO VARYING INDOOR CLIMATE CONDITIONS IN THE PAST, PRESENT, AND FUTURE

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SUMMARY
Future climate change might considerably affect vulnerable historic buildings and their collections. In the European project Climate for Culture, we try to assess the risks for valuable historic objects exposed to changing indoor conditions as a result of climate change. Earlier studies have already shown that many historic buildings in Europe may be at risk, in particular due to increased precipitation amounts, but did not yet assess the climate-induced risks to valuable historic art objects. In the present study, a multi-zone hygrothermal building simulation model is used to predict the indoor climate in a characteristic historic building subjected to a varying outdoor climate. This outdoor climate can be constructed from a historical data file (more than 100 years ago), recent meteorological data (less than 50 year ago) or predicted future data from outdoor climate scenarios (for the next 100 years). The simulated indoor climate is coupled with damage functions to predict climate-induced risks for art objects. This paper deals with the modelling approach and shows the potential for damage risk evaluation. The historical, present and future indoor climate conditions in the building have been modelled and the climate-induced risks to art objects have been compared when the building is virtually placed on 468 different locations in Europe. In this way, the vulnerability of historic buildings and their collections to future climate change can be assessed for areas all over Europe.

INTRODUCTION

Future outdoor climate scenarios indicate that the outdoor climate is changing and will continue to do so in the near future. This change in outdoor climate might greatly affect vulnerable historic buildings and their valuable interiors and objects. In the EU project Noah's Ark, the impact of global climate change on built heritage and cultural landscapes was analysed and the results were shown on a wide geographical area centred on Europe (Sabbioni et al., 2010). This project mainly focused on the damage potential of outdoor climate change to historic building facades. The results indicated that historic buildings might be at risk in many areas in Europe due to increased annual precipitation amounts, particularly in Northern Europe, as well as longer periods of consecutive precipitation all over Europe. This affects physical, chemical and biological decay processes of built heritage. It is estimated that the most significant changes will occur in the far future period (2070-2100). The EU project Climate for Culture (CfC) investigates the impact of global climate change on historic buildings and their interiors. The CfC project mainly focuses on buildings that are lacking thermal insulation and have a limited climate control system. The purpose of the project is to develop more effective and efficient sustainable adaptation and mitigation strategies to preserve built cultural heritage (Climate for Culture, 2013).

An assessment of the impact of global climate change on historic buildings requires knowledge of historical and recent meteorological data and future outdoor climate scenarios. In the present study we have used data from historical and recent weather files provided by KNMI (Royal Netherlands Meteorological Institute, 2013), and numerical weather prediction models provided by our partners in the CfC project. The outcomes are data files with (hourly) values of the historical, present and future outdoor climate. We had already developed building physical computer simulation models to predict indoor climate of buildings, using (hourly measured) weather data files compiled by meteorological institutes over the past 50 years. For example, Meteonorm (Meteotest, 2009) provides hourly weather data files for over 100 weather stations across Europe that represent an average climate for each weather station over a period of one year. Up to now, these data have generally been used to predict the indoor climate and energy use of buildings in the design stage of a building, or later. A study that compared the future indoor climate within a historic house for several locations in Europe and coupled the results with damage functions for paper and salts can be found in (Lankester and Brimblecombe, 2012). The authors of this article derived a linear transfer function between the indoor and outdoor climate for each month during their research period. However, linear transfer functions may not accurately take into account climate control systems and variable internal heat loads due to irregular use of shading devices and differences in user behaviour. With multi-zone hygrothermal building simulation models it is possible to vary internal heat loads, ventilation rate and climate control set points per hour to obtain an accurate prediction of the indoor climate in the entire building. Two preliminary studies, one that used hygrothermal building simulation models to predict the impact of future climate change on two historic buildings in Western Europe and a second that compared the present indoor climate conditions in a historic church for different locations in Europe can be found in (Huijbregts et al. 2012a) and (Huijbregts et al. 2012b), respectively.

In this paper, historical, present and future outdoor climate data are used as input for building simulation models to predict the changing indoor climate in a historic building when the building is projected all over Europe. The impact of the predicted indoor climate conditions on possible future damage to valuable art objects has been estimated by damage functions. These damage functions have been derived from literature and are based on laboratory experiments. To date, there is little literature providing a coherent approach from outdoor to indoor climate, microclimate and predicted damage to objects. This paper attempts to provide and evaluate such an approach.

The next sections describe the simulation model, the meteorological data, the case study building and the damage functions. Hereafter, the results are presented and the conclusions and discussion are given.

METHOD

Simulation model

The indoor climate simulation model HAMBase (de Wit, 2006) was used to evaluate the climate conditions within a historic building. With HAMBase, the thermal and hygric indoor climate and energy use for heating and cooling of multi-zone buildings can be simulated using building material properties, set points for climate control systems and outdoor climate data. HAMBase characterizes the indoor climate by three properties that are assumed to be uniform in the zone: air temperature, radiant temperature and RH. The program makes use of a standard weather file with boundary conditions for diffuse solar radiation [W/m2], air temperature outside [°C], direct solar radiation (plane normal to the direction) [W/m2], cloud coverage [1...8], relative humidity (RH) outside [%], wind velocity [m/s] and wind direction [°].

Artificially generated historical climate data

To evaluate the effects of climate change over a much longer period, we can make use of historical measured handwritten, and subsequently digitized, weather data. The KNMI data centre contains historical climatic data from the 1850s for six weather station locations in the Netherlands (Royal Netherlands Meteorological Institute, 2013). These data involve wind directions, wind pressure, temperatures, daily precipitation, surface air pressure, cloud cover and RH that were manually recorded three times a day. However, to use these data in a simulation model, the manually recorded data have to be converted to semi-continuous data with a temporal resolution of one hour. The interpolation was calculated based on hourly measured data from KNMI over the years 1971 to 2005: the recent past files. In general, the MATLAB interpolation function balances the smoothness of the missing data in the historical files with the recent past files. As mentioned previously, the data in the historical files are based on three time intervals, and the interpolation will estimate the values that are in-between these known data points to match the unknown missing data with known data from the recent past files. The data were selected on the basis of a best fit in a period in the recent past files, comparable with the period during the examined year, i.e. with comparable sun elevation and azimuth. The interpolation searched for the same value at a certain time within the same time interval of the given available data in the historical climate file. In this way, historical outdoor climate data files for the years 1881 until 1896 were created. For example, on 1 January 1881, the cloud cover at one of three recorded times was 5. So, in the weather file from 1971 to 2005, also on 1 January, the interpolation function would look for the same value of cloud cover of 5 in a comparable time interval. This cloud cover value was used to calculate the ratio of the solar radiation in the historical weather file. The missing hourly values for temperature and RH were calculated by linear interpolation.

Present meteorological data

Meteorological data from the regional climate model REMO of the Max Planck Institute for Meteorology (Jacob, 2013) were used to analyse the present and future outdoor climate all over Europe. The REMO model is based on the former Europe model: a numerical weather prediction model from the German Weather Service (Majewski, 1991). REMO can be used for weather forecast and future climate simulations on a grid with a minimum horizontal resolution of approximately 10km. In REMO, climate data from the reference period 1961 to 1990 were used for a control run. The weather forecast, however, could not be predicted for individual days, but it is possible to generate an assumption for the average conditions for an area and the probability and magnitudes of the deviations from this average. The general averaging period is 30 years, because this period is long enough to be regarded as climatologically significant (Sabbioni et al., 2010). REMO data for air temperature, surface temperature, RH, precipitation, wind speed and direction and global radiation were provided with a temporal resolution of one hour. For the evaluation of the present climate, a dataset was composed of climate measurements from multiple weather stations throughout Europe from 1960 until 1990 to represent characteristic climates for the different regions and locations. The meteorological data were thereafter interpolated on a regular grid over Europe. Figure 1 shows an overview of locations and altitudes of the 468 grid points which were used. Some grid points are located at very high altitudes (>1000m), such as in The Alps or Dolomites. The weather data provided for these points may considerably differ from weather data of nearby points at lower altitudes.

Future outdoor climate scenarios

REMO recently produced future outdoor climate scenarios for two periods: the near future (2020-2050) and far future (2070-2100) for all 468 grid points over Europe. The scenarios were based on the IPCC A1B emission scenario for the period 2001-2100 (IPCC, 2007). This emission scenario assumes a world of very rapid economic growth, a global population that peaks in the mid-century, and a rapid introduction of new and more efficient technologies that balance between fossil intensive energy sources and non-fossil energy sources.

Reference building

Three requirements have been defined for the reference building: it has to be a historic building, it has to represent a typical building style that can be found all over Europe and it has to be in use for its original function. A small church near Eindhoven, the Netherlands, was selected (Fig. 2). The church, which was built in the nineteenth century, has been registered as a state monument since 1968. Massive brick walls, slate roofing, and single glazing characterize the building. The church is frequently used for services, marriages and funerals. Continuous on-site measurements of the air temperature, surface temperature, and RH at various locations in and around the church were started in March 2011. In addition, measurements of the air exchange rate and heat flux through the walls were carried out.

A HAMBase model was created of the entire church, consisting of four zones: the sanctuary, the consistory, the attic above the sanctuary and the attic above the consistory. This study focuses on the results for the main zone in the church: the sanctuary. A comparison between the measured and simulated indoor temperature, RH and humidity ratio is presented in Figure 3. It should be noticed that in the simulation model, the number of visitors during ceremonies was kept constant and only ceremonies on Sunday morning were taken into account. Additionally, a constant value was assumed for the air exchange rate. The simulated temperature generally varied within ±2°C of the measured temperature, RH was predicted within ±10% of the

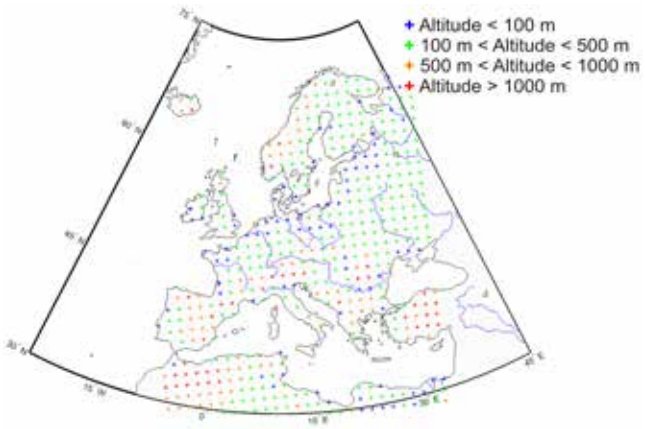

Figure 1. Overview of the locations and altitude of the modelled meteorological datasets on a uniform grid over Europe.

Figure 2. The historic reference building

measurements and the humidity ratio was predicted within ±2g/kg of the measurements.

DAMAGE FUNCTIONS

Martens (Martens, 2012) developed a methodology to assess damage in objects due to the indoor climate. This method is based on the indoor climate an object is experiencing due to the response time of the object. The response time is defined as the time, needed for an object to react for 95% to a step change in RH. The RH of the object is derived from the measured indoor climate, using the response time of the object according to Equation 1:

$$RH_{response,i} = \frac{RH_{response,i-1} + \frac{3}{n} \cdot RH_i}{1 + \frac{3}{n}}$$

where n equals the number of measured data points in the response time and RHresponse of the object at time i is determined by taking the previous RHresponse at (i-1), adding a fraction of the current RH in the room and dividing by 1 plus that fraction. For a 95% reaction, the fraction equals 3/n.

Biological degradation

A method of Sedlbauer (Sedlbauer, 2001) is used to determine biological degradation by fungal growth. Combinations of temperature and RH determine whether the fungus germinates or grows.

Chemical degradation

The concept of the Lifetime Multiplier (LM) is used to describe the time an object is usable, compared to a reference indoor condition (20°C and 50%RH). Apart from T and RH, the LM also depends on the activation energy, which is a material property (Michalski, 2002). A small risk on chemical damage may occur when LM > 1, a medium risk may occur when 0.75 ≤ LM < 1 and a high risk is predicted when LM ≤ 0.75.

Mechanical degradation

Hygroscopic materials react to changes in RH by absorbing or desorbing moisture from the air. The changes in moisture content imply dimensional changes of the materials. If these materials are not free to expand or contract, stresses occur in the object, which may lead to damage by mechanical degradation. As panel paintings are representative objects in many historic buildings, the hygroscopic and mechanical behaviour of panel paintings have been subject of a number of extensive studies, e.g. (Mecklenburg et al., 1998), (Rachwal et al. 2012a) and (Rachwal et al. 2012b). In this paper, therefore, panel paintings are chosen as reference objects for mechanical degradation. For this kind of paintings, two types of mechanical damage are important: damage to the wood support and damage to the pictorial layer. Damage to the wood support may occur when the entire object responds to a slow change of RH over time. The dimensionally changes of the object may be hindered by the construction of the object and lead to damage, such as cracks. Damage to the pictorial layer may occur when RH variations last longer than the response time of the panel. The moisture content within the panel changes and the object will swell or shrink. As the response of the gesso layer to RH variations is very fast, the mismatch in the response of gesso and the unrestrained wood support can lead to fracturing of the pictorial layer.

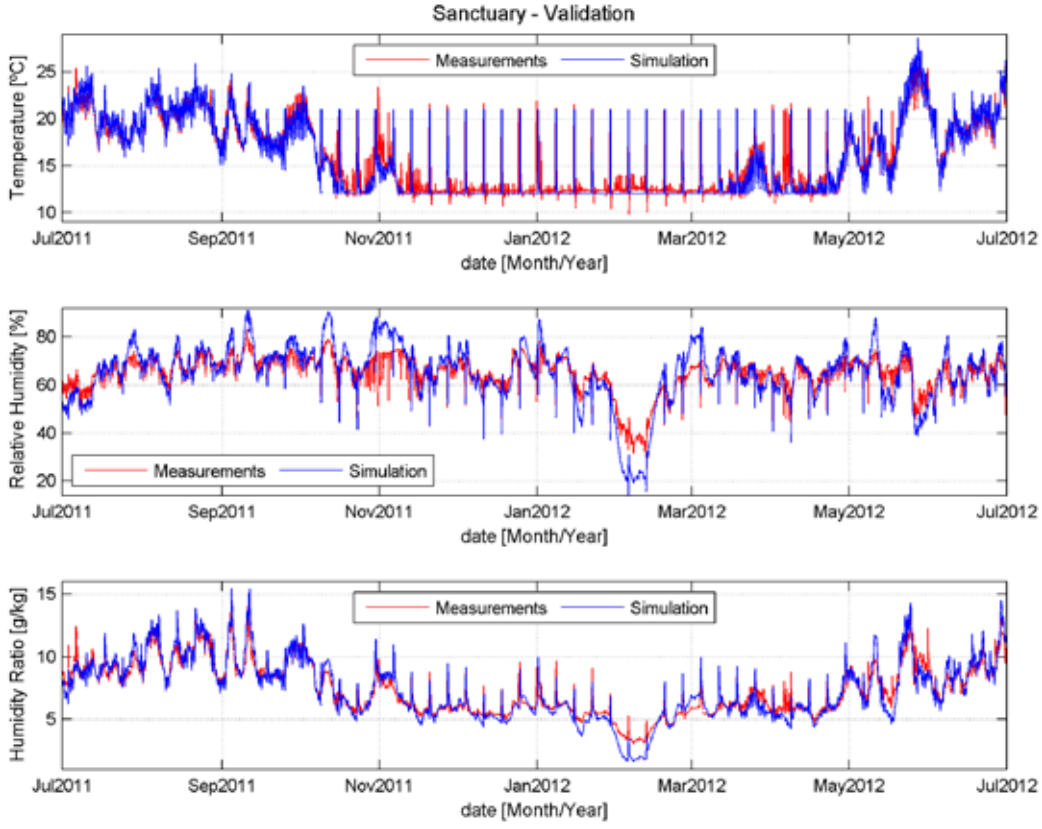

Figure 3. Validation of the indoor climate simulation model of the sanctuary in the reference building

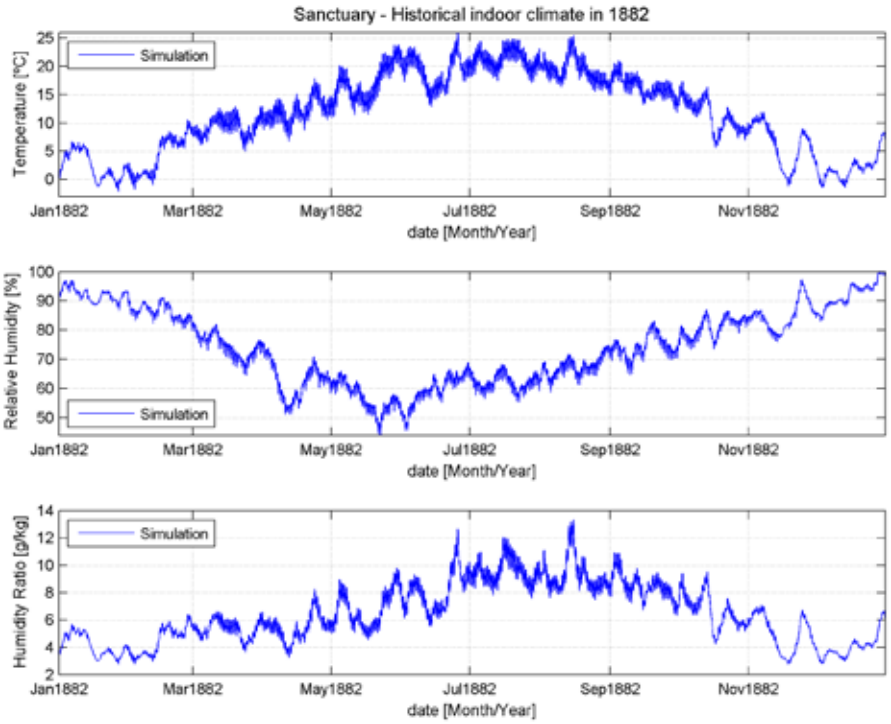

Figure 4. Projected historical indoor climate conditions inside the sanctuary in 1882

RESULTS

Projected historical indoor climate in the reference building

A projection of the historical indoor climate in the reference building was generated by combining the HAMBase model with the artificially generated historical climate data as was described in the Method section. In the simulation model, it was taken into account that the building remained unheated and 50 persons on average attended weekly ceremonies on Sunday morning. The estimated temperature, RH and humidity ratio in the year 1882 are shown in Figure 4. It is predicted that the minimum indoor temperature is slightly below freezing point and that the maximum indoor temperature is around 25°C. High RH values are predicted: RH remains above 60% for most of the year and regularly exceeds 90% in winter.

Present indoor climate in the reference building, virtually placed all over Europe

The calculated meteorological data and damage risks were interpolated to a grid over Europe. The grid used has a resolution of 376x226 data points and covers the area between 30°N to 75°N and 28°W to 45°E. The mean indoor temperature and humidity ratio in the recent past (1960-1990) are shown in Figures 5-6. The mean temperature inside the church when it is virtually placed all over Europe varies between -5 and 25°C, while the mean humidity ratio varies between approximately 3 and 9g/kg. In Northern Europe, the average indoor climate in the 31-year period is characterized by low mean temperatures (-5 to 10°C) and mean humidity ratios varying between 3 to 6g/kg, which leads to high mean RH values (80 to 90%). The indoor climate in the Mediterranean area is generally warm (10 to 20°C) and has a mean humidity ratio of 4 to 7g/kg inland and 7 to 9g/kg in coastal areas, leading to a medium mean RH (40 to 60%). In between, the area around the United Kingdom and Ireland shows a temperate climate (5 to 15°C) and a medium mean humidity ratio (5 to 7g/kg) leading to a high mean RH (75 to 80%).

Future indoor climate in the reference building, virtually placed all over Europe

The impact of future climate change on the indoor climate conditions in the reference building was predicted by calculating the difference in mean temperature and humidity ratio between the recent past, near future and far future. Figure 7 shows that in the near future, the average indoor temperature may increase by approximately 1°C in Western Europe and 1 to 2°C in Southern, Eastern and Northern Europe. A small increase in the mean humidity ratio is predicted in all areas, varying between circa 0 to 0.4g/kg in Southern Europe and 0.4 to 0.8g/kg in Eastern Europe (Fig. 8). Consequently, the mean RH may slightly decrease in most areas, in particular in Southern Europe. Larger changes are predicted in far future: the mean indoor temperature increase in Western Europe is approximately 2°C, while a mean

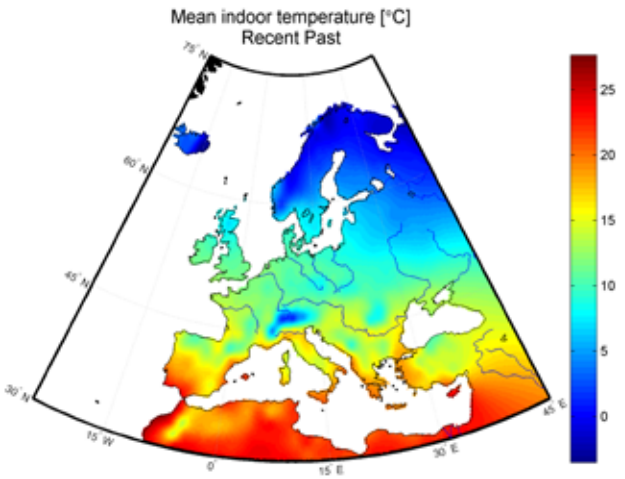

Figure 5. Mean temperature between 1960 and 1990 inside the sanctuary when the church is virtually placed all over Europe

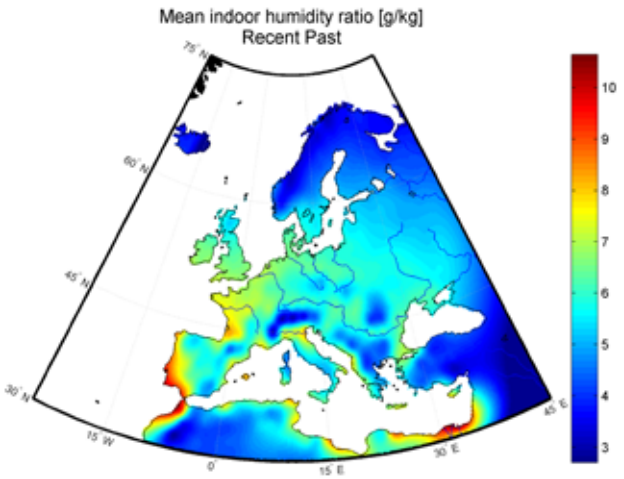

Figure 6. Mean humidity ratio between 1960 and 1990 inside the sanctuary when the church is virtually placed all over Europe

indoor temperature rise up to 4°C may occur in Northern and Southern Europe (Fig. 9). The predicted mean humidity ratio change is highest in Eastern Europe and the coastal areas (1.2 to 1.6g/kg) and smallest in parts of Great Britain, Norway and in the inlands of Southern Europe (Figure 10).

Damage functions

The previously described damage functions were used to predict the risks of biological, chemical, and mechanical degradation, based on the calculated indoor climate for the unheated reference building in the recent past, near future and far future. Figure 11 shows that a high risk on mould growth is predicted in Great Britain and the coastal areas of Western Europe and Scandinavia. The risk on mould growth may considerably increase in the near future and far future in and around these areas, while the predicted mould growth risk in Southern Europe remains low. The recent past map in figure 12 shows that LM exceeds 1 for most areas in Europe, except for part of the coastal areas in Southern Europe. The LM gradually decreases in the near future and far future, which causes an increased risk on chemical degradation of objects particularly in coastal areas in Southern and Western Europe. No location in Europe has been found where the indoor climate conditions in the reference building may prevent mechanical degradation of the wood support or pictorial layer of panel paintings. Damage to the wood support is likely in some areas in Northern Europe in the three periods, but no consistency is found between the locations where this high damage risk is predicted (Fig. 13). Damage to the pictorial layer is likely in the recent past and near future in many areas in Northern, Eastern, and Southern Europe. In far future, damage is likely in almost all areas (Fig. 14).

CONCLUSIONS AND DISCUSSION

This study presents a modelling approach to predict the historical, present and future indoor climate conditions in a historic building, when it is virtually subjected to an outdoor climate at various locations all over Europe. The indoor climate conditions were calculated by a hygrothermal building simulation model. Based on the predicted indoor climate conditions, the damage potential of biological, chemical and mechanical degradation was evaluated for the recent past, near future and far future.

The preliminary results suggest that it could be possible to predict the indoor climate conditions and risk for damage in a building over a large area, using regional climate data from the past, present and future. Based on the applied future outdoor climate scenario, a small increase in indoor temperature and humidity ratio is predicted in the near future, while a considerable rise in temperature and humidity ratio may occur in far future. Damage evaluation shows that there are no places in Europe where no damage to objects is to be expected in the recent past, near future and far future. In cold, humid climates, the risk for chemical degradation is regularly low, while the risk for mould growth and mechanical damage is rather high. In contrast, in warmer, dry climates, mould growth risks are rather low, while chemical and mechanical degradation are more important. Climate change may considerably increase the mould growth risk in Northern and Western Europe. Additionally, a higher risk on chemical degradation may occur particularly around coastal areas in Western and Southern Europe. No consistent impact of climate change on the predicted mechanical degradation of panel paintings was found.

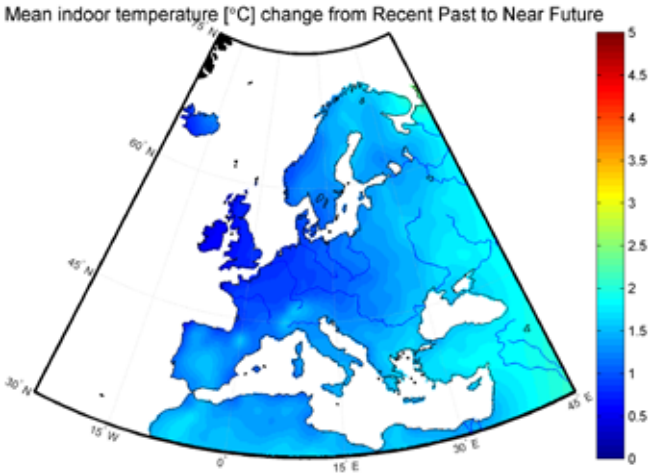

Figure 7. Mean indoor temperature change from recent past to near future (a positive change means a temperature increase in near future)

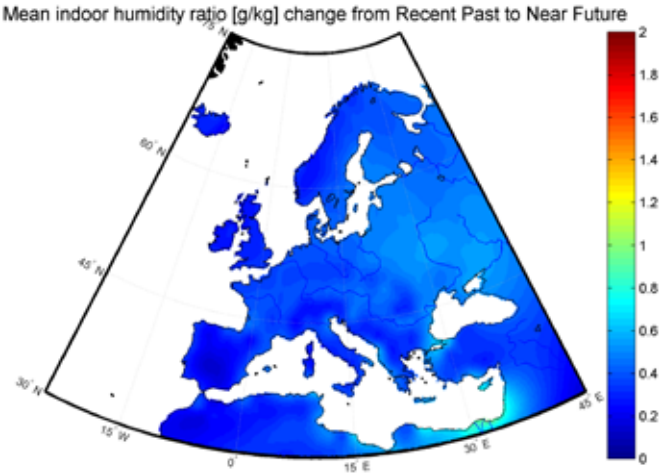

Figure 8. Mean indoor humidity ratio change from recent past to near future (a positive change means an increasing humidity ratio in near future)

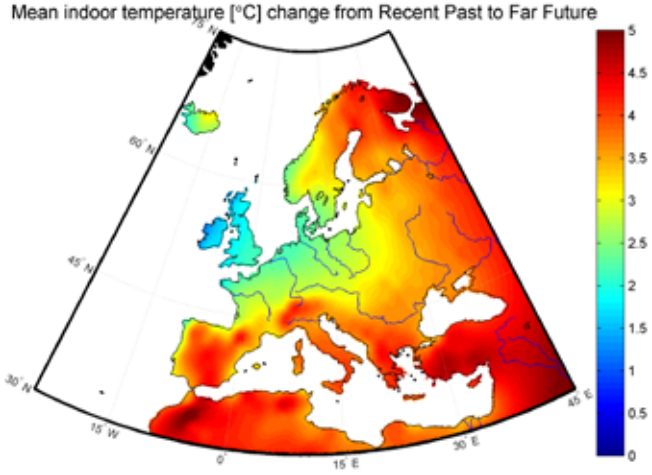

Figure 9. Mean indoor temperature change from recent past to far future (a positive change means a temperature increase in far future)

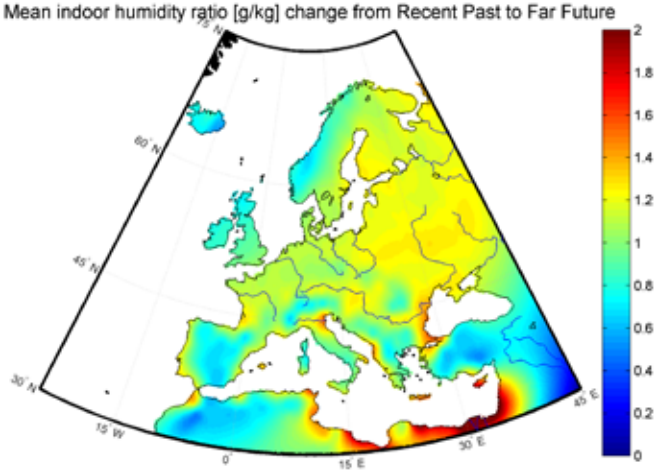

Figure 10. Mean indoor humidity ratio change from recent past to far future (a positive change means an increasing humidity ratio in far future)

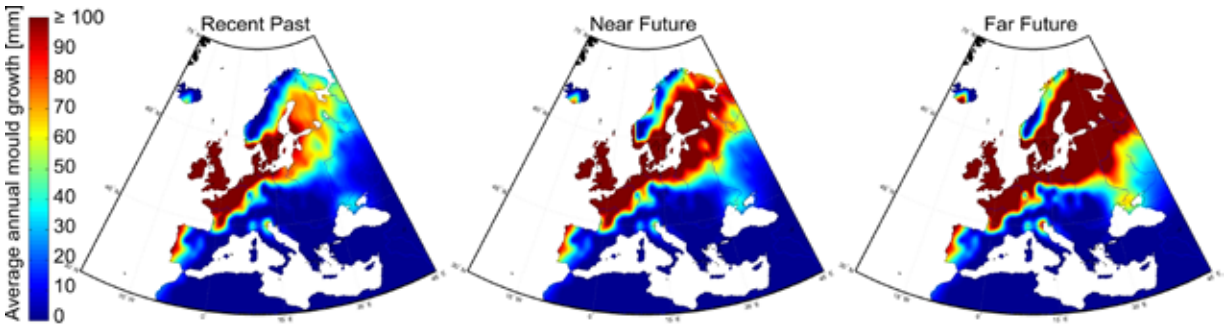

Figure 11. Predicted mould growth risk in recent past, near future and far future.

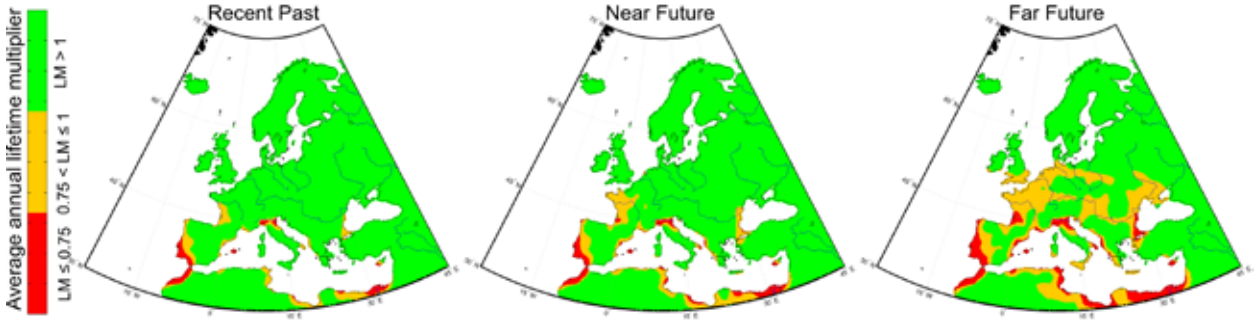

Figure 12. Predicted average annual lifetime multiplier in recent past, near future and far future.

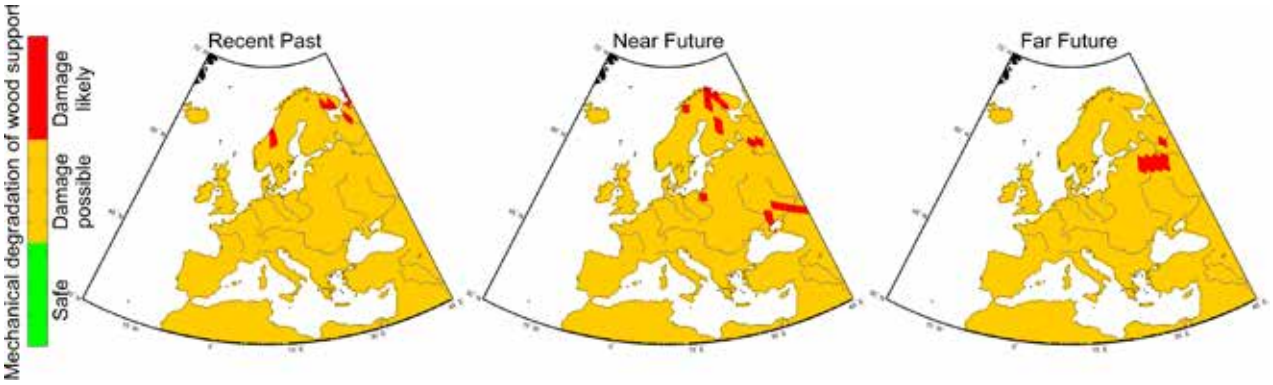

Figure 13. Predicted mechanical degradation risk of wood support in recent past, near future and far future.

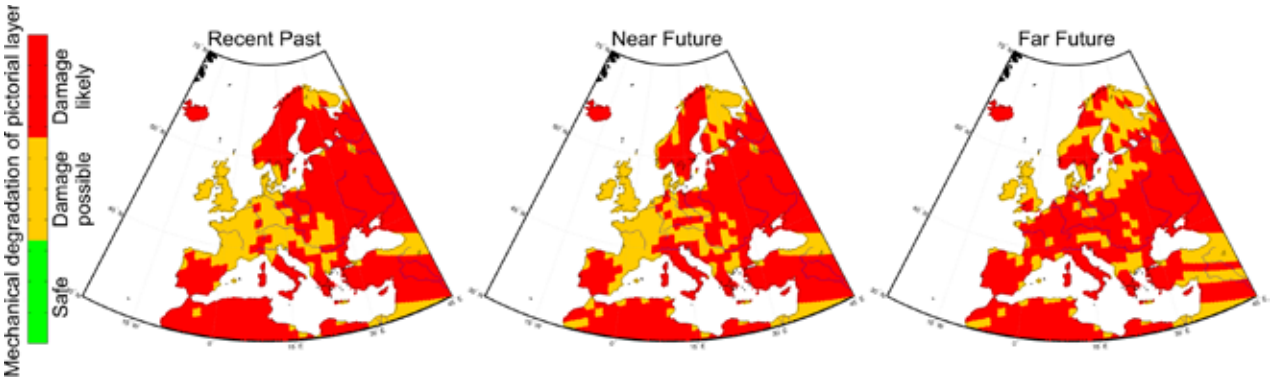

Figure 14. Predicted mechanical degradation risk of pictorial layer in recent past, near future and far future.

One of the most critical problems in using this approach is the uncertainty in people's use of the building and its HVAC systems. Also the fact that materials will adapt to the long term local situation is not taken into account. Besides that, the current outdoor future climate scenario is based on only one IPCC emission scenario, which means that there is a high uncertainty in these data. In the near future, more generic building types for different areas in Europe will be selected to acquire more appropriate reference buildings for each location. Furthermore, the microclimate around objects could have an essential influence on the risk evaluation of objects and should be object of research in future. More objects will be included in the potential damage analysis, e.g. wooden organs, and the impact of climate control systems and climate adaptive measures will be investigated as well. The presented risk maps are not yet suitable for climate management in historic buildings, but should be seen as illustrative examples of potential impacts and risks.

ACKNOWLEDGEMENTS
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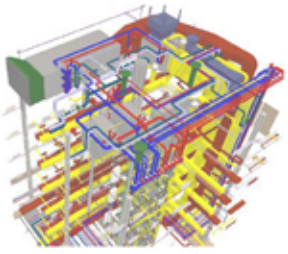
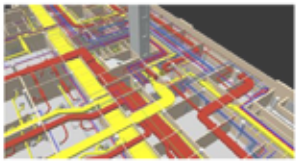
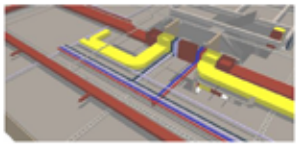


VECCINS 3D has its own philosophy about it. They have begun to apply the Principe commissioning for residential construction. This Principe is based on the setting of performance that you want to achieve on the basis of Money, Organization, Time, Information and Quality and where every decision is made during the design and implementation process, or performance be achieved, however, checked. This Principe runs like a thread through the whole scheme of the software developed by DDS. VECCINS 3D and DDS have invested a lot since recent years. Meanwhile, according to this principle already in BIM several large projects are realized in full BIM, from nursing homes to office buildings and also a large distribution center. This effort has resulted that VECCINS 3D the Winner was with the best BIM model at 2011, a competition which is annually organized by TNO Building Netherlands. Meanwhile VECCINS 3D is working for more than 120.00 m² of BIM models, where both design- work and as built models are modelled, with all information in one place is accessible.
All the systems are modelled in the models such as rainwater drains, sewers sloped, plumbing, heating, ventilation, cable ways, switchgear, fire protection, sprinkler, access control, video surveillance and security.





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