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Study Association Building Physics and Services

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raduation project Jelle Loogman & Ivo Visser

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Foreword

Marthe Doornbos



A couple of days ago I attended a drink with a mixed group of scientists and business people. After a while the conversation entered the subject of sharing knowledge. The opinion of the business people was clear: knowlegde was the way to generate money. For the scientists among us, this is hopefully not the only incentive. Sharing knowledge can improve our research and our results. Maybe even enhance our creativity and generate new insights.

With this edition of the INSide we want to stimulate sharing knowledge within our department. Therefore we tried to give a full picture of all ongoing activities within our unit in this magazine.

Several articles will give you this insight, for example, while writing this foreword there are only two days left before the study trip to China. Another form of sharing knowledge and learning from each other and especially other cultures. With the release of this edition I can hopefully say that is was a tremendous success. The travel journal of the trip, with inspiring pictures included, can be read on page 36.

Apart from the Chinese culture we will also have a look closer to home. As the front picture of this edition already reveals, the measurement expedition of Ancient Acoustics could not be omitted. The Greek acoustics mystery is revealed on page 44.

Furthermore, several companies have contributed to this INSide Information by providing a wide range of articles about a new airport in Abu Dahbi to tips and tricks to be used on LinkedIn.

I wish you all the best for the upcoming exams, finishing a master project and for some people their graduation. Hopefully you will all have some time left for a well deserved holiday.

On behalf of the entire INSide committee, I wish you a great summer and hope you will enjoy reading this INSide Information,

Marthe Doornbos

Dear reader,



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COLOPHON

INSide Information

Volume 18, Number 2, June 2015

The INSide Information is published by s.v.b.p.s. Mollier

Front pic: Niels Hoekstra Back pic: Bram Botterman

Printing office: Drukkerij Van Druenen BV

Visiting address TU Eindhoven Vertigo 5th floor

Post address

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

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Abu Dhabi International Airport: an exquisite pearl in the desert

Arabian grandeur

There are airports and then there is Abu Dhabi's Midfield Terminal Complex. Designed to blend into its natural desert environment, the new complex – part of Abu Dhabi International Airport and scheduled for completion in 2017 – will provide an alluring gateway into one of the world's fastest growing cities. On top of its breath-taking Arabian grandeur, the airport represents a mind-boggling technical and logistical complexity. Deerns is co-responsible for the design of the terminal's myriad airport-specific systems.

Text and photo's: DEERNS

"You only witness a couple of projects like this in a lifetime," says Airport Consultant Fokko Edens of Deerns." The scale, the complexity, the many different and interdependent demands – all those factors contribute to making this an immensely challenging and enriching experience for everyone involved." To illustrate his point, Edens mentions a few details of the prestigious Abu Dhabi project. The Midfield Terminal building itself is one of the largest terminal buildings in the world and will cover 730,000 square metres. "Even the outbuildings in which the irrigation is controlled, or the structures to which the passenger boarding bridges are connected, have a cathedral-like vastness that houses very wide-ranging and complex systems," says Edens.

The electric systems involve some 6,000 kilometres of cables. The terminal will have 50,000 telecom outlets and around 10,000 surveillance cameras. By 2020, the terminal is forecast to process around 30 million passengers a year. Set to rank among the largest and most advanced airports in the world, the Midfield Terminal Complex is on its way to becoming another gem in the crown of Abu Dhabi – a rapidly growing business metropolis that combines ancient Arabian charm with high-tech sophistication. Says the Midfield Project's Design Team Manager Jens Hardvendel of Kohn Pedersen Fox Associates (KPF), one of one of the world's pre-eminent architecture firms, "When in 2006, together with NACO/Deerns and ARUP, we won the competition to design the new terminal, the Abu Dhabi Airport Company (ADAC) officials were very clear: they wanted a state-of-the-art, best-in-class airport. So that's what they're getting."

UNIQUE ARCHITECTURE

To KPF, whose portfolio includes numerous airports and terminals worldwide, the Midfield Project presented some special challenges. Says Hardvendel, "We learn a lot from every project. In this one, the learning curve was in dealing with the complexity of requirements, the range of partners and stakeholders and the extended development time: we won the design competition in 2006 and were busy designing until 2012. Actual building only began in 2013. Also, design began before the recession, yet we have managed to answer to all the requirements – a compliment to the design team." The Midfield Terminal's architecture is unique, says Hardvendel. "The ADAC did not want a standard line of gates stretching out endlessly; they wanted something special. We came up with an X-shape that combines maximum efficiency with unusual aesthetics."

Apart from accommodating 50 or so gatehouses, the design had to take into account many other functional requirements – from airplane and passenger numbers to peak loads, environmental and climatic conditions. "For instance," says Hardvendel, "the forecasts tell us that a high percentage of passengers landing at Abu Dhabi International Airport will be transfer passengers. So rather than getting off the plane, collecting their luggage and heading for the city, these people will be spending time at the airport. This has major design implications. For instance, we have included superior landscape views, gardens, museums and hold rooms at the gates that, unlike those at many other airports, actually offer enough seating for everyone. The retail scheme is also interesting: the ADAC wanted a retail concept that would offer everything travellers might want – but at a higher level



Figure 1 Kohn Pederson Fox Associates (KPF)



Figure 2 Midfield Terminal Project

than usual. The result is a very luxurious range of shops and foodservice outlets with a distinctly local flavour: it's like a very classy Arab souk."

PF used dry-climate landscaping to reduce the use of potable water and cut back on energy costs by combining efficient use of natural daylight with low-energy lighting. For protection against the scorching desert sun, internal sun shields were introduced. "External louvers in this environment would get clogged up with desert sand in no time," says Hardvendel. He adds, "This is one of the biggest airports we have ever designed from scratch – and so far, we are very pleased with the results."

Last October, the base for the terminal's impressive roof was assembled. In January, the first of 18 steel arches that will make up the building's main structure was erected – the first visible sign that the new building may indeed change the Abu Dhabi skyline forever. "Already, this site is taking on iconic dimensions," says Fokko Edens of Deerns.

SIX YEARS AT THE DRAWING TABLE

While the terminal's scale may be impressive and its visual appearance stunning, what really inspires professionals like Edens and his colleagues is the technical complexity of the project. Deerns spent six years at the drawing table. Deerns' assignment encompasses all the airport-specific systems for four separate project components: the Midfield terminal building; the 'airside', or airport area designated for airplanes and all related facilities; the 'landside', or front end where the public goes in and out; and the – rather extensive – car park area (see also the text box on 'The role of Deerns').

Inside the terminal, Deerns designed and planned the entire IT and telecommunications infrastructure, including every cable, cabinet and connection. In the area of Special Airport Systems (SAS), the firm developed the Airport Operational Database, or AODB. "A kind of super-database application", as Edens calls it, the AODB contains all the data needed for running the airport safely and securely – from flight schedules to luggage processing and from passenger flows to refuelling programmes. Edens and his colleagues also worked on the terminal's Flight Information Displays (FIDs), area-specific Public Address and Voice Evacuation Systems, wifi spots,



Figure 4 Midfield Terminal Project



Figure 3 Midfield Terminal Project

telephone systems, indoor GSM extension and much more. "Our job, primarily, is to figure out down to the last detail which materials and applications are needed in every technical area, in which sizes and quantities, to draw up all the requirements and specifications involved, the functionalities, the procedures for operation – and then to make sure it all gets properly installed and up and running. Basically, we create the systems on paper; the contractor does the actual installing, testing and commissioning."

CLEAN APRONS

he project has offered Deerns many opportunities to outdo itself. One of the highlights that stand out for Edens is the 'clean apron' concept Deerns developed. The aprons, or platforms near the gates at which airplanes are parked in between taking off and landing, are a major hub of systems: electricity, fuel and water supplies for the plane, luggage transport routes, maintenance facilities, docking and guidance systems and much more. Ideally, these systems, and the jungle of pipe and wiring systems accompanying them, are concealed beneath the apron surface, with outlets emerging from special pits. This leaves the apron itself as uncluttered as possible. The main benefit of a 'clean apron' is reduced risk of damage. Says Edens, "In the Midfield Project, we have succeeded in developing exceptionally clean aprons. I think it's safe to say that our experience in Abu Dhabi has placed Deerns at the forefront of clean apron development worldwide. It's only a detail, but to us airport engineers it is a very special one."

Perhaps the biggest challenge in creating clean aprons at Midfield was in providing adequate cooling for airplanes on landing: the combination of ambient temperatures up to 50°C and strict regulations regarding minimum air temperatures and maximum airflows allowed inside airplanes made it proper cooling within the short time frames expected at a major airport almost impossible. Deerns consulted with a range of parties, including airplane manufacturers, and eventually came up with a unique, pioneering solution Edens calls 'deep cooling'. "We were only able to pull it off because of the sheer scale of the project," he says. "In a smaller project, we would never have had the leverage to even consider an out-of-thebox option like this one."



Figure 5 Midfield Terminal Project

SMART DECISIONS

eun Vrolijk, United Arab Emirates Representative at NACO, the party that contracted Deerns for the Abu Dhabi job, emphasises that while during construction the role of technical engineering consultancies is nonetheless vital. "An airport terminal, ultimately, is a functional building," he says. "It's not like a palace or an art museum. Aesthetics are important and with this project KPF has set a new standard for airport attractiveness. But the technical engineering side is decisive for the success or failure of a project like this. Everything has to work perfectly."

his is one reason why NACO hired Deerns. Says Vrolijk, "We have worked with Deerns for 30 years now. They are specialists, like NACO is, in the field of airport master-planning, terminal buildings and airside and civil works-side projects. Apart from its size, the Abu Dhabi project has some extra challenging aspects, such as the whole security programme, which in the Middle East comes with tougher and more complex requirements than it does in many other parts of the world. One of the smart decisions Deerns made was to avoid going into too much detail in the planning phase. They left the details to be decided on during implementation. That way, they avoided prescribing materials and technologies that by the time of realisation would be long outdated."

rolijk agrees with Hardvendel and Edens that contributing to the Midfield Terminal Project is a unique experience. "This project is of immense importance to Abu Dhabi, so the pressure is huge. They are keen to make an impression, not just with the size of Abu Dhabi International Airport, but also with its outstanding quality. The way things are going, they are likely to succeed."

THE ROLE OF DEERNS

Depends on the new Midfield Terminal in Abu Dhabi. As far as the terminal building is concerned, this includes the following:

- Passenger screening;
 Baggage screening;
 Vehicle screening;



Kuijpers

Kuijpers & Mollier Resultaat door **betrokkenheid**

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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Personal Branding

Tips & T<u>ricks by KP&T</u>

Nowadays there are very different ways to find the perfect vacancy for your internship, graduation project or job. Not only applicants are trying to find the right job and apply for it, but companies more often try to get in contact with possible employees as early as possible.

n the changing way of finding the right position, personal branding gets more important every day. We differentiate the 'traditional' and online way.

TRADITIONAL

We all know the 'traditional' way of presenting yourself; you find a vacancy, write a motivation letter and send it with your résumé to the contact mentioned. Nothing wrong with that, at least if you are doing it right! Here are some tips:

- Check your resume and letter for typing errors and grammatical mistakes;
- Make sure your resume is orderly (e.g. ordered from present till past);
- Give a broad oversight of your (working) experience (e.g. college projects, internships, additional jobs etc.);
- Don't forget to mention software- and language knowledge; Do you have a LinkedIn profile? Then add the friendly URL to your personal- /contact information.

ONLINE

Speaking of LinkedIn, if you don't already have a profile, make sure you create one on short-term! Linkedin is the most used and world's largest online professional network. A perfect channel to use for presenting. We've listed some benefits for you:.

- LinkedIn gives the possibility to make a digital resume which you can extend with additional documents and information, project descriptions and team members, recommendations, personal skills, etc;
- It's an easy way to get and keep in contact with classmates, teachers, (former) employers. So no more collecting and afterwards losing business cards;
- You can join groups and follow companies to expand your network and keep up with news, development and career opportunities.

inkedIn made creating a profile 'easy peasy'. Just follow the steps and the basics are set. During using your profile, Linkedin will give optimisation tips. To benefit LinkedIn's services to the fullest, following components need your attention:

- Provide your profile with a summary. Make sure the summary contains keywords that represent your qualities, ambitions and career wishes;
- Same goes for the experience, projects and skills you display on your profile.

The keywords you use, will determine which vacancies LinkedIn will show and which persons, groups and companies they recommend to get in contact with.

MORE TIPS

Do you want to learn more about personal branding, how to use LinkedIn or even how to prepare yourself for application procedures and job interviews?

Don't hesitate to call or e-mail: Deborah Dielis | 06-57311185 | d.dielis@kpt.nl

CONNECTING TECHNICAL PROFESSIONALS



Techniek is jouw toekomst. Voor een baan of traineeship kom jij dus graag in contact met die ene interessante organisatie. KP&T verbindt je doelgericht aan de opdrachtgever die echt bij je past. Met veel aandacht voor jouw kwaliteiten en ambities creëren we de samenwerking waarin jij op je plek bent. Samen brengen we je kansen in kaart. We helpen je op weg naar je sollicitatiegesprek en begeleiden je terwijl je werkervaring opdoet. Al zin om te starten? Bel of mail een van onze adviseurs in jouw regio voor een afspraak.

> KP&T verbindt professionals. In bouwkunde, civiele techniek, elektrotechniek, energietechniek, High Tech, installatietechniek, Oil & Gas en werktuigbouwkunde.

Lunch lecture ARUP

3abette Mattheü

LUNCH LECTURE #1

The first activity of Mollier this year was a presentation given by Arup. During the lunch two employees of Arup gave an interesting presentation about the company and their projects to 41 members of Mollier.

irst, Adam Foxwell gave an introduction of Arup and how it is to work within the company. Then he continued with examples of the type of work he himself is doing in the field of acoustics. The second part of the presentation was given by Filique Nijenmanting, a former Building Physics student of our own university. After her graduation project at Arup she started her career at the office in Amsterdam. Several interesting projects in the field of Building Physics (and a little services) were discussed.



Actiflow case-study



Thursday the IIth of December a case-study was hosted by Actiflow. The study started with a introduction of the company and showed a diversity of their projects. Actiflow is specialized in computational fluid dynamics (CFD) calculations and have therefore projects ranging from new car designs to building physics and maritime problems. An example is the prevention of water spilling of hot tubs on ship decks under increasing wave heights.

A nother project is the design of a skydive centre. This Was also the project that was used for the case study. In groups of 5 students a design for this centre was created considering the airflow, inside temperature and energy consumption. After the brainstorm session all the ideas were presented and discussed. The case study resumed after a short break with some snacks and drinks. In the last part of the study the inside temperature of the tubes was scrutinized and different design perspectives were discussed.

Meet and Greet

Babette Mattheüs

On the 26th of February the yearly Meet & Greet with sponsors of s.v.b.p.s Mollier took place. With 9 sponsors represented by 18 speakers and 40 members of Mollier it was a great success.

The afternoon started with an elevator pitch of each individual sponsor followed by the Meet & Greet. Here students and sponsors got the opportunity to get to know each other and discuss possible projects, internships or (part time) jobs.

Through this post we would like to thank the sponsors and students again for their contribution to the Meet & Greet of 2015! More information about the companies that attended the event can be found in the Meet & Greet information guide.



Lunch lecture KP&T and VECCINS3D

LUNCH LECTURE #2

On the 9th of December 31 students attended the second lunch lecture. This time KP&T and Veccins 3D presented their company and their relation with building physics and services.

In the first lecture Tom Zentjens and Deborah Dielis represented KP&T, a secondment agency in the field of Engineering. First they gave a global explanation about the work KP&T does and their vision find a suitable job for them. Subsequently, Karin Conen, an old board member of s.v.b.p.s Mollier, gave insight in how KP&T helped her to find a traineeship at Unica.

The second presentation was held by Frits van Enk from Veccins 3D, which is a installation engineering consultancy that only works with BIM (Building Information Model) techniques. The company's vision is that most construction errors can be eliminated by the use of a BIM model. Veccins 3D uses an OpenBIM program where information can be exchanged between all parties in the construction process with the use of IFC (Industry Foundation Classes). One of their projects is 'Hoog Catharijne', a shopping mall in Utrecht.





Lunch lecture Heijmans and LBPISIGHT Babette Mattheüs



LUNCH LECTURE #3

The third lunch lecture took place on the 19th of March. Two of Mollier's sponsors, Heijmans and LBP|SIGHT, presented their company and some of their interesting projects to 38 mollier members.

Starting with Berend Doedens, the former treasurer of the 7th board of Mollier, Heijmans was presented. In contrast with most presentations, the focus was on civil engineering ranging from tunnels to bridges.

ollowing the first lecture, LBP|SIGHT was represented by Janneke van der Weerd, who is also familiar with the TU/e as a former student of Building Physics and Services. LBP|SIGHT is a consultancy for building, environment and sustainibility. The presentation focused mainly on 'The Edge' that currently is the most sustainable office building in the world. Since it has the highest BREEAM classification so far.



11 -

Communities at TU/e

Written by:

PROF. DR.-ING. HABIL. ALEXANDER ROSEMANN



The request to write a column for the Inside magazine came at a time that coincided with discussions around communities. In a few otherwise unrelated meetings this topic came up. Over the last few weeks, I kept thinking about communities in general but also specifically here at TU/e.

verybody has an idea of what is meant when the word community is being used. Using an internet search engine, I attempted to look up its definition and was immediately overwhelmed by the multitude of different definitions regarding this word. Two definitions/descriptions resonated with me in the context of communities in research environments: "the condition of sharing or having certain attitudes and interests in common" and "a similarity or identity". One needs to digest the meaning of these words and see if and how they apply to our work life on campus.

would like to bring some attention to one of many special communities on our campus: the Bachelor Honors Academy. I caught a glimpse of how enthusiastically the students work there and how they interact in an interdisciplinary setting. While working on projects they advance their personal development and leadership skills at the same time. I am most familiar with the Honors Track "LightForce" that is already running successfully for a few years now. The department of the Built Environment is starting the H-nors Track "Smart Cities" in September and is currently asking for applications from Bachelor students. I am sure that this additional track will see a lot of interested Bachelor students who want to participate and create a community.

When I came to work at TU/e, I was impressed by the number of established active communities. This is certainly a feature for which many other universities may envy us. The success of communities is not determined by how many such communities exist. The success depends on the active participation of all of their members. There is value for everyone including, but not limited to, learning opportunities, the creation of innovative ideas or establishing a collaboration of sorts. I am looking forward to the continuation of so many active communities here at TU/e.



Stage of afstuderen bij Nelissen ingenieursbureau?

Als integraal adviesbureau op het gebied van bouwfysica en installatietechniek, loopt duurzaamheid als een rode draad door al onze werkzaamheden heen. Veel van onze collega's hebben aan de TU/e gestudeerd dus heel wat expertise in huis! Wil jij bij ons stage lopen, heb je een interessante afstudeeropdracht of ben je in de gelegenheid om naast je studie één dag per week bij ons te komen werken?

Stuur dan je curriculum vitae met motivatie naar Marie-José van Eck, adviseur P&O, m.vaneck@nelissenbv.nl.

www.nelissenbv.nl

Internship? Annelous Bossers

A re you busy working on your Master? Did you just finish your Bachelor? Or maybe even still working on your Bachelor? At any moment in your education it can be useful to do an internship. It is currently not compulsory, but absolutely very educative. It might even help you with making choices in your education plan. Would a traineeship be something for you?

Some students are doing an internship to develop their personal skills, whereas others feel that is it a valuable addition to their curriculum. On the other hand, some graduates have to choose for an internship since they cannot find a job directly and this might help them in the right direction. I did not know exactly whether I wanted to focus the second half of my Master's education on one of the aspects of Building Physics, or whether I might have chosen to keep a broader orientation. Another reason for an internship might be to have a practical orientation on your graduation project or maybe even since it is simply compulsory. There are many reasons why one could do an internship. For students who start their Master's degree in September 2015, there is no choice anymore: doing an internship (abroad) will be a compulsory element of their education.

Where to start?

If you are thinking about an internship, it is smart to make a list of your preferences. Do you want to cooperate in a company and work on their projects, or do you want to perform your own research with supervision from the company? Do you want to delve into a specific aspect of building physics, or a broad internship with many different aspects? Will you have delay in your study because of the internship? How many days do you want to have internship and will you be taking any courses next to this internship? And last but not least: did you know that you can obtain study credits for your internship?!

When looking for an internship position, I can recommend you to visit activities organized by Mollier such as the Meet&Greet or lunch lectures. Companies have short presentations and you will have the ability to network afterwards. This is also the way I used to find an internship. Mollier's website also lists ads by companies looking for internship trainees. As third



option you might want to visit bouwfysica.nl. On this platform, both companies and students are able to place messages for internship requests. And last: the Inside! Even in this edition are ads printed for (graduation) internships.

It's all about you!

Are you still doubting? Maybe this will convince you. An internship is an wonderful addition to your resume: you will gain experience during your education, which you will not see at university. You will meet a lot of people, who can maybe help you later in your career. And there is a bonus: you can earn no less than 11 ECTS for your internship (course 7NN11). To get these credits, you must write an detailed internship report in which you explain your personal goals, motivation and experiences.

I can recommand an internshiwp to you all. Make the best of it!

My experiences at Royal HaskoningDHV

During the first semester of this academic year, I performed an internship at the Fire Safety and Security department of Royal HaskoningDHV. Supervised by Daan Jansen, I focused completely on topic of fire safety – and not without a reason.

As a little girl I have seen the enormous panic when fire starts in a building. People were screaming and running while the flames were becoming bigger and engulfed the building. This left a deep impression that it influenced my choices during my education. In all my Bachelor projects, fire safety has been a recurring item. In the multidisciplinary project, the choice for securing safe egress was an easy choice. And during the first year of my Master, I performed a project under supervision of Ruud van Herpen (Fellow Fire Safety Engineering) and followed his course. This project was very interesting, but I wanted to know more. I already had a little knowledge about the Dutch legislation, but what does a fire safety consultant more than applying the rules?

One of the projects I worked on during my internship is Prinses Máxima Centrum in Utrecht. In this Pediatric Oncology Center, children will be hospitalized for their treatment. But also laboratory research to the treatment of cancer will take place in the same building. The areas in which the young patients will stay with their parents are completely designed for the patients. The attention is in the detail: counters are adapted with little steps to include children in conversations and each child will get his or her own room, adjacent to the room of the parents. In this project, I assisted during the development of the total fire safety plan. In this document, the structural fire protection systems (e.g. fire barriers), electrotechnical services (e.g. fire detection or sprinkler system) and organizational arrangements (e.g. in-house emergency plan) are described. The new building must comply with the minimum requirements applied in the Dutch Building Code, but also the client has is its wishes and requirements. Furthermore, coordination with the statutory authority (fire service) is needed. They must approve the total safety concept before the construction of the new building starts.

I have worked on a lot of different projects, from a new subway line in Saudi Arabia up to the renovation of a monastery. Every project presents its own challenges and every project needs a unique approach. I learned a lot during my internship. And I enjoyed working for Royal HaskoningDHV. After this internship, I decided to do my graduation project on topic of fire safety. I hope to work one day as a fire safety consultant as well.

Are you looking for an international challenge?



At Deerns we are always looking for young, technical talents with an academic engineering degree. Are you an innovator? Are you a team player? And do you want to work in an international environment? Than Deerns is the right choice for you.

Deerns, founded in 1928 in the Netherlands, has become an international engineering firm with 600 staff working from twelve countries. Deerns serves clients in the markets of airports, data centres, cleanroom technology, commercial and public office real estate, leisure and culture, and health care, with an innovative focus on energy and material efficiency.

...brings concepts to life

Abu Dhabi International Airport

www.deerns.com/vacancies

'Digital Building Management' All information up to date, fast, reliable, fully accessible and always available.

There is a lot of interest in the market for the Digital Building Management app that was presented in the autumn of last year by engineering and consultants agency LBPISIGHT from Nieuwegein. The interest in the app isn't misplaced seeing as it means an entirely new approach to building management; all information will be available in a more secure, faster, cheaper and efficient way.

Text and Figures: LBP|SIGHT & First Polygon

Digital Building Management will mean an end to filingcabinets and folders full of permits, technical descriptions, material specifications and plans in various different formats, many of which aren't even relevant anymore. Above all, a lot of data isn't up to date because of the differences in legal requirements. Studies show that a building manager loses up to 30 percent of his time searching because of this out-dated method!

The app will replace this undesired time and money-wasting state of affairs that can lead to dangerous situations. Digital Building Management is developed by LBP|SIGHT together with the young company First Polygon from Utrecht, who specialise in developing interactive 3D apps.

BIG TIME SAVER

"This very advanced and extremely reliable technology offers unprecedented possibilities in the management of large buildings," says engineer Hans Geleijns of LBP|SIGHT. "With literally just the touch of a fingertip on a wall or other parts of a building, a complete and current dossier will appear in 3D with materials used, regulations, technical specifications and other relevant details (figure 1)." This will not only save a huge amount of time, but also the accuracy and safety will benefit. According to Geleijns: "With all projects, changes are made during the construction that depart from the original plans which means that the data on file in physical documents is no longer accurate in the management phase." Analogue archives are often unavailable, not current and incomplete.

INTUITIVE AND USER-FRIENDLY

The app by LBP|SIGHT and First Polygon will not only save time, but also mean a faster response should calamities occur, thanks to the quality of information available. "The Dutch Fire Department is interested in the app with good reason," says Hans Geleijns of LBP|SIGHT. "In the future, fire brigades will be able to see what situation awaits them, even while en-route to the incident. It is clear that this will benefit the safety of buildings greatly."

Digital Building Management allows the manager access to a 3D model of the building, which he can navigate, with information in layers making it simple to update. He can communicate directly through the app with suppliers, maintenance departments and other relevant parties. "In this app we visualise the building", Willem Noyons of First Polygon explains, "the programme is navigable, as though you were walking through the building in a natural, intuitive way. With the arrival of internet and Google, the way we look up information has changed a lot, but we are looking to make an even bigger improvement," according to Noyons. "With Digital Building Management, we are making all the data linked with a building visual and therefore more easily accessible. This is also an important development in the world of BIM's, Building Information Models, which are becoming increasingly important in the international construction sector."

EXTREMELY SECURE

Because all data is safely stored in the cloud and managed by an expert at LBP|SIGHT, the information is always up to date and reliable. "That takes away a responsibility from the owner and manager of a building," says Noyons."Especially if you take into consideration that you can test and monitor the Wi-Fi, air-conditioning, heating and climate control constantly right in the app (figure 2). If something isn't working properly, the manager is notified straight away. All maintenance schedules can be linked to the agenda which benefits the energy efficiency and sustainability of a building."

REVOLUTIONARY

ans Geleijns is convinced of the revolutionary implications of Digital Building Management for the management of bigger buildings and that's why he isn't surprised by



Figure 1 Complete building dossier in 3D on your tablet

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the amount of interest the app is generating in the market. "This app is a beautiful and practical result that combines the experience and expertise of LBP|SIGHT and the gaming creativity of the young, bright people at First Polygon. For the first time, these two worlds meet and that has led to something excitingly innovative."

Willem Noyons agrees wholeheartedly with that sentiment. "We at First Polygon use our experience in the gaming industry when creating and developing our products," he says. "Utrecht is known as the gaming capital of the world. This app is a good example of serious gaming where practical usage takes the lead instead of entertainment," Noyons emphasizes. "It serves an important social purpose. The app Digital Building Management is the result of a collaboration between two completely different companies. Without each other's knowledge we would never have been able to create this fantastic product. And let's be honest: it's even fun to work with!"

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Schoone Leij Spring Activity



Figure 2 Test and monitor the Wi-Fi, air-conditioning, heating and climate control constantly right in the app

Or visit the website: www.digitaalgebouwbeheer.nl info@digitaalgebouwbeheer.nl

A SHORT INTRODUCTION

choone Leij is the alumni association S for graduates of the master program Building Physics and Services (BPS). So the alumni association is for 'old' Mollier-members. Students who have started with the specialisation BPS of the master track Architecture, Building and Planning (ABP) at the TU Eindhoven and are a member of Mollier, have the opportunity to become candidate members of the alumni association. As a candidate member it is possible to take part in the activities organised by Schoone Leij. This creates opportunities to meet 'old' students and possible future colleagues.

THE SPRING ACTIVITY

Saturday, the 2nd of May 2015, the yearly spring activity of Schoone Leij took place. After a delicious cup of coffee, tea or soda, we went for a workout on high level. The group was split in two for the first activity of the day. The program consisted of a parcours. Safely anchored at inhuman heights, we had several ropes, straps, braces and other very unpractical bridges to cross. While one group was hanging at these great heights, the other group was climbing a pole up to a small platform. Each time three persons reached the platform, they needed to lean back and fall off the platform while trusting their fellow Schoone Leij members to take care of a safe landing. Everyone reached the ground safely, although the temptation to let people hang helpless for a minute could not always be withstood by some of the safe keepers on the ground.

A fter safely accomplishing the two activities, the group was split in four smaller groups to build a catapult. Of course the competition was high, since only one group could shoot the farthest and win this battle. Surprisingly, the group with three of the four Schoone Leij board members won. This is probably due to their good teamwork.

After the physical activity, the barbecue was truly deserved. The good weather made it possible to sit outside, so we could chat about the day with some delicious thirst-quenching drinks.



Introduction of:



MARCEL VAN AARLE

Responsibilities at the BPS Lab:

- Calibration of sensors;
- Building Physics measurement technologies;
- Support in education;
- Support of master students and PhD of the chairs building physics, building performance and building services;
- Support and design of test setups.

WOUT VAN BOMMEL

Responsibilities at the BPS Lab:

- Hardware support dataloggers and sensors;
- Support, development, design and building of electrical and electronics parts test setups;
- General electrical and electronics support of master students and PhD in the laboratory.

HARRIE SMULDERS

Responsibilities at the BPS Lab:

- Linux, Labview, Python and Building physics software support;
- System administrator BPS high performance computing cluster;
- Design, development and maintenance of software for test set ups and dataloggers;
- Maintenance, design and development of databases and data websites;
- Chemical analysis and
 measurement technologies.



Responsibilities at the BPS Lab:

- Management of the laboratory;Financial controller of the unit BPS;
- Support of master students and PhD of the chairs building light, building physics, Building per formance, building services and building materials;
- Linux, Radiance, Python and data loggers software development and support;
- Support and design of test setups;
- Safety (BHV).

ANNEKE DELSING

Responsibilities at the BPS Lab:

- Support in physical and chemical analyses and measurement technologies;
- Support of master students and PhD of the chairs building materials , building physics and building performance;
- Support and design of test setups;
- Safety (BHV).

GEERT-JAN MAAS

Responsibilities at the BPS Lab:

- Mechanical support, design, development and building of test setups;
- General mechanical support of master students and PhD in the laboratory;
- Maintenance mechanical components machines and test setups.







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Study Abroad Christina Randjiet-Singh



ello, my name is Christina. Some of you might know me from the 18th board of s.v.b.p.s. Mollier. Last year I started my graduation project and I decided to do this in collaboration with Rural Spark. Rural Spark is a company that tries to provide everyone in rural India with electricity by means of a solar panel energy kit. Doing this project was an easy choice, because I'm interested in renewable sources and India was also on my bucket list to return to my roots.

On the third of November, I left the cold Netherlands for warm and dusty India. Once I had arrived in India, one of the employees of Rural Spark picked me up and brought me to the home office where I would stay. The journey to the office was a whole new experience, with all the traffic, people, honking and dusty air. The next day, the journey to rural India started: a 12 hour train ride from Delhi to Gaya. Together with three other Rural Spark employees we traveled to the train station, with the knowledge that two of our four train tickets weren't confirmed yet. This resulted in a last minute plan in which two of us traveled by train (upgrade to first class) and the other two by air plane. I got lucky and could travel first class: what an experience!

n the first class I was welcomed with a rose and received a lot of snacks, water, tea, juices and dinner. After dinner, they



mop your wagon and even spray some refresher. After a 12 hour long ride we arrived at Gaya station at 4 o'clock in the morning. I didn't expect that there would be so many people at the station at this time.

he next day Kunal, Rural Spark's local agent, took us to customers of Rural Spark. I gained a broader understanding of how they live by interviewing them. It's almost unbelievable that these people don't have electricity. They are also lacking normal facilities like a bathroom, sewer, running water while gas is also missing. Instead, they have to wash themselves with water from a ground water pump, and they have to do their sanitary needs in the open sewer. They use cow dung for cooking and take about 3 hours to prepare the meal. Normally dinner should be ready before dark, but with the energy kit of Rural Spark it is possible to charge lamps and cook after sun set. The energy kit is of value to the local people, but the lights do not charge well when it is cloudy. Another notable issue is the lack of knowledge about maintaining the parts of the product, such as the PV panel. It is up to me to find a solution to make the Rural Spark products more reliable and usable in rural India.

A fter all these very interesting observations, the train ride back to Delhi was even more exciting than the outward journey, because none of us had confirmed tickets which resulted in bribing the conductor. Miraculously, it worked and we all got back to Delhi safely. The rest of the week I spent time at Rural Spark and experienced working live in India. I experienced the Indian way of negotiating, Indian culture and food, and got used to the chaotic traffic.

With a lot of impressive memories I went back to the Netherlands. The discovery that I have my roots in Bihar, the state that I visited and where I experienced that I could understand the people better, made the trip bahuta acccha!

Photometric assessment of an optical fibre laser lighting system

dr. ir. M.B.C. Aries W. Westerhout Prof. Dr.-Ing. A. Rosemann

INTRODUCTION

Optical fibres can be applied to highlight objects and buildings at moments with low or no daylight. This allows to emphasize the overall shape of a building or to draw attention to a specific part thereof. The optical fibre is fed with a light source at one or both ends of the fibre. Originally, these light sources are Metal-Halide (MH) reflector lamps which have a high system luminous efficacy of around 75-100 lumens per watt. The nominal system wattage of projectors equipped with these lamps is generally rather high (200 W and up). Laser light is quasi-monochromatic, meaning that that light output contains only one wavelength. The human eye is not equally sensitive for all wavelengths of the visual spectrum, and therefore different optical fibre lighting systems will be perceived differently if fed with various coloured laser lights.

The research project "Energy-efficient Façade Lighting" was funded by the 3TU.Bouw Foundation within the first Lighthouse call alongside with additional in-kind contributions from BL Innovative Lighting, Vancouver, BC, Canada. Experiments were carried out by the Building Lighting group of TU Eindhoven (TU/e). Within the project students and researchers worked on the photometric assessment of the optical fibre laser lighting system as well as the analysis of the system's energy-efficiency. The system was demonstrated though a temporary pilot installation on the roof of the TU Vertigo low-rise building.

METHODOLOGY

A fter energy performance determination, photometric assessment focused on two main sets of measurements: illuminance measurements indicating the relative luminous flux coupled out from the fibre, and luminance measurements under different observation angles. In order to characterize a luminaire that is up to 80 m long, specialized setups were designed to carry out the measurements required for the characterization of the overall system.

The project was executed in the laboratory of the Building Physics and Systems (BPS) group of the TU/e Department of the Built Environment. This laboratory includes a lockable facility equipped for laser research and meets all health and safety criteria for working with laser light sources. Appropriate laser goggles hing the applicable wavelengths were worn while operating the laser lights.

The optical fibre used in this research is a BLFO-SL Solid Core Side Light Optical Fibre with a length of 80 m and a diameter of 1.27 cm (0.5 inch). These transparent thermoplastic fibres are made of poly-methyl methacrylate (PMMA), allowing for radiant illumination along its length. PMMA is resistant to heat, vibration, and elongation. The BL Side Light Optical Fibre can be used indoors and outdoors. Outdoor applications have to include an appropriate (additional) UV protection, which was not applied during the photometric measurements of the fibre system.

The photometric assessment was done for three laser types (Changchun New Industries Optoelectronics Tech. Co., Ltd.) with monochromatic colours red (HD-655-HS-4W; λ =655 nm), green (MGL-F-532-2W; λ =532 nm), and blue (SD-447-HS-4W; λ = 447nm). The different laser types connected to the fibres are shown in Figure 1. Each laser had an optical on/off sensor (safety switch) and was connected to a matching power supply (e.g., 90-264VAC-type PSU-H-FDA for the green system).

This article focuses on the photometric assessment of system's relative luminous flux output. Additional measurements carried out within the project also include the system's power consumption, it's the temperature dependence of the luminous flux output and the luminance under various viewing angles.

The main photometric characteristic assessed is the luminous flux which can be obtained by integrating the illuminance over a closed surface around a light source. Illuminance measurements allow to determine the relative luminous flux leaving the fibre at a given point along its length.

The illuminance measurements were carried out using a Hagner E4-x illuminance meter along the fibre as well as around the fibre. This gave an indication over the attenuation of the extracted light and also the uniformity of the light extraction. These measurements involved a mat black,



Figure 1 The three laser types (red, green, and blue) connected to an 80 m long fibre

light-tight box, specifically developed and designed for this experiment (see Figure 2). Measurements were taken every four meters along the total fibre length of 80 m. Since the illuminance sensor was very close to the fibre, this can be regarded as an indicator for the relative luminous flux leaving the fibre at that particular point. During the measurements the box was also covered by a black cloth to avoid surrounding light admittance. While the fibre was kept in its position, the sensor box was turned around the diameter of the fibre to measure the output in the four main directions top, right, bottom, and left output (0, 90°, 180°, and 270° respectively), as a measure for the uniformity in all directions. All these measurements were done with all three available laser types (red, green, blue) for uni-directional and bi-directional feeding (i.e., the lasers were attached on one end and on both ends of the optical fibre respectively).



Figure 4 Illuminance measurements around the fibre along its length together with the mean value per measurement



Figure 2 Light-tight box (accompanied by a distance meter) to measure the relative luminous flux leaving the fibre

RESULTS

The illuminance measurements described here represent the data collected from the green laser (λ = 532 nm) system only. As the results in Figure 3 show, the illuminance for a uni-directionally fed system (represented by a dotted green line in the figure) attenuates over the length of the fibre. The data for a system fed by only one laser shows that the relative luminous flux drops by one order of magnitude at a distance of approximately 55 m. A fibre system that is fed by two lasers (represented by a solid green line in Figure 3) shows the expected symmetric behaviour. The minimum occurs in the middle of the fibre. There the relative luminous flux is approximately 40% of its initial value. The measurements for a one laser system can be mirrored to calculate the relative luminous flux along the fibre. Calculations results and measurements results show a good match.

As a measure for the uniformity in all directions, the illuminance was measured on the four spots around the fibre (Top, Right, Bottom, and Left). Figure 4 shows the results for the four directions as well as the mean value based on the four values. The output over the entire length of the fibre is very uniform. The most noteworthy non-uniform light extraction can be observed at the beginning of the fibre. This is likely caused by slight misalignments of the laser axis and the axis of the fibre that are believed to cause non-uniform light losses at the beginning.



Figure 3 Illuminance measurements along 80 m of optical fibre, fed with one (dotted line) or two (continuous line) green laser lights

DISCUSSION AND CONCLUSIONS

The laser-fed optical fibre system can be used as a luminaire to highlight features of a building. The photometric assessment required a specialized device to characterize the relative luminous flux leaving the fibre along its length. Such a device was designed and built up within the project. The measurement data shows that this measurement device is a practical solution to perform the measurements within a reasonable amount of time.

The results show the expected exponential decline of the relative luminous flux leaving the fibre along its length if the system is fed by one side only. For a bi-directionally fed fibre, the measurement results prove a symmetric distribution of the luminous flux. Overlaying the uni-directional data as if they were fed by either side corresponds very well to the measurements from the bi-directional system.

With the exception of the beginning of the fibre, the uniformity of relative luminous flux emitted in the four main directions are all very close. This indicates a uniform luminous intensity distribution around any point of the luminaire. The differences at the beginning of the fibre are explained by imperfect axes alignment of the feeding laser and the fibre. This can be overcome by system optimization within the final product design.

A fter 55 m, the relative luminous flux drops to about 10% of the initial luminous flux. That indicates that a difference in brightness can be detected between these two points. In a bi-directionally fed system, the ratio between minimum and maximum relative luminous flux is 0.4. This stays well within this 1:10 ratio so that there is no perceived difference in brightness distribution along the length of the fibre.

The system has been demonstrated between December 2014 and March 2015 at the roof of the TU Vertigo low-rise building and can be seen in figure 5.

The full reporting of the measurement results including luminance performance and the significant reduction of energy consumption will be submitted to a scientific journal.



Figure 5 Accent lighting at the roof of the TU Vertigo low-rise building



Verbind jezelf aan een veelzijdige technische carrière.

De realisatie van de A2 landtunnel. Het volledige energiesysteem van het Oosterdokseiland. De projecten van Cofely zijn al snel bijzonder. Als grootste technisch dienstverlener van Nederland kun je bij ons innovatieve oplossingen creëren voor bijvoorbeeld Shell, ASML, Heineken en Rijkswaterstaat. Of je nu technisch specialist bent en je vakinhoudelijk wilt verdiepen, of jezelf via een van onze Management Development

Programma's in een leidinggevende rol wilt ontwikkelen: binnen onze veelzijdige organisatie kies je zelf welke kant je op wilt. Cofely is groot maar persoonlijk, internationaal en toch dichtbij. Heb jij een passie voor techniek en de drive om het beste uit jezelf te halen? Ontdek dan hoe ver jij kunt komen op werkenbijcofely.nl of neem contact op per e-mail via Larren.van.meeteren@cofely-gdfsuez.nl.



A local ventilation system for the operating theatre

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 Royal HaskoningDHV, Eindhoven, The Netherlands
 Interflow, Wieringerwerf, The Netherlands



Figure 1 Impression of the local ventilation system; (a, b) configuration 1 with clean air supply around and parallel to the wound area and instruments, (c, d) configuration 2 with clean air supply from the top surface of the blanket and instrument table.

INTRODUCTION

surgical site infection (SSI) occurred in 2.9% of all surgical operations in conventionally ventilated operating theatres (OT) in The Netherlands (PREZIES, 2012). A SSI is associated with a serious health risk of the patient and increased healthcare costs. Lidwell et al. (1982) found a significant positive correlation between the contamination of the air and the number of SSIs in OT. As a result, the effectiveness of unidirectional flow (UDF) ventilation systems have been studied increasingly and such a system was prescribed in Dutch guidelines. Although the system performs properly in an at rest situation, several studies showed concerns related to the position of the surgical light, limited space available for the operating team and instrument tables. Furthermore, clean air first passes the surgeon before reaching the wound, while research has shown that persons are the main source of bacteria in the OT.

ontrary to the previous Dutch guideline, in 2014 a performance based guideline was introduced which offered the opportunity to develop alternative ventilation systems for the OT (WIP, 2014). Therefore, a new ventilation system is researched in this study which makes use of a reversed airflow direction, from critical to less critical areas. The clean air supply is released around the wound area from a blanket which is spread out over the patient's body during the operation. Two configurations were designed: configuration 1 concerns a blanket where HEPA-filtered air is supplied around and parallel to the wound area (figure 1a); configuration 2 makes use of HEPA-filtered air which is supplied from the top surface of the blanket, perpendicular to the wound area (figure 1c). Similar approaches were applied to the instrument tables as well (figure Ib and d). The performance of the local ventilation systems was studied in a fullscale experimental set-up. However, first a parameter study was applied in order to evaluate a wide range of situations.

PARAMETER STUDY

A parameter study was performed on a simplified model, which represents the wound area of the patient and its immediate surrounding (figure 2). Both particle measurements and computational fluid dynamics (CFD) simulations were performed to investigate the performance. Particles of size 0.5-0.7µm were measured in the center of the wound at 0.12m height (figure 3). Next to this, Steady-state RANS CFD simulations using a RSM model were performed on a replica of the experimental model (figure 3). Contamination was modeled as a scalar.

The supply velocity and supply temperature of the clean airflow were the two most critical parameters. For the non-isothermal situation the supply temperature of the clean airflow was 22°C higher than the contaminated air in order to prevent for hypothermia of the patient. For configuration 2 a supply temperature of 5°C lower than the contaminated airflow was considered to increase comfort for the surgeons.

easurement results of configuration I showed that a higher supply velocity of the filtered airflow significantly reduced the particle concentrations, while a higher supply temperature significantly increased the particle concentration. No significant differences were observed for different velocities and temperatures of the filtered airflow regarding configuration 2. Furthermore, under isothermal conditions, comparison of configuration 1 and 2 showed no significant difference in the measured relative particle concentration at a supply velocity of 0.40m/s and 0.30m/s respectively. The smoke visualization and CFD simulations demonstrated that for both configurations a layer of clean air is created around the wound (figure 4 and 5). In general, simulated particle concentrations showed similar trends as the measurement results although results were more positive compared to the measurements.





Figure 3 Impression of the measurement model at the TU/e, which was used for the parameter study (above) and used grid for the CFD study (below).



Figure 2 Origin of the geometry for the parameter study. The geometry represents the wound area with a contaminated airflow (red arrows) coming from the side of the surgeon and HEPA-filtered airflow (blue arrows) supplied at the wound area (configuration 1) or from the top surface of the blanket (configuration 2). The outlet was located at the right side, opposite to the contaminant supply.



Figure 4 Smoke visualization of the contaminated airflow in the measurement model under isothermal condition of configuration 1 (left) and configuration 2 (right). In both situations it is clear that the contaminated air is lifted over the wound area.



Figure 5 Smoke visualization of the contaminated airflow in the measurement model under isothermal condition of configuration 1(left) and configuration 2 (right). In both situations it is clear that the contaminated air is lifted over the wound area.

In conclusion, based on the results of the parameter study a supply velocity of 0.40m/s and 0.30m/s was used in the full-scale setup for configuration 1 and configuration 2 respectively. Furthermore, for configuration 1 the non-isothermal situation could not be neglected in the full-scale setup and was therefore taken into account as well.

FULL-SCALE STUDY – METHOD

Next, the performance of a prototype of the local ventilation systems was explored in a full-scale mock-up OT at Interflow, illustrated by figure 6. Particle measurements ($\geq 0.5 \mu$ m) were performed in an at rest situation, without people, according to the Dutch guideline (VCCN RL7, 2014). There was no additional ventilation in the OT and the fans for the local ventilation devices were placed outside the OT. A relative particle concentration was derived by comparing the particle concentration in the contaminated periphery. Measurements were divided over two series to improve the reliability of the data. Furthermore, smoke tests were conducted to visualize the airflows.

FULL-SCALE STUDY – RESULTS AND DISCUSSION

The results of the full-scale measurements are demonstrated by table 1. Regarding the ventilated blanket, a significant difference was observed between the two measurement series of the same configuration. The differences were probably caused by imperfections of the hand-made prototypes. Smoke tests showed that for configuration 1 turbulent air was supplied from the long side of the blanket, while a more constant airflow was supplied from the short side (figure 7, left and middle). Regarding configuration 2, entrapment of contaminants in a local eddy above the wound area caused a high range of relative particle concentrations (figure 7, right). Summarizing, configuration 1 yielded significant lower relative particle concentrations in the wound area than configuration 2. However, a relative particle concentration of O.1%, as required by the WIP (2014), was not met for both configurations.

The instrument tables of both configurations demonstrated more uniform results compared to the ventilated blankets. The instrument table of configuration 2 satisfied the Dutch standard, while the instrument table of configuration I demonstrated significantly higher relative particle concentrations.

Table 1 Median (range) of the relative particle concentration [%] for particles \geq 0.5µm (N=60). The topview shows location of the measurement positions.



• Cblanket	

	Series 1 Series 2		
Configuration 1	5.0 (1.0-10.5)	0.9 (0.2-6.7)	
Configuration 2	1.7 (0.5-4.5)	6.1 (0.8-28.5)	
C _{table}			
Configuration 1	1.7 (0.5-3.1)	1.7 (0.5-3.1) 0.7 (0.3-1.9)	
Configuration 2	0.0 (0.0-0.0)	N/A	





Figure 6 Full-scale test setup of the ventilating blanket and instrument table of configuration 1 (above) and configuration 2 (below) in the mock-up of the OT, the blue arrows indicate the clean airflows.



Figure 7 Smoke tests for the long and short side for the configuration 1 blanket (left, middle) and the short side for configuration 2 (right).

FUTURE APPLICATIONS

A ccording to the Dutch guideline the full-scale measurements showed that only the ventilated instrument table of configuration 2 was sufficient. For this reason, this could be a promising solution for application in OTs, for instance as an addition to the vertical UDF system to enlarge the clean area. Although results of the other ventilation devices did not satisfy the guideline, they might be used as an addition to OTs with a mixed ventilation system to improve the air quality at wound level and around the instruments. Furthermore, the local ventilation devices might be applied outside the OT where in that case operations can occur more safely (i.e. during field operations, operations in treatment rooms).

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Wil jij zien op welke wijze Heijmans aan de ruimtelijke contouren van morgen bouwt? En ben jij nieuwsgierig welke spraakmakende en innovatieve concepten Heijmans ontwikkelt en realiseert?

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ໂາຍເງັmans







Building Materials

_ara Quaas

ECO - concrete

INTRODUCTION

Most of you will probably know, but still I want to remind you of the difference between cement, mortar and concrete. Cement is the binding element in mortar and concrete. Mortar is composed of cement and sand. Water is added to hydrate the cement and provide the binding in the mix in order to get into a solid state. Finally concrete, it is mainly composed of cement, sand and gravel or other aggregates. Concrete has a higher strength due to the aggregates in it. Whereas concrete can stand alone, mortar is used to hold together components such as bricks or stones.



Figure 1 MSW incineration process



Figure 2 Bottom ash

Figure 3 Overview of the tests

Therefore, in the project about ECO-concrete, we try to find a new recipe for mortar with a high sand replacement that has no negative effects on the strength or durability but with a lower CO_2 -footprint. In my project I mainly focus on bottom ash fines as a sand replacement and other by-products as cement replacement. Bottom ash is a Municipal solid waste incineration by-product. The municipal garbage is collected, separated and burnt. The process and its several by-products are shown in figure 1.

CO₂ - FOOTPRINT

ement-based building materials have a high environmental impact. To produce I ton of cement, 2 tons of raw materials are required. This process causes 4% of the global CO₂emissions through the decomposition of limestone and another 4% from fuel combustion. That makes 8% in total. This is the reason why it is necessary to try to improve the material to reach a smaller CO2 footprint. The replacement of cement with other cement-like materials or the replacement of aggregates made from waste products is therefore beneficial for the environment. It also has positive effects on the sustainability because the amount of raw materials needed will be reduced.

USE OF MSWI BOTTOM ASH IN CONCRETE MIXTURES

Bottom ash, shown in figure 2, is a heterogeneous material, which contains glass particles, synthetic ceramics fragments, minerals, metals and unburnt organic matter. The dimensions of the particles can range between 0 - 40 mm. Certain waste particles in the bottom ash can contain large concentrations of contaminants, such as heavy metals that are mainly absorbed by the smaller size bottom ash particles, which can lead to higher emissions. Bottom ash is mainly used as a road base material so far, but it can also be upgraded for use in concrete mixes. This replacement can still have an non-beneficial effect on the strength of the concrete that is going to be made, and this is the main problem.

METHODS

Before a recipe with bottom ash can be made, some tests meed to be done to investigate the characteristics of the material. Some of those tests are for instance laser diffraction to investigate the particle size distributions and density measurements or XRF measurements that detect which elements the sample contains. Also leaching tests need to be performed to find out how much impact the material has on the environment. Therefore, it will be measured how many contaminants will leach out, as it would when it is applied in a building exposed to rain. An overview of some of those tests is shown in figure 3.

Those tests will give some results which are summarized in figures like figure 4. With the gathered information recipes can be made and tested. The first thing investigated is the flowability of a fresh mixture. Then the mortar will be poured in moulds and the strength in a hardened state will be tested after 1, 3, 7 and 28 days. Afterwards, the environmental leaching test procedure needs to be redone for the crushed samples to investigate how much the material is still contaminated. The crushed parts will be reused as aggregates in new mixtures, and tested again to find the best recipe.





Building Physics

Menno Spierenburg & Simone Teuwen

Thermal insulation of a vault in monumental churches

INTRODUCTION

he reduction of energy consumption is an important research subject as a part of sustainability in the built environment. This topic is trending for both new built and renovation projects. Within the context of sustainability and cost reduction for monumental churches, the possibilities for applying thermal insulation are investigated in this master project. Thermal insulation is often not applied, because a proper vapor barrier cannot be provided. Therefore, a high risk of damaging the construction or deterioration of the insulation material occurs, which is not allowed for monumental buildings. However in the context of energy savings, vault insulation might be a suitable solution. In this case, indoor climate change and energy saving potential are important parameters which have to be analyzed as well.

Until now, there is often no proper argument to substantiate the application of vault insulation in monumental churches. Unfortunately in this case, minimal scientific literature is available about vault insulation in particular. That is why the general information regarding insulation of monumental buildings is combined with a field study of four churches in the Netherlands. Two churches were selected with vault insulation – Pieterskerk Leiden and Protestantse kerk Beusichem-Zoelemond - , both provided with a wooden construction. And two churches without vault insulation - Church in Beets and Petruskerk Eindhoven - were investigated, respectively with a wooden and a stony vault.

CHURCHES WITH VAULT INSULATION

s the analysis of the cases without insulation proves, insulating a wooden vault is possible without damaging the construction. However, the application of the insulation material has to be performed carefully. An air tight construction is important hereby. In this research simulations are performed with COMSOL, where the boundary conditions are extracted from both measurements and HAMbase simulations. According to the simulations, no surface or internal condensation will occur in both churches, which leads to low damage risks

he results however have to be analyzed with caution. That is because the analysis is based on a simulation length of one year, while it is important to evaluate multiple years to predict if moisture storage occurs. Unfortunately, at one church moisture damage was visible during visitation, which cannot be explained with the simulation results. The mismatch between simulation results and the actual situation might be caused by the simplified simulation models, since several assumptions for boundary conditions had to be made. It is also possible that the damage was not caused by the additional insulation material, which was the main focus of the analysis. Further research is needed to investigate this aspect and to provide a general conclusion since only a small part of the vault is investigated in both cases.

CHURCHES WITHOUT VAULT INSULATION

Obtained insights from the literature and from the cases with insulation provide the information to predict the influence of vault insulation in noninsulated churches. The research of



Figure 1 Nave of the Petruskerk Eindhoven, which currently has an uninsulated stony vault



Figure 2 Simulation position visualized in 3D. The underlined text corresponds with the simulation group. The standard text corresponds to the exact position within the group.

the church in Beets is still ongoing. For the Petruskerk Eindhoven - which has a stony vault, as can be seen at Figure 1 - both measurements and simulations were performed. For the simulations an insulation material is applied with a high moisture resistance. This material already shows good results, compared with the other churches. Insulation with a thickness between 30mm and 100mm proved to have the highest energy reduction with the least amount of material. Figure 3 shows that adding insulation increases the relative humidity near thermal bridges, still for both 30mm and 100mm insulation there is no risk at condensation. The models used for simulating are similar to the models of the churches with insulation, therefore further research is required to see if insulating the vault indeed could be performed without damaging the construction.



Figure 3 Temperature and relative humidity simulations positioned at the transverse rib. The simulation shows a comparison between the current situation without insulation (solid) and the situation with 30mm insulation (dotted) for the year 2014.

Building Acoustics

Wouter Reijnders

The Distance in Parameter Errors

This research is a continuation on: *Room in Room Acoustics: Using Convolutions to find the Impact of a Listening Room on Recording Acoustics*', by Hak & Wenmaekers [1]

BACKGROUND

Room in room acoustics is about the effects of a room on a reproduced sound. It is imaginable that the acoustics of a playback room influence the capability of hearing fine details in recorded sound. Research found that the reverberation time of the playback room must be half of the recording room in order to hear (i.e. perceive) the same reverberation time [2].

Most of the research done within this topic is conducted with impulse response measurements performed in the diffuse field. The question that needs an answer is: What acoustic properties are needed in order to assess hard to hear acoustical parameters when a sound is reproduced? The goal of this research is to find the influence of the direct field.



Figure 1 Photo taken during the measurements

METHOD

To assess the direct field, measurements were done in a sport hall at the student sport centre, a sport hall suits the research well because there are no walls near the receiver to cause reflections. The measurements consisted of 100 impulse responses equally divided along a 10 meter line out of the centre of the source.

The sound level difference in the first 50 ms of the Schroeder decay curve (from now on referred to as initial step) is used to describe the presence of the direct field, see figure 2 (left). The Schroeder decay curve results after backwards integration of the squared impulse response and is frequency depended.



Figure 2 Left: first 50 ms of the Schroeder decay curve for the measurement at 2.5m from the source and the octave band 1 kHz; right: sound level difference in the first 50 ms (i.e. $\Delta S(t) = S(0) - S(0.05)$) of the Schroeder decay curve for 100 measurements for measurements in the octave band 1 kHz



Figure 3 Overview of the deviation made in parameters plotted against the initial step: T20 (reverberation time); C80 (clarity); TS (centre time), all sources presented in this figure have the same signal. Light blue: 125 Hz; green: 250 Hz; dark blue: 500 Hz; red: 1 kHz; black: 2 kHz; the dashed line represents the JND.

By means of linear increasing source receiver distance (small steps) the course of the initial step can be determined, figure 2 (right) shows the sound level difference in the initial step as a function of the source receiver distance.

To find the magnitude of the influence of the room, a signal with known acoustic characteristics is virtually reproduced over all impulse responses. Then a comparison is made with the source signal to find the influence or error caused by the room.

or acoustical parameters a just noticeable difference (JND) is defined (i.e. 50% of the people were not able to detect a smaller difference). The JND is used to find a minimal initial step where the error is below the JND.

RESULTS AND DISCUSSION

igure 3 presents an overview of the deviations in room acoustic parameters: T2O is the reverberation time, C8O is the clarity which is an early to late energy ratio and Ts is the centre time which is calculated as the centre of gravity of the squared impulse response.

The results are allwderived from one room and only the first ten meters are measured. The first step in the Schroeder decay curve appears to be a very good indicator of the direct field, research is needed to determine if this can be done for all room impulse responses. With increasing initial step the error decreases, this can be seen in all octave bands and besides the presented parameter similar results are found for: definition and the modulation transfer index (about speech intelligibility).

CONCLUSION

The initial step in the Schroeder decay curve should be at least 20 dB (in all octave bands!) in order to reduce the influence of the room on reproduced sounds to below the JND of room acoustic parameters. This holds for the room this research was conducted in.

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[2] C. C. J. M. Hak and R. H. C. Wenmaekers, "The Effect of Room Acoustics on the Perceived Acoustics of Reproduced Sound," Proceedings of the Internoise, 2008.

Stichting Promotie Installatietechniek (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.







SEB&C Smart Energy Buildings and Cities

A PROFESSIONAL DOCTORATE IN ENGINEERING, SMART ENERGY BUILDINGS AND CITIES'

That is quite a mouthful, but what is it exactly?

PDENG PROGRAM

APDEng program is a two-year (post-Master) designer's program which is part of the Stan Ackermans Institute. This institute has operated since mid-2006 on behalf of the three universities of technology in the Netherlands (Eindhoven, Delft and Twente) as the 3TU.School for Technological Design, Stan Ackermans Institute. Similar to a doctoral candidate a PDEng'er has the status of employee of the University and will receive a Professional Doctorate in Engineering (PDEng degree) when completing the program successfully. The program consists of a first year of professional, technical, entrepreneurial preparation and advanced education, followed by a major design project in a company.

SMART ENERGY BUILDINGS & CITIES PROGRAM

The SEB&C program is one of the many PDEng programs that are offered at the TU/e. In the Smart Energy Buildings ϑ Cities program MSc graduates are trained to become a technological designer. The goal is to integrate relevant knowledge in the field of energy and sustainability with a multi-disciplinary approach in a process of Integral Designing to a dedicated, Smart Energy system for the built environment. Based on the specialty, a SEBC designer can contribute to the development of.

- Intelligent and energy efficient building components and/or - Building concepts aimed at the intelligent use of as less as possible energy and/or

- Energy generation in the built environment, and/or

- Intelligent networks aimed at the alignment of supply and demand of energy.

- Investigate strategic development for innovating companies in the field of energy and sustainability.

he team that is in charge of the SEB&C program consists of prof.dr.ir. Jan Hensen (Scientific director), dr.ir. Pieter-Jan Hoes (Operational director), Nienke Vording (Industry liaison) and Francien Clijsters (Program assistant). They ensure the quality of the content of the program and strive to continuously evolve the program to make it better every year.

o this is what the PDEng SEB&C means in theory, but what $oldsymbol{ extsf{D}}$ does it look like in practice and who are the SEB&C'ers?

SEBC GROUP 2015

very year, after a couple of selection rounds, a group of about 10 trainees is selected to start the program at the end of January (application for 2016 will be open in August 2015). The team consists of a group of trainees with different educational backgrounds. This year, in which the fourth group of trainees started this program, the group consists of the following 7 trainees:



CRISTIAN BOSCHERI (Italy)

IMMANUEL GEESING

Technoloav.

(the Netherlands/Denmark)

Bachelor in Mechanical engineering and Master in Sustainable Energy

Energy Engineer with a MSc in Sustainable Energy technology.





MOHAMMADHOSSEIN GHASEMPOURABADI (Iran/Canada)

Registered architect who achieved two professional masters in Architecture and Building Engineering.



EVDOXIA PLOUMPIDOU (Greece)

Diploma in Electrical and Computer Engineering with specialization in Electrical Energy.



RAM RAMACHANDRA (India)

Degrees in Mechanical Engineering and Sustainable Energy Technology



KONSTANTINOS TZANAKAKIS (Greece)

Diploma of Electrical and Computer Engineering and completed a MSc in Sustainable Energy Technology



FINN VOSSEN (the Netherlands)

Master of Science in both Architecture and Building Physics & Services

So as you can see, the group is not only multidisciplinary but very multicultural as well. And that is precisely the reason why working in this group is so interesting. First, you gain exposure since everyone has a different background and his/her own favorite interests and passions regarding sustainability and the built environment. Secondly, you gain exposure since everyone grew up in a different culture with its own customs and habits.

 $\ensuremath{\mathsf{S}}$ o this is who we are, but what exactly are we doing every day?

CONTENT OF THE PROGRAM: YEAR 1

During the first year we are prepared for a company assignment in the second year. This means that every week, our program assistant Francien, makes sure our agenda is scheduled crammed with peer education, workshops for professional skills and entrepreneurship training. More in detail, this encompasses the following:

'e get workshops about topics within different disciplines, ${
m V}$ given by professional from different university faculties. In blocks of about 2 to 3 weeks we are educated in Building Sciences, Computer Sciences, Mechanical Engineering, Electrical Engineering, Chemical engineering and Physics. So don't be surprised to find yourself wearing a lab coat in the laboratory of chemical engineering doing experiments; to learn the language of programming; to get a guided tour by the architect of the flux-building; to be informed about the solar panels on the rooftop of the vertigo building etc. Additional to these knowledge workshops at the TU/e, which are often concluded with writing a report or doing a presentation, there are three international workshops in the first year, organized by universities participating in EIT (European Institute of Innovation and Technology) and on specific topics that are relevant to improve the in-depth knowledge required for the design cases.

urthermore, we get workshops to enhance professional skills. So far we were taught to give an elevator pitch, collect and develop ideas by brain writing, work in a group based on co-creation, enhance innovation performance based on LEGO play (yes, LEGO is still very useful when you are a post-master), give and get feedback, get to know your own personality by using the Myers-Briggs Type indicator (definitely worth it to google that!) etcetera.



Figure I Lego workshop



Figure 2 Company visit Imtech



Figure 3 Photo of the group

Next to these workshops, we work as a group on two integrated design projects in which we can apply the gained knowledge from the workshops and our own interests. The first project focuses on building and component scale, while the second is focuses on district scale in line with the course program.

ur first project consists in designing the sustainable renovation of the Potentiaal building at the TU/e campus. As you may know, the former Electrical Engineering building will be refurbished as a building for student housing, cultural activities of Scala and the University College. The design of this has already been made by DuraVermeer in cooperation with DiederenDirrix. However, we are challenged to make an even better, and of course more sustainable, design. Each of the members of our team uses his/her expertise, background and network to generate ideas about how to deal with this renovation. Hereby we have a broad overview about interesting technologies, companies and processes that are going to be very useful for our project. It is good to see how everyone has its own approach to a design problem: some are more practical, some more theoretical, some focus on building level, while other focus on component level. Everyone works on a part he or she is interested in or wants to gain more knowledge about. In June 2015 this project will be concluded after which we will start on our second project till January 2016.

YEAR 2

The second year of the program is reserved for the company assignment and we are expected to work within the company structure. Our Industry liaison, Nienke, looks for interesting companies that want to hire one of the trainees. Nienke will then match the company with the trainee that

suits the companies' request most. During this year we will be coached both by researchers from industry and university and the results will be used to come to new products or applications. With the gained skills in the first year, a business plan for implementation or marketing of the project or product will be made as well as part of the final report.

And after two years, we will be professionals that are able to create efficient, innovative and sustainable solutions in terms of planning, services, products, and designs for our future built environment.

opefully, it is now more clear what these people at the sixth floor next to the coffee machine are doing. Of course you are very welcome to come have a chat with us at VRT 6.07!

More information about us and the project we are doing can be found at our website. Here you can also find a blog about all things we like to share.

http://www.turningpotential.nl/

If you would like to have some more information about the SEB&C program you can find it both on the TU/e website and the website of the Stan Ackermans institute.

http://www.tue.nl/en/university/departments/built-environment/education/graduate-program-built-environment/designers-programs/smart-energy-buildings-cities/

http://www.3tu.nl/sai/en/programmes-and-tracks/sebc/



Figure 4 Potentiaal at TU/e campus

Building Services

Werner Vink

Productiveness as a next step towards energy management

Inlarged demands on electric energy combined with the implementation of new generation techniques increases the complexity of the electricity grid. High peak loads make power systems highly susceptible to instability as can be seen in the blackouts of USA in 2003, India and Brazil in 2012. To retain the grids distribution function it's needed to manage the supply and demand to avoid high peak demands, reducing the change on instability and blackout scenarios.

he built environment has a $\pm 40\%$ share on energy consumption in western countries, making it the biggest shareholder. Due to its big share unidentified potentials in the build environment can give outcome for smart energy control, also called smart grids. A smart grid strategy applicable to buildings is Demand Side Management (DSM). Goal of this strategy is to obtain energy efficiency and/or load shifting during peak demand hours (11:00 -17:00). Electric energy, especially in commercial buildings, is mainly used for the appliance of lighting, ventilation and cooling. When applying DSM this needs to be done in consideration with the effect on retaining the quality of the original designed task of the machinery.

ithin this research the focus was ${f V}$ on the chiller, where the first objective was on discovering energy management potential by means of cooling. The original designed task of a chiller is to retain Thermal Comfort (TC). When choosing to shut down the chiller for an x-amount of time, demand reduction will be obtained but comes with increasing risk on worsened TC. Especially in commercial buildings the occupant (employee) is the most expensive post for a building exploitation. Therefor the building owner is highly interest in minimizing the amount of Occupant Productivity Loss (OPL) that can occur.

Besides decreasing the demand of the chiller during peak hours, the effect it will have on TC and eventual OPL is one consideration of great importance. Productiveness refers to the quality of the final product, optimizing cost and quality of a unit energy. Regarding the topic of this research productiveness is defined as the ratio between energy cost and the quality of obtaining/ retaining the indoor TC by the chiller. Therefor the second objective was on providing an advise on creating an operation mode arranging DSM by means of productiveness.

irst numerical experiments where performed with a temperature bandwidth of 21-23°C. Second experiments where conducted using a temperature bandwidth of 21 - 25°C. Noticeable in the first experiment was that no load reduction could be obtained in the south-orientated room. For the second experiment only for lower ambient conditions some load reduction could be realized in the south-orientated room. For the north orientation in both experiments significant load reductions are realized. Where for the bandwidth 21-23°C an average of 10% reduction could be obtained and for 21-25°C an average reduction up to 40%.

A lthough significant reduction on chiller consumption could be obtained, arranging load reduction by means of productiveness means that it needs to be done in consideration with TC, or more detailed, OPL. From literature two methods where found, one stating that productivity loss is negligible between 21-25°C, the other using polynomial equations as a function of Predicted Mean Vote (PMV), generated from researches conducted over the years.

ventually, calculating indoor conditions in relation to potential smart grid services in this research is highly dependent on two variables; quantification of OPL and the difference between the economic value of OPL and energy management (i.e. load reduction). Productiveness optimization with the appliance of OPL as a function of PMV would resolve in lower risk on exceeding thermal comfort boundaries and retaining a better working climate compared to the method stating OPL is negligible within the temperature bandwidth 21-25°C. Nevertheless, besides the methods of OPL is chosen, when creating an operation mode that arranges by means of productiveness, it is advised that the flow chart of the operation mode is setup as presented in figure 1.



Figure 1 Flow chart for optimization DSM by means of productiveness





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Studytrip to China

Studytrip group

the restaurant. There we were served an exeptionally delicious dinner, with excellent guidance from our Chinese friends.



On May 14th the studytrip to China started for 20 members of Mollier. Beijing, Tainjing and Wuhan were the three destinations of this trip, together with assistant professor Qingliang Yu an enthousiast group departed to China.

FRIDAY MAY 15TH

The flight from Frankfurt to Beijing took approximately eight hours which was a quite long trip. The time difference between Schiphol and Beijing is six hours. When we arrived at 7 a.m. in Beijing, it was actually 1 a.m. back home, this was the start of the second day. The weather in Beijing was outstanding, except for some clouds which vanished after a while and luckily there was no smog.

A fter the lunch we arrived at ARUP. There we got a warm welcome and Arup gave a presentation about sustainable architecture and the role of Arup in its design. The visit ended with a presentation about the application and efficiency of elevators in highrise buildings. The view from ARUP's highrise office was amazing, because the office is situated at the 30th floor next to the CCTV tower, which is designed by the Dutch architect Rem Koolhaas.

n the evening we went to the Red Theater for a show with Kung Fu martial arts, the performance at the Red Theater of the acrobatic monks was spectacular.

SATURDAY MAY 16TH

With subway cards in our pockets and flip flops under our feet we began todays journey to the Lama Temple. It was quite the picture, although there were some doubts whether all artifacts were actually ancient. So far, we have been extremely lucky with the weather: 28 degrees Celsius and no smog in the sky. This is rather special for Beijing! The next stop was Tiananmen Square. An enormous square with numerous highlights. Our presence, a large group of long Western people with colorful hair, didn't go unnoticed and we were frequently photographed by the Chinese. Most pictures were intended to be taken secretly, but some were taken shamelessly in front of our face. The adjacent Forbidden City gave a good impression how the Chinese emperors and their entourage leisurely spended their time. The afternoon ended in style: everyone was dressed in traditional Chinese clothing for a photoshoot. Word of this got out guickly and within seconds we were surrounded by dozens of Chinese photographers. Those of us who were keen for some adventure got on a traditional Riksja for a trip to

SUNDAY MAY 17TH

After a short night we took a private bus at 8:00 A.M. to the Great Wall. Again, the weather was really nice; cloudy but warm. At 10:30 A.M. we arrived at the Great Wall and we started to hike to the top of the 'Jin Shan Ling' east gate. Once, we were on top of the wall the view was amazing. After the Great Wall we went to the Olympic Park of Beijing, where the 2008 Summer Olympics were played. Most of us took the opportunity to grab some sleep in the bus. Arrived at the Olympic Park, we first went to the Water Cube and followed a guick tour. The building was also analyzed by groups of two on different aspects of building physics and services. Next to the Water Cube was the Beijing National Stadium 'Birds nest'. There the members had some free time to explore this massive stadium. When the afternoon was over we left with the bus, since it became a little dark we could catch a small glance of the illuminated Water Cube. After the Olympic Park the bus dropped us at a restaurant where Xin made a good deal. This time, no weird food was put on the table and we enjoyed especially the Peking Duck.

MONDAY MAY 18TH

After 4 hours of sleep we had to leave at 8:00, during the morning rush of the Beijing metro system. Just to give you an overview of the morning rush, we tried to count the Chinese people. This resulted in 4576,5 Chinese, but do not forget the 21 blue colored Mollier members!

On our way to the University we got a little lost, a discussion about in which direction the sun is rising and if Peking differs from home did not help. Finally,



at 9:00 A.M. we got a warm welcome from professor Xudong Yang, who works for Tsinghua University that we were visiting. There we listened to five inspiring presentations from Chinese doctorate students. Between presentations the entire room was measured. Again a quick overview: the Chinese students were bothered with 15 hard English sentences for a speech intelligibility test, 3 dutch students were hanging out of the window trying to measure air particles, and 4 students made an attempt to keep the light out for indoor lighting measurements.

After an inspiring speech of Dr. Xiaobin Liu from the Oake Ridge National Laboratory in the US about ground source heat pumps, we were indulged with an amazing lunch. This lunch gave us strength for a long walk, read 8 km, around the university campus. This was a real new expericence for us, since it had a real green strip. Chinese spend their budget not on renovating and innovating buildings, but on parks, waterfalls, fountains, canals and grass. These facilities can al be found in the University campus. After our last supper in Beijing, we left with the strategy of throwing our luggage in the metro. And if you thought we had a crowd when putting on traditional Chinese clothing, you should have seen us waiting at the train station playing cards and football.

TUESDAY MAY 19TH

This day began when we arrived in Tianjin. After finding the hostel, we found a bar and had some fun. All the things you would expect from an Asian club were present, this resulted in a very short night's rest.

The next morning we visited Tianjin Port Museum, Tianjin Port cruise ship terminal, and a few places at Eco-city. This is a new city that is designed by specific sustainable values. It tries to ensure that its basics do not have the traditional disadvantages that most other cities developed over years. The last place we visited was a research building for low carbon emission, where several design solutions limit the exhaust of carbon dioxide. After visiting these buildings we went to an amazing dinner organized by a friend of dr. Yu.

WEDNESDAY MAY 20TH

Last night we were invited by a close study buddy of dr. Yu. At the restaurant there was plenty of food and drinks. We had a couple bottles of wine from Yu's buddy, these were imported just this day at Tianjin Port. As usual the night went on in a club.

Currently, we were well trained in waking up early. Manon had already prepared some pans to help us rise and shine softly at 7 next morning. However, above all expectations this was not necessary, since Manon underestimated



the liveliness of the participants. After a guick hangover breakfast, including a 'well' boiled egg, we left by taxi to Tianjin University. This was experienced very differently between cabs. Some of us could enjoy a singing driver, while others enjoyed a spitting driver, whom occasionly opened the door to empty his throat. Our private drivers brought us to our destination no matter what, dodging traffic jams by taking the curb or oncoming lanes, while of course honking loudly. When we finally arrived at the school of environmental sciences and engineering. The visit at the university consisted of sharing presentations and a tour over the campus. We were joined by 20 Chinese. A small speech intelligibility test was done in between presentations for our study related assignments. After a difficult explanation in English, the English test was performed... the results were as expected but led us to think the following. With their poor English we wondered if they even understood our presentations. At last, we could also enjoy a wonderful lunch at the campus cafeteria, here it was not unusual to find a long black hair in your meal. Afterwards, the program continued with a tour to the faculties architecture, civil engineering and environmental sciences and engineering.

In the evening we took the night train to Wuhan, and slept in three storey bunk beds.

THURSDAY MAY 21ST

After a good sleep in the nighttrain, we had arrived at Wuhan. With our private bus, arranged by Wuhan University of Technology (WUT) we drove to our hostel. This trip was quite an experience as there seems to be very less traffic rules, maybe they are colorblind, while there is no difference between red, orange and green traffic lights. Aside from that there are a lot of construction sites, that transform roads into a bumpy rollercoaster ride.

After dropping our suitcases at the hostel, we were led to the energy flower. The energy flower is a sustainable building. This has been achieved by making use of several modern systems, like PV panels, windturbine, natural ventilation. After a quick visit we drove to the WUT to install the measurement equipment for our assignments. While Dr. Yu gave a presentation at the University of Wuhan, we went to Hubu Alley, where we could taste local food, like octopus, frog and fruit salad, and where souvenirs were bought.

After that we were brought back to the university. From there we had a 20 minutes walk to the restaurant. Where we were invited for dinner by several different professors of WUT. This was a very luxurious restaurant. We were introduced to some new traditions of the WUT students during the delicious diner. The tradition is as following: To show your respect to someone during a dinner, you should toast with



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your guests. This is mostly done with the famous and lovely Chinese Liquor: rice wine!! To show your respect to one another, you should toast with all people who sit at that table.

FRIDAY MAY 22ND

In the morning a delicious breakfast was served, while everybody woke up enjoying the well known embedded marketing technique of the Efteling. The program of the day started with a tour over the campus of the Wuhan University.

The moment of truth was immediately after the tour: the measurements and the accompanying presentations. Unfortunately, most of it went 'into the soup' due to the many adaptations in the program. Therefore, a few groups were unable to obtain any relevant data.

When we left the university instead of driving, we were bouncing to the Technical Research Institute of Wuhan. Our program here was filled with irony and controversy from the point of view of building safety requirements. For example, research was conducted to the quality of safety helmets, while in the hall next to it, a glass facade of 15m high was constructed without any helmets or any other safety measures. After everyone had dinner and changed clothes, we got into cabs and went to the clubs to spend our time in the Chinese night scene.

SATURDAY MAY 23RD

After a successful night and a good night's rest, we actively joint the guided tour in Jiedaokou metro station in Wuhan. The guided tour was very nice and informative. We saw all the parts of the metro station you would normally never see, like the control panels, very large HVAC systems and fire safety facilities. The engineer who guided us helped with the design of the whole metro net and could tell us a lot of all the design challenges like the under and over windpressure, that is caused by the metro trains, and the solutions that he had made. Later we would find out this was an enormous privilege that we got the guided tour because this area was extremely forbidden for all outsiders.

The lunch was spend in Han street, which was one of the spectacular streets of Wuhan according to the local Chinese students. Han street was a street with typical old Chinese shops like H&M, C&A, Jack and Jones, etc..

SUNDAY 24TH

24th May was our last day in the city Wuhan, we went to Guiyuan Temple and Yellow Crane Tower. I did not know what interesting things they had in the day, but I went through the most exciting story during the entire studytrip which happened in that evening.

As planned, we arrived the railway station for the train back to Beijing. We ate dinner inside the station and everything went fine until we stood in line for boarding the train. we noticed the thrilling news from station broadcast: our train was delayed for at least 2.5 hours due to flood! dr. Yu immediately collected everyone's passport and rushed to the clerk at the boarding gate. That lady understood the situation and offered a solution that we refunded all tickets and bought standing tickets of the punctual train. On the very early morning of 25th May, we arrived in Beijing at Beijing West Railway Station. proceed to Beijing Capital International Airport by subway for the flight back to The Netherlands. Fortunately, we weren't trapped in heavy traffic and arrived at the airport earlier than estimated with nobody left behind. In our last day in China, the weather was also very pleasant. After an 8-hour-long fly we arrived in Frankfurt, rest people finished the flight to Amsterdam and dismissed at the airport.

We all can look back on a succesful and pleasant trip with information about studying, working, eating and living in China!









The business network for education and research

The Engineering of Fire Safety



Examples of student research projects:

- Experimental research on fire and response of structures and separation constructions under fire conditions
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- Probabilistic approach of fire safety objectives in relation to rules and regulations

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Healthy Building 2015 Europe at the Eindhoven University of Technology

Marcel Loomans

rom the 18th of May untill the 20th of May the Healthy Building 2015 Europe conference was held at our campus. With around 400 participants in total, 250+ paper presentations, 16 workshops, 5 keynotes, a plenary discussion, well taken care of non-content related details (e.g. conference diner with silent disco), positive responses from many people, the conference is regarded a success. That of course is a good outcome given the time and people required to organize such a conference!



Figure 1 A nearly sold out '*Blauwe Zaal*', Auditorium at Eindhoven University of Technology

ealthy Buildings 2015 Europe was the first example of a new concept to continue the renowned ISIAQ Healthy Buildings conference series at a different pace parallel at different places around the world, bringing it more close to regional issues and practice. It was also the first time that a conference with this size and on this topic had been organized in The Netherlands. The organization was a joined effort between the Eindhoven University of Technology, ISIAQ.nl (the Dutch chapter of ISIAQ) and ISIAQ.

SIAQ is an abbreviation for the International Society of Indoor Air Quality and Climate. It is an international, independent, multidisciplinary, scientific, non-profit organization whose purpose is to support the creation of healthy, comfortable and productive indoor environments. And that is what Healthy Buildings 2015 Europe was all about!

As we spend around 90% of our time indoors, exposure to a high and a good (healthy) indoor environment is therefore important. Though we have come a long way there is still ample room for improvement. Indoor environment science

from the start has been a multidisciplinary effort; designing buildings is an integral effort. Both indicate the need to learn from each other, to work with each other and to look at boundaries as opportunities.

Whith Healthy Buildings 2015 Europe the aim was to provide a platform where we could walk along these boundaries and gain knowledge from adjacent scientific fields. Of course at the same time we should be able to enjoy and acknowledge the new developments and research results within our own broad field. In addition we do not want to forget the application potential of all the good work being performed.

or the organization of the conference we selected six adjacent fields that the conference was built around. The Healthy Building 2015 Europe Core diagram was used to design the conference (Figure I). This diagram stressed the multidisciplinarity found and required in arriving at healthy buildings. In the keynotes, the technical parallel sessions and the workshops all themes were covered.



Figure 2 Healthy Buildings 2015 Europe Core diagram

Though the division between the themes cannot always be made that clear, we did hope it allowed to widen the view on the topic of healthy buildings. It truly will need multidisciplinary actions to continue to make steps towards (re)creating healthy buildings! Where indoor air quality and thermal comfort topics still formed the vast majority of the conference, we were very glad that in this conference also lighting and certainly also acoustics were discussed. Where lighting already received a bit more attention in the past, for acoustics the contribution in these type of conferences has been marginal so far. We hope this change will continue.

esides a plenary discussion with different stakeholders Consumer', building owner, 'EQ consumer', building owner, scientist) based on short videos from everyday health issues in buildings, we invited keynotes from the identified fields. For example, Adrian Leaman from the Usable Buildings Trust is one of the first researchers who identified the importance of including the occupant into the analysis of buildings, or Wouter van Marken Lichtenbelt from Maastricht University who is one of the frontrunners in making the link between human physiology and the built environment. The close link between energy and indoor environmental quality was discussed by Christoph van Treeck from RWTH Aachen University. From the point of view from the sources Miia Pitkäranta from the Vahanen group in Finland detailed the latest options to identify microbiological contamination in dwellings. State-of-the-art technology is currently applied for that and even can go back to the level of DNA analysis. Finally, Séverine Kirchner from CSTB informed us about the difference between science outcomes and policies adopted. This is not an easy step and there are clearly more issues at stake than purely the outcomes of research.

esides the compact timeline, it was also intentionally(!) Besides the compact dimension, it was also and the amount of abstracts received (over 360) and with over 270 papers accepted it clearly showed that there is a need for having a venue available at regular intervals to discuss the latest developments in IEQ research and practice. Not only in technical sessions, but certainly also in the interactive workshops. With these numbers, being 'compact' it provided some challenges. For example, with respect to the available time for presentations and poster sessions, normal activities were ongoing at the university (including room use). Based on the outcomes, the challenges were all dealt with and in the end appreciated. The conclusion is that short presentations (9 minutes) do not mean less information transfer, but a more effective transfer of information. Poster viewing provided more variety in the discussions with more value during the whole conference. Keynotes of less than half an hour can still be appreciated a lot. Workshops with real interaction add value to a conference with this format.

had the pleasure of organizing the conference together with Atze Boerstra (BBA Binnenmilieu and PhD-student at BPS), Lisje Schellen (President of ISIAQ.nl, BPS-alumni and former PhD student at BPS) and later on with Marije te Kulve (BPSalumni). The timeline was very short, but with the help of many volunteers, the conference office and many sponsors, the job was done within less than a year. These volunteers were really important as the work that needs to be done is massive... We were glad that we were able to gather such a good group around us. Also the cooperation with study association Mollier was appreciated a lot. We found a nice way of working together so that money became available to sponsor Molliers study trip to China. A nice example of a smart combination!

Overall it was a very nice experience and an honor to organize this conference. But at this point I would also like to take the opportunity to thank everybody at BPS and the department (staff and students) that allowed me, helped me and supported me to make this organization possible. Thank you for that!



Figure 4 Rob van Gijzel, Mayor of Eindhoven, welcomed the participants on behalf of the City of Eindhoven



Figure 5 Meeting between colleagues (Jan Sundell, Jeffrey Siegel, Hal Levin and Miia Pitkäranta)



Figure 3 Opening session (handing over of the 'baton' from Healthy Buildings 2012 in Australia)



Figure 6 Discussions at the posters (the one explaining is Glenn Morrison, current president of ISIAQ)



Figure 7. Panel discussion with Atze Boerstra as moderator

BIM : The solution to a manageable process for any project!

VECCINS 3D BV is one of the pioneers of BIM for the installation sector. Nine years ago they started with the software of DDS from Norway, since that time it has been a stormy development because of working with DDS. VECCINS 3D and DDS have motivated each other the past few years in such a way that the software is not about 3D modelling but to the process.

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.

The models are also made various calculations, such as excess temperature calculations, transmission calculations, piping calculations, lighting calculations and calculate the power cables. By early to make such calculations with the IFC model keep your grip on the Process. Performance and principles are fixed in the model, and can therefore be continuously monitored. Great savings are easy to generate and tune with the manufacturer in the 3D model.

BIM is intended to control the process. Based on the commissioningsprincipe.

BIM is the future. It requires a different way of thinking. Thinking is processes rather than in or sign pointing technique. When you succeed as an organization, then you will only win the battle with BIM.









Further information VECCINS 3D te Wezep www.Veccins3D.nl

Ancient Acoustics

Research expedition to Greek theatres

Bas Peeters

INTRODUCTION

or decades, the Greek civilization is known for their buildings and their beautiful architecture. For example, the ancient Greek theatres which were built thousands of years ago are still standing strong. Besides the beauty of these theatres they have one more thing in common: they are known for their exceptional acoustics. However, there is little scientific support for these claims.

This had triggered researcher Constant Hak already for years when Bareld Nicolai, Niels Hoekstra, Adonia Diakoumis, Bas Peeters, Marco van der Wilt and Chris van Loenen took the initiative to organize a research expedition. It became clear that this would be our research topic. Together with researcher Remy Wenmaekers, Constant Hak supervised the expedition. The research expedition is a sleeping initiative for students that is rarely organized. It requires a large amount of work which is not necessarily rewarded with a satisfying amount of credits. The last successful attempt dates from 2006 when student organized an expedition to Cappadocia, Turkey. The first preparations of this expedition date from the end of October. After a time of gathering funds, getting the required permits, organizing the trip and making a detailed research plan, on the 22nd of March we took off to Athens.

PREPARATIONS

Preparation is key. Because of the limited time we had in each Greek theatre we wanted to tackle as much problems as possible in advance. Therefore we went to the 'Kersouwe' outdoor theatre in Heeswijk-Dinther where we performed the measurements on a small scale. The custom made measurement signal was tested, the time needed to build up and move the setup was timed and the settings of the recorders and receivers were tested. We also performed worst-case scenario tests on the TU/e campus with lots of environmental noise to find the limits of our measurement method. Besides our measurement methods, our equipment also had to be expedition-proof. Custom lightweight microphone stands were created which were able to adapt to the corroded stairs of the theatres. Even custom flight cases were built to safely transport our equipment to Greece. After lots of improvements on the method the day before we left we felt that we were ready to go.

ANCIENT THEATRES

The first of the three theatres we visited was the Odeon of Herodus Atticus theatre on the Acropolis in Athens. This is, with its 5,000 seats, the smallest of the three investigated theatres and the only theatre with a façade behind the stage. The second theatre was the Epidaurus theatre (Figure 1) which is the oldest one and contains 14,000 seats. The third and last theatre was the theatre of Argos which is the largest theatre with a capacity of 20,000 seats.

MEASUREMENTS

The theatres were mapped acoustically by use of an innovative wireless measurement technique. Constant Hak



Figure 1 Ancient Theatre of Epidaurus

was closely involved in the development of this technique. Because of this technique we were able to measure a large amount of source-receiver positions in a relatively short time-path compared to the common wired measurement techniques. A drawback of this method is that the post processing of the data is much more intensive and timeconsuming. Each six hours recording contains a large number of "sweeps" (measurement signals) which have to be cut out manually. These recorded sweeps have to be deconvolved into impulse responses using the original source signal. From there we can calculate objective acoustical parameters from the impulse responses and we can determine the acoustical quality of the theatre on the measurement positions in the theatre. We used two omnidirectional sound sources (Figure 2) at the same time, sending out sweep signals with a short time delay. On average, 2,000 impulse responses per theatre are obtained from the raw measurement data.

igcap imultaneously with the acoustical measurements we Dmeasured the outdoor circumstances which might influence the acoustic transmission: the air temperature, relative humidity, wind speed and wind direction. The acoustical and meteorological data combined are of great value. The acoustic transmissions can be analyzed more accurate since the speed of sound in air changes with temperature and this temperature is known. Besides that, the data is very useful for validation of acoustical models in the field of outdoor acoustics.

CHALLENGES

We have had to deal with a lot of challenges in the preparations phase as well as in Greece. In the beginning there was a great idea and a lot of enthusiasm, but we realized that without financial support we would never make it to Greece. Besides the flight tickets, transportation costs in Greece and hotels, we needed to arrange an enormous amount of measurement equipment. We invested a lot of time in a professional website and sponsor brochure because we had to convince parties this was a professional research and no holiday on their costs! When the first sponsors participated and media like "De Telegraaf", "Cobouw" and "Eindhovens Dagblad" reported about our research we got the feeling that this expedition was really going to take place. From Da Capo we borrowed 20 professional DPA microphones which we mounted on custom-made stands (Figure 3) and PelserHartman provided us with a Total Station so the exact dimensions of the theatres could be measured.

POST-PROCESSING

t will still take a lot of time to analyze all the data and come up with conclusions, but so far the measurements are of good quality which enables us to give a scientific explanation for the exceptional acoustics of the theatres. Or aren't they that good?

ACKNOWLEDGEMENTS

e would like to thank our main sponsors of our research expedition:

- Da Capo Orchestral Audio;
- DGMR;
- LBP Sight;
- Level Acoustics:
- PelserHartman;
- TU/e Chair Building Acoustics;
- TU/e Unit Building Physics and Services.

Furthermore, we would like to thank our sponsors and contributors. For more information visit our website: www.ancient-acoustics.nl



Figure 2 Two omnidirectional sources in Odeon Herodus Atticus



Figure 3 Close-up of custom-made microphone stand





Deel je onze passie?

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

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nhouse dagen 2015

We organiseren voor studenten en net afgestudeerden Inhouse dagen, waarover je op onze carrieresite meer informatie aantreft. Voor 2015 staan deze gepland voor dinsdag 9 juni en donderdag 10 december. Tevens tref je op www.werkenbijarcadis.nl informatie aan over onder andere onze (afstudeer)stage vacatures en filmpjes van medewerkers.

Contact

Wil je graag meer weten over ARCADIS, een eventuele (afstudeer)stage of onze Inhouse dagen? Neem dan contact op met Thijs Pruijssers, onze Campus recruiter. Hij is bereikbaar via telefoonnummer 06-27060616 of via thijs.pruijssers@arcadis.nl



ICE BREAKER



Since I came to the Netherlands, I have been asking myself two questions for I don't know how many times: where I am from? And why I choose to study in the Netherlands?

The answer to the former question is Chongqing, China. But how embarrassing is that, I haven't met anyone who is not from China that knows this city before I tell, hopefully they remember it afterwards. So I think I should make a brief introduction here.

hongqing is my hometown where I was born, grew up and studied. I had not left the city for more than 30 days until I resided to Eindhoven in August 2014. I can say the Netherlands is extremely flat, Chongqing is on the contrary: extremely mountainous. Actually the whole city was built on mountains very inland to the southwestern of China. Two large rivers flow through the city, forming a beautiful peninsula. My home university, Chongqing University, is located on the bank of one of these rivers. Because of this terrain, things there look unique or magic as many people say: unaccountable skyscrapers and high-rise buildings, giant bridges crossing rivers with different architecture, crooked ragged roads and walkways, crowded streets and congested traffic... Climate there is so unpleasant that even locals haven't been used to, as it is up to 41°C hot in summer, and cold, humid and overcast in winter. Probably influenced by harsh natural conditions, local citizens tend to be tough and passionate, but sometimes referred to as boorish. Last year the Netherlands re-opened its consulate in Chongging after 60-years of closure. I think my hometown will be known by more and more Dutch people therefore.

As for the latter question, my answer may be a story. Initially, I chose bouwkunde as my bachelor major in 2010 just because I thought designing buildings was a cool, and of course a money-making job. I planned to work as a building engineer after obtaining my masters degree at the same university. However, I changed my mind later, as a series of severe air pollution events striking China in 2013, which touched my heart deeply. It was like this: thick smog blotted out the sky and covered the sun continuously for days, air became turbid and toxic, and many people were



sick with respiratory diseases. Meanwhile I realized I should do something to help stop this, not make it worse. Thus I decided to get involved in technology that is directly related to people's wellbeing and environment, such as energy, services and lighting. I thought it would be ideal that I become a practitioner who implements green building technology or a researcher who develops it one day. To achieve this, studying abroad in a country where sustainable technology is superior would be very necessary, then the Netherlands became a logical and natural destination.

By May, I have been studying at Unit Building Physics and Services for 10 months. It seems everything is moving towards my expectation: I enjoy my life here very much and stay happy almost every day; I have known many friends with whom I have wonderful experiences; I get very interested in solar energy and lighting, and I have completed two master projects about this topic; I am learning Dutch and I find it not so hard as I thought first.



As an international student, I have to admit that there was much difficulty when being a newcomer. During the very first days at TU/e, everything was brand-new and strange to me. I had no idea about Dutch education, or about local customs, or about what a student's life is like here. I complained a lot about the fickle weather, the cold lunch and my omafiets whose seat is apparently too high for me. Fortunately, several Mollier members offered their warm welcome and provided some essential introduction, which comforted me to a very large extent.

To conclude this icebreaker, I would like to quote that cliché from the movie Forest Gump: life's like a box of chocolate you'll never know what you are gonna get. It is true. Take myself for example, five years ago when I was a teenager wandering on the streets of Chongqing, I anticipated neither I would study building sciences nor come to the Netherlands. Even 10 months ago while I walked out of Schiphol Airport, I was not sure about what fortune was ahead of me at all. However, everything gets clear along with the time. So, how about saying so: life's like a box of chocolate you'll never know what you are gonna get, please enjoy the taste as long as you open it.

Reaching Thermal Energy Balance at the Campus 2020

Tjeerd Spruijt

Supervisors: prof.dr.ir. J.L.M. Hensen dr. M.H. Hassan Mohamed PDeng J.I. Torrens Galdiz

INTRODUCTION

very building requires a certain amount of energy to keep the indoor climate at a comfortable level. This amount of energy (heating ϑ cooling) is unique for every building and depends on the outdoor climate and the building's properties. When a building requires cooling in summer and heating in winter, a mismatch in time exists¹. If said in another way, this might sound even more obvious:

"When in summer thermal energy (heat) has to be removed from a building, and in winter thermal energy has to be supplied to that same building, a mismatch in time exists."

THERMAL ENERGY STORAGE

To overcome this mismatch, the thermal energy can be stored and made available for later use when the energy is required. Storage of thermal energy is possible with a Thermal Energy Storage (TES). The type of storage to use in the Netherlands is a simple choice, as aquifers (watercontaining layers between two impermeable layers) are commonly available in the whole country. This is the reason why the ATES systems are becoming more and more popular in he Netherlands. It is even expected that in the year 2020 around 20.000 of these systems will be operative².

REGULATION ON ATES

Since an ATES system makes use of a common source (the freshwater), it is bound to regulations. These regulations are there to prevent overexploitation of the source, making a common source unavailable to others³. The regulations are contained in the Water act⁴, the Milieu act⁵ and the official gazette of the Netherlands⁶ which states that:

"An open ground energy storage system reaches a moment where there is no excess heat within 5 year after first use and repeats this within 5 year after the last time this situation occurred."

Excess heat as used in this law occurs when the total amount of thermal energy which is infiltrated into the ground is larger than the total amount of thermal energy that is extracted. On top of this, both heat and cold should be used, only in exceptional cases discharge to the air or surface water is allowed to create a balanced situation underground⁷.

TU/e CAMPUS

he ATES system located on the TU/e campus is a large open circuit system created out of 32 wells (16 cold and 16 warm) divided over 6 clusters (3 cold and 3 warm) [Figure 1]⁸. The clusters are connected to each other making use of two ring tubes (cold and warm), the rings are kept at around 6°C and 18°C under a pressure of 2.5 bar. With this ring system buildings can extract or supply heat and cold at the same time. The most common heat and cold delivery systems at the TU/e are direct cooling and heating via a heat pump, in most cases a peak load system with boilers is installed to deal with outdoor temperatures below -5°C.

RESEARCH

As a response to the new European goals, the TU/e created its own plan to come to an energy neutral campus. Part of this plan is the "Campus 2020" which is a plan to increase the energy efficiency and decrease the carbon emissions. This large renovation of the TU/e campus is happening as we speak. The renovation of the campus includes multiple buildings that are currently energy inefficient, as well as the optimalisation of installations like the ATES system. This system is currently unbalanced and two cooling towers are used to balance it out.

1	2A	2B	3
Sportcentrum	Ceres	Hoofdgebouw	Flux
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Vertigo	Spectrum	Gemini-Noord	Vestide toren
Matrix	Laplace	Gemini-Zuid	Studenten dorp
Helix	Catalyst		
Cyclotron			
Kennispoort			

Table 1 TU/e buildings divided into groups



Figure 1 TU/e ATES sources

he renovation of the campus includes multiple buildings that are currently energy inefficient, as well as the optimalisation of installations like the ATES system. This system is currently unbalanced and two cooling towers are used to balance it out. This is a waste of thermal energy, as well as electricity and money. This is a waste of thermal energy, as well as electricity and monev.

CLASSIFICATION OF BUILDINGS

o create some overview in the wide range of buildings located on the TU/e campus four partitions were made, of which one can directly be excluded as it contains the buildings that are not and will not be connected to the ATES system. The division is based on data from the Annual Energy Reports (AER) of 2003-2010 and the Management review Multiple Year Agreement Energy Efficiency TU/e. These documents contain the annual energy consumption per building in gas, water, ATES cold and ATES heat. For determination of the future ATES users, the pamphlet "TU/e science park" is used⁹.

ccording to these documents, Atwelve buildings were connected to the ATES one year after it was built in 2002. Of these twelve buildings, only seven will remain the same between 2010 and 2020, the other five will be changed, renovated or demolished. Nine buildings will be newly connected to the ATES system before 2020. The division of the buildings over the groups is given in Table 1.

SIMULATION

he collected data is used as input for the computational simulations using Dymola, which is a simulation environment in the open Modelica modelling language. The model used is based on the ISO-13790 which is a five resistances 1 capacitance (5R1C) model¹⁰. Extra additions to this model are a user schedule, ventilation with heat recovery and weather influences.

RESULTS

base load was calculated using Acomputation simulation models of the first group, this group has been calibrated using the real measured data. This base load represents the load that has always been and will be present, from this point the balance is checked. The second step was to add group 2A, this is possible by adding the measured data, which is available for 3 of the 5 buildings since they are already in use. The other two buildings will receive minor changes in their system, resulting in a different energy demand towards the ATES system.

he third group (2B) was simulated using the same calibrated model of group 1, the current un-renovated building was the main input for this model. The insulation values of the most



Figure 2 Energy extraction from the ATES

recent Dutch Building Code are applied to the model, and the function change is kept in mind.

he simulated energy demand off all groups is combined to analyze what the balance without new buildings will be. This gives an indication if the new buildings will need to use more heat or cold energy from the ATES.

DATA MODIFICATION

s an example the Vertigo building A is used in this article. The real measured data of the Vertigo building contains gas, ATES warm, ATES cold and electricity for the heat pump. The total amount of heat was calculated with the following steps:

- Gas use multiplied by 9. This value is the result of the caloric value of gas which is approximately 32MJ/ m³ multiplied by the efficiency¹¹. 1kWh is equal to 3.6MJ so, 1m³ of gas can provide 8.88kWh with an optimal combustion efficiency of 100% the conversion value was estimated at 9.
- The heat energy provide by the ATES is already in kWh_thermal

and can be added after a check if the measured values of the real estate department are the same as the values provided in the AER.

The electricity use of the heat pump is a more difficult story this is split between the heating and cooling, if cooling exists without heating, then the electricity for the heat pump is multiplied by 5 (EER) and otherwise it is multiplied by $4 (COP)^{12}$.

DISCUSSION

urrently the ATES is imbalanced and according to the regulations all heat and cold should be used and cannot be emitted into the air. As a result of this there is currently an imbalance of around 6MWh/year when the cooling towers are not taken into account.

he imbalance for the buildings of group I (base load) is a lot better (46% cold 54% heat) than the original balance of 70% cold versus 30% heat. When the renovated and new buildings of group 2 are added, the imbalance increases again. This might be due to the trend to increase the insulation (reducing glazing is increasing insulation as well) of the buildings, resulting in a lower heating demand and a higher cooling demand.

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