Academic year 2013 - 2014 #1 | December

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

Furnace experiments for fire engineering

Thermal breakage of glass in case of fire

Beyond boundaries

A journey to Australia

2nd lustrum Schoone Leij

Lille, 2013

Foreword

PRESIDENT MOLLIER

Bart Kok

Dear fan of Mollier,

The last INSide Information of 2013 and also the first INSide information of the academic year has finished. The result is a brand new INSide information with updates about s.v.b.p.s Mollier and interesting articles from companies and researches of students and professors.

It's the last month of the year, so the countdown to 2014 has started. From now it is allowed to have a look on the past year. s.v.b.p.s Mollier has organised many events last year, varying from company visits, a job training, a study trip to the Meet and Greet, and we will continue in 2014. In this Inside will be frequently looked back on the successful organised activities!

Besides events, also some new researches are presented that have be done by members of s.v.b.p.s Mollier. These researches have very different subjects and each of these researches, contributes to the innovation in the construction sector. These presented researches are just two of the dozens interesting researches and fields of research. So if you can't get enough, over about a half year we will present you a number of new researches in the next Inside!

I will thank every company, professor and student on behalf of the entire board, for the collaboration with s.v.b.p.s Mollier and especially for the creation of this INSide information. Because without your input, will there be no future for this interesting magazine.

I'll hope that by reading, you will be also inspired through our field of building physics and services.

Enjoy the reading!

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This INSide


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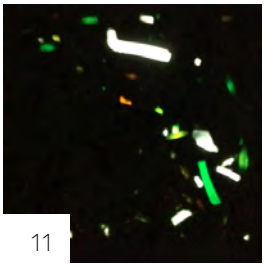
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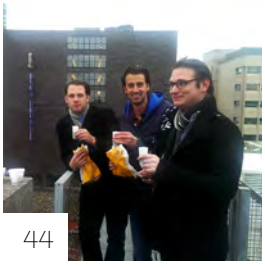
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New board of Mollier

And the 18th Constitution

Written by Christina Randjiet-Singh

BART KOK
PRESIDENT

As 18th president of Mollier, I have the honor to introduce myself first. My name is Bart Kok, 23 years old and was born and raised in Bunschoten-Spakenburg, a unique place nearby Amersfoort.

Before I came to the University of Eindhoven, I studied the bachelor Building environment and transport in Zwolle, where my specialization building physics and building techniques was. At the beginning of 2012, I received my bachelor degree after graduation on the subject the new Building act 2012.

After my bachelor degree, I found that I wasn't done with studying. So I continued where I stopped. So it was natural for me, that I went to the University of Eindhoven, because it is the one and only university, that has the full focus on building physics and services.

What did me convince to become the 18th president of Mollier? At the first place it seems to me a nice chance and experience to be a member of the board of Mollier. At the second place I was delayed with my premaster and the 17th board asked me to be a member, because they had the thought that I was suitable. And the last important reason was, that the three ladies needed a male president. I'm just kidding, just like always. That's me!

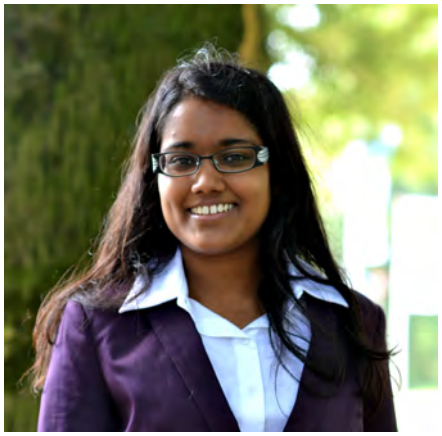
During my bachelor study, I started my own company. In the beginning it was only for the fun and experience, but now it's paying my beers too. My work consists of advising in building regulations and especially the Building act. Besides that, I help people and companies to realize there construction wishes, by involving the right businesses to reach their goals. The tasks we do for instance are abolish penalty clause, apply for building permits, check the design with the building act and a lot more.

I hope that during the year, we will have good times with each other, with serious and unserious moments. So I end up with the following ambiguous wise sentence:

You better regret the things you did, than the things you didn't do.

BART KOK

President



CHRISTINA RANDJIET-SINGH
SECRETARY

Hello, my name is Christina Randjiet-Singh, 23 years old, born and raised in Uden. I went to the havo and after that I decided to study 'Bouwkunde' at Avans in 's-Hertogenbosch. During my internship at Nieman I discovered my interests in building physics and building services. After my graduation I couldn't find a job and that's why I decided to start with the master Building Physics and Services.

And now, a year later I finished my pre-master, joined the study trip commission and am constituted as the secretary of the 18th board of Mollier. My job is to keep in contact with the members and to inform them about activities. I also do the administrative duties of the board. During my previous study I was the secretary of the student council and that's why I'm confident that I will succeed this year.

In my spare time I play the keyboard and piano. Sometimes I sing and write my own songs. I enjoy music a lot and I like to dance, especially with Karin Conen (my twin sister ;)). Going out, dining out and just hanging out with my friends is something I also really like to do. In the weekend I work at McDonald's so I can go out on dates with my lovely boyfriend who I met at Mollier.

CHRISTINA RANDJIET-SINGH

Secretary

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BEDRIJVENDAGEN

Word jij het nieuwe bestuur van de Bouwkunde Bedrijvendagen 2014?

Voor meer informatie of om je aan te melden:

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Wij gaan voor 'n tien!

Doelgericht in detacheren en selecteren

Ben jij bijna klaar met je studie en op zoek naar een leerzame startersfunctie? Of ben je nog op zoek naar een afstudeerstage? Onze gespecialiseerde adviseur begeleidt je bij het in kaart brengen van je wensen en ambities, in de voorbereiding op je sollicitatiegesprek en tijdens het opdoen van je eerste werkervaring. Zo helpt KP&T je doelgericht in je zoektocht naar een passende uitdaging!

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DETACHERING
SELECTIE
VAN TECHNICI

This year's board wants to improve the contact with the students. So become an active member of Mollier and maybe you'll meet someone special.

LISETTE DRAAISMA VICE-PRESIDENT AND COMMISSIONER OF EXTERNAL RELATIONS

Dear all, my name is Lisette Draaisma. I live in Eindhoven for three years now. I was born in Breda, but due to my father's work we moved to Den Helder. There I went to the primary school and learned to talk with a 'harde G'. After the primary school I went to vwo in Schagen. After six years in middle school it was time to leave and I went to Eindhoven. I doubted between the Bachelor 'Bouwkunde' and Earth science. But in the end I went for 'Bouwkunde' because I was more interested in all the facets of buildings than digging in the earth. So 'Bouwkunde' it was, but where? I did know I did not want to be an architect, so the decision was made easy: Eindhoven.

So I registered myself at the TU/e. The next step was finding a room in Eindhoven. I respond to different ads and I was invited to a 'kijkavond' in Strijp. I was lucky and got the room. I did not know anyone in Eindhoven so I went to the introduction week where I met Manon. I also joined the rowing club Theta and study association Cheops and went to different activities. In my second year I joint the study trip commission of Cheops. In my second year I did more technical projects and one of them was a building physics project. I liked it more than the other topics, so in my third year I did a minor in BPS and BPS was my discipline in 'Multi project'. I wanted to do something study related and do something useful for a study association. The 17th board was searching for new board members so the decision was made easy.

My function in the board is Commissioner External Relation and Vice President. I hope to continue the good work of the previous boards and obtain a lot of sponsor money for Mollier. I try to intensify the relation with our current sponsors and hope to find interesting new companies. Besides this, we will try to get more (bachelor) students involved with the association.

MANON DERKS TREASURER AND COMMISSIONER EDUCATION

Hello, I'm Manon Derks, born and raised in Mill. It's a small village in Brabant half an hour away from Eindhoven. After primary school I went to the VWO in Uden. Next I started with the Bachelor 'Bouwkunde' at the TU/e. During my first week I discovered I didn't want to be an architect and throughout the bachelor I focused more and more on BPS. This summer I moved to Eindhoven, because I was tired of travelling every day. Now I don't have the pressure to make it to the bus station in time in the morning which results in me being late for classes. What can I say, I just hate mornings.

But when I finally get out of bed and made it to the TU/e I'm ready for what the day will bring. In my spare time I like to play soccer and I'm doing that for about ten years now. I'm still playing with the same team in my home town and I'm not going to change that. One of my other hobbies is music. I like to go to concerts although most of the artists I want to see only tour in America. Lucky for me they sometimes come to festivals nearby. For example last year I went to Rock Werchter, realized I still had to make my exam philosophy so I drove back to Eindhoven for one day. With a little bit of luck I passed the exam so I was able to start my master.

With this master in the direction I like I wanted to be more active in the study association. I didn't do this in my bachelor, because in my opinion Cheops focusses too much on architecture instead of an equal distribution between the different profiles. Lisette and I came in contact with Mollier in the period where they were trying to form next year board. I saw this as a great opportunity to be more involved.

During this year we hope to continue the good work in modernizing and professionalizing the association. The 17th board made already a great start and left a wonderful foundation for us to continue this innovation. My functions in this board will be the Treasurer and the Commissioner of Education. With all the new developments in the education program, meaning Bachelor College and Graduate School, we're looking at the future and trying to get more 'brand awareness' under bachelor students.

LISETTE DRAAISMA

Vice-president and commissioner of external relations

MANON DERKS

Treasurer and commissioner education

Constitution

On 18 September the change of the 17th board took place. After a successful year, the 17th board is replaced with new and fresh members.

During the general meeting of members, Richard Claessen (president 17th board) gives a beautiful speech about how the board took the challenge to give Mollier more name recognition. But also how the board members developed themselves and all the fun and frustrations they shared. After the speech, the 18th board is constituted with four strokes of the hammer.

The change of board started with Bart (president 18th board) who took his time to knot his tie. According to the minutes it took more than 6 minutes! After that, Bart was officially the new president and constituted the rest of the new board. Christina Randjiet-Singh became secretary, Manon Derk treasurer and commissioner education, and Lisette Draaisma as external relations and vice president.

The policy plan of the 18th board was presented. The main goals of this year's board consist of working on the future, realize a more continuous contact with sponsors and become more professional.

After the general meeting of members, the new board headed to the Skybar to celebrate her constitution. Old and new members of Mollier where present this evening, but also other student associations, friends and family. Because of the high amount of Mollier members and old members, the Mollier anthem was sung many times while drinking Jägermeister. For some of the board a little too much and therefore the wall was a great friend for Christina and Lisette. At the end of the evening, Manon was standing alone on the podium.

The great evening continues with a dinner at the Movies. 54 Mollier members joined the dinner and later on the party continued in the city of Eindhoven. It was an unforgettable day!

Translucent concrete: Utilization of waste glass in concrete

Spyridon Rouvas

Supervisors:
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Concrete sector is by far the most used in the building industry (15.000 million tonnes in 2008 compared to 4000 million tonnes of timber which was second). However, environmental legislation over the last decades has led in the utilization of recycled or waste materials as concrete ingredients. Waste glass is selected in this research as one of the alternatives. The modified Andreasen and Andersen equation for an optimized particle packing was the mix design approach that was followed in Self compacting concretes. Different tests (strength test, Alkali-Silica Reaction test, translucency test) have been applied in different mixtures to develop an integrated material with good properties. Results showed that it is possible to apply 60% of glass content and obtain high mechanical properties, ASR resistant and translucent concrete. In that case, sustainability (no landfilling of waste glass, no extraction of raw material) and profitability are achieved.

INTRODUCTION

Concrete is the most used material in the building industry. According to the estimation of 2008, 15.000 million tonnes have been produced, when the second building material (timber) was produced in 4.000 million tonnes. Good mechanical properties, low price and high flexibility of its form (on-site casting) are the main reasons for this common use. However, the increasingly stringent environmental legislation over the last decades has attracted the attention of recycled or waste materials as concrete ingredients.

Waste glass can be considered as one of these alternatives. It is a material which is characterized inappropriate for further recycling of glass. Pollution and other materials attached to the glass surface which cannot easily be removed, are the main reasons. As a result, waste glass is either sent for landfilling or it has to be stockpiled. Additionally, glass is not a biodegradable material and an estimation of the biodegradation of a glass bottle is about 1 million years. Therefore, the utilization of waste glass in concrete can be very sustainable for the environment, as it prevents the harmful landfilling but also, it can be economically profitable, because there is no need for extraction of raw materials for the production of concrete.

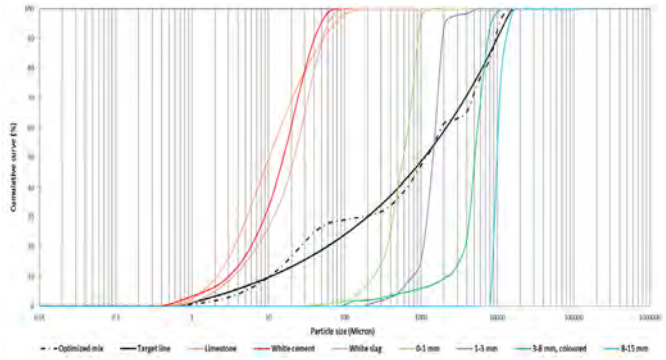


Figure 1 Particle size distribution and optimized particle packing of Mix 12f

This graduation project intends to develop a sustainable material composed of concrete and high glass content, which consists of good mechanical properties, ASR resistance and translucency and potentially can be used in the building industry for future applications.

METHODOLOGY

Different mixes have been designed to investigate the behavior of the different glass fractions in concrete. All the mixes are Self-Compacting Concretes (SCCs), which simply means that are flowable. An algorithm based on the modified Andreasen and Andersen (A&A) equation for an optimized particle packing was followed. If the material is denser, then fewer pores are in the matrix of the concrete and therefore, higher mechanical properties are obtained. The (A&A) is given as follows:

$$P(D) = \frac{D^q - D_{min}^q}{D_{max}^q - D_{min}^q} \quad \forall D \in [D_{min}, D_{max}]$$

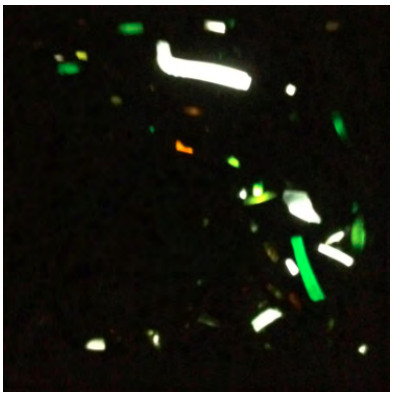


Figure 2 A plate of 10 mm of Mix 12f

For the optimization of the packing for every mix, the maximum and minimum particle size (D_{max}, D_{min}) of the materials and the distribution modulus (q, which determines the proportion between the fine and the coarse particles and in this research, it was 0.23) is needed, but also the particle size distribution (PSD) and the density of the used materials are necessary. The A&A equation is responsible for the design of the target curve of the mixture and by incorporating the PSD of the used materials, the optimized curve of every mixture is also developed. An example is given in Picture 1, which shows the small deviation of Mix 12f of this research between the optimized and the target curve.

When optimized particle packing has been successfully applied, the mixtures are tested under the spread flow test, the compressive and flexural test, the alkali-silica reaction test (ASR) and the translucency test. The final scope is the development of an integrated mix with high glass content, which presents adequate properties in every test.

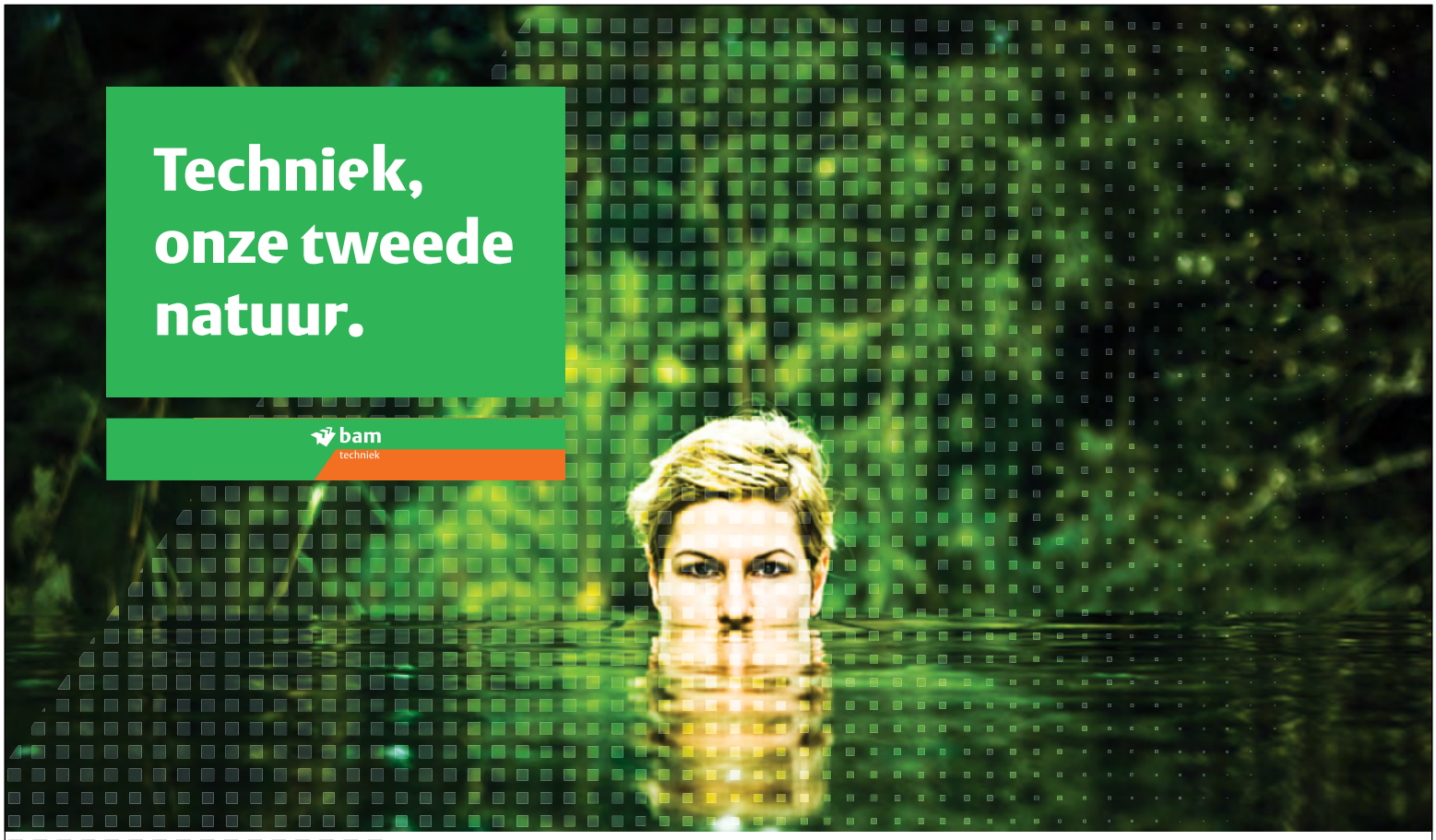
RESULTS AND DISCUSSION

A reference concrete composed of only conventional aggregates and no glass content has been designed for a comparison with the other mixes. The results showed that when the waste glass replaces up to 20% of the conventional aggregates, there is an insignificant reduction of the compressive and flexural strength. When a conventional material of the reference concrete (limestone, sand, gravel) is replaced totally by a glass fraction of the same PSD, there is a reduction of the compressive and flexural strength of 25%. The glass powder was the most negatively influential glass fraction on the compressive and flexural strength, however, it was very effective in suppressing the ASR. Additionally, when all conventional aggregates are replaced partially (50%) by glass fractions of the same PSD, there was still a reduction of 25% of the compressive and flexural strength. In all previous mentioned cases, the glass content in the mixes was approximately 30%.

Based on the previous results, mixes composed only of glass fraction, increased cement content and pozzolanic materials have been developed. The glass content in that case was 55-60% (making the concrete highly sustainable) and the compressive and flexural strength was only 30% lower than the reference concrete. Subsequently, the presence of pozzolanic materials suppressed the deleterious ASR which could be responsible for the development of cracks in concrete. Finally, the presence of glass particles up to 15 mm, was highly important for the development of translucent plates. Specifically, 1% of translucency was obtained in plates of 10 mm thickness. An example of the translucency of Mix 12f is given in Picture 2, where the same plate of 10 mm is presented in an indoor environment and illuminated by a lighting source from the back side in a dark environment.

The results showed that 60% glass content in concrete can be applied without provoking problems in the properties of the material. Moreover, Mix 12f managed to combine successful results for every test. The compressive and flexural strength were high enough (42 MPa and 6.4 MPa), the ASR expansion was below the recommended limit and the translucency obtained in plates of even 14 mm thickness. Aesthetically, the material could be used for decorative concrete, as the translucency along with the elongated shape of the glass in shiny surfaces, makes the material very attractive. Picture 3 illustrates the final material.

Figure 3 A representation of the material



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

Wij kijken onder en boven het oppervlak

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

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

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

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

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

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Furnace experiments for fire engineering: Thermal breakage of glass in case of fire

Ruud van Herpen MSc. FIFireE
(TU/e: fellow Fire Safety Engineering / Nieman RI: technical director)

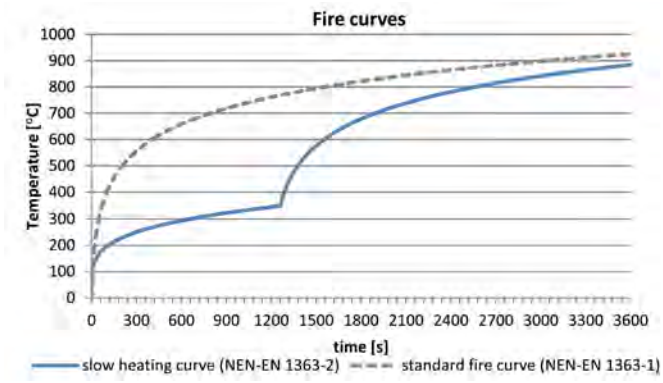

Figure 1 Slow heating curve, compared to the standard fire curve.

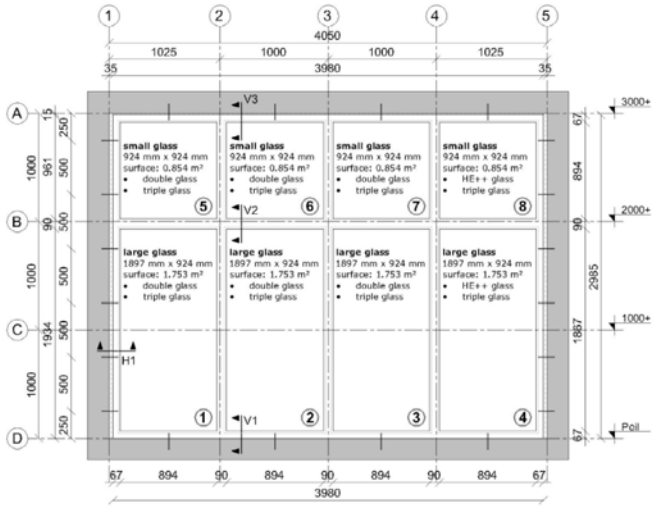

Figure 2 Experimental set up for both double and triple glazing in the furnace

INTRODUCTION

The application of double glazing is widely spread in current buildings. However, in low-energy buildings (like passive houses) the application of triple glazing becomes more common. Triple glazing reacts differently in case of fire than double glazing. Especially glass fallout is an important factor that influences the fire development in an enclosure fire.

A smouldering fire seems more likely when the glazing system remains intact, while a flaming fire will be more likely in a situation with major glass fallout. A smouldering fire will lead to higher toxicity hazards for the occupants and an increased risk on backdraft. A flaming fire, on the other hand may lead to flash-over in the fire room. It is important to know which fire scenario will be more likely, in order to anticipate with adequate measures. Until today assumptions are made about the performance of both double and triple glazing in relation to glass fallout during fire without any scientific basis.

A start for a scientific basis is made with the master thesis of Ronald Huizinga (TU/e, 2012). In his master thesis he tried to find answers on the following research question: "To what extend does the fallout period of triple glass affect the indoor fire conditions in dwellings differently, compared to the fallout period of double glazing?" The research is based on experiments in a fire furnace and supporting simulations to assess the likelihood of a fire scenario in a dwelling. The experiments consist of a double and triple glazing assembly with four large and four small windows. Individual temperatures of the glass surface, shaded area, and temperature differences were analysed in relation to glass fallout. The analysis of the results revealed a wide spread between temperatures and glass fallout. Engineering correlations, such as the internal energy in gasvolume and the maximum temperature before glass fallout were established to quantify the difference in performance between triple and double glazing. The results show a detectable difference between the performance, and provide an indicative criterion of glass fallout as a result of internal energy in the gasvolume. Additionally a comparison is made between the experimental results and reference literature on the performance of double glass to verify the obtained criterion in relation to a vertical temperature gradient.

FIRE FURNACE EXPERIMENTS

Two windowframes with a double and triple glazing assembly were exposed to a standardized slow-heating temperature curve in a fire furnace (Peutz, Mook NL). The dimensions of the fire furnace are according to the ISO 834 standard, with respectively 3.0 m in height, 4.05 m in width, and 0.75 m in depth.

The slow heating curve is defined in NEN-EN 1363-2 and seems to be most suitable for representing both the pre flashover and post flashover phase of an enclosure fire. The slow heating curve will increase in severity after 21 minutes, see figure 1.

The fire curves in figure 1 represent an operative furnace temperature. In this operative temperature both convection and radiation are included. The operative temperature is measured by the thermocouples in the furnace. Thermocouples are thermal light devices with a 'black body' surface for radiation from the furnace envelope (walls). The operative temperature (To) measured by thermal light thermocouples can be derived from the heat balance in equation (1).

$$q_{conv} + q_{rad} = 0$$
$$q_{conv} = h_c\,(T_g - T_o) \qquad [W/m^2] \qquad \text{(equation 1)}$$
$$q_{rad} = \sigma\,(\varepsilon_w T_w^4 - T_o^4)$$

With:

q Heat flux by radiation (rad) or convection (conv) [W/m^2]
T Temperature of the gas (g), the furnace envelope (w) or the thermocouple (o) [K]
h_c Convection coefficient [W/(m^{2}K)]
ε Emission-absorption coefficient of the furnace envelope (w) [-]
σ Constant of Stefan-Boltzmann (5,67•10^{-8}) [W/(m.K^2)^2]

Equation (1) gives a solution for Tg = Tw = To, meaning that convective temperature and radiation temperature are equal. In natural compartmentfires convective and radiation temperatures are more or less the same. In a furnace the radiation temperature is determined by the furnace envelope and in most cases lower than the convective temperature, due to the lower temperature of the furnace envelope. That means that in a furnace the convective gas temperature Tg is higher than the operative temperature, while the radiation temperature is lower than the operative temperature. So there is a difference between furnace conditions and natural fire conditions, even when the operative temperatures are equal. In this study, this difference is neglected. This corresponds the assumption that the furnace envelope has more or less the same temperature as the gas mass in the furnace.

The experimental set up is shown in figure 2 and figure 3. Table 1 shows the glass characteristics.

RESULTS OF THE EXPERIMENTS

The average fallout of glass, related in time, in the experiments for double glazing and triple glazing is given in table 2.

Figure 4 shows the results from table 2 in a time-related graph. This graph shows clearly the difference between double glazing and triple glazing. The difference between large windows and small windows is less clear.

Apparently, the gas temperature in the furnace is not a suitable criterion for glass breaking. Not only the temperature but also the duration of heating determines the probability of breaking of glass. Therefore, the 'energydose', the internal energy in the gasvolume cumulated in time, is a better criterion for determining the probability of breaking of glass. In this energydose both temperature and duration of heating are taken into account.

Equation 2 provides a method to compare the internal energydose according to a standard fire curve in the fire furnace, to the internal energydose of a natural fire in a specific fire compartment.

Figure 3 Experimental set up, double glazing (left) and triple glazing (right)

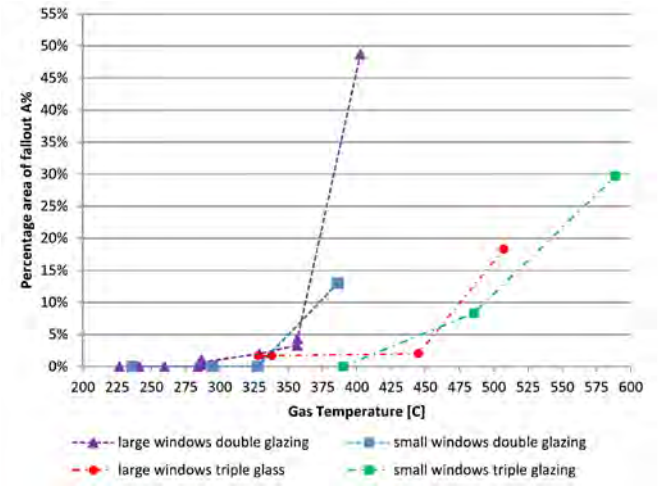

Figure 4 Average glass fallout as a function of the gas temperature.

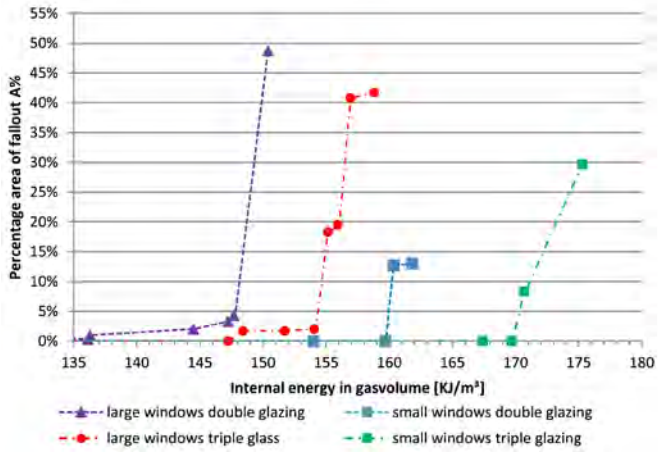

Figure 5 Average glass fallout as a function of internal energy dose in the gas volume.

Table 1 Characteristics of applied types of glass

name	type	Composition [mm]	U-value [W.m-2.K-1]
Double glazing	Thermobel standard	4 - 12 Ar90% - 4	2,7
Triple glazing	Thermobel TG Tri Top N+	4 - 12 Ar90% - 4 - 12 Ar90% - 4	0,7

Table 2 Percentage of glass fallout in relation to time

	Average fallout of double glass		Average fallout of triple glass	
Time [mm:ss]	Large window [%]	Small window [%]	Large window [%]	Small window [%]
00:00	0.0	0.0	0.0	0.0
10:00	0.3	0.0	0.0	0.0
15:00	1.0	0.0	0.0	0.0
20:00	1.0	0.0	1.7	0.0
21:00	4.3	12.7	1.7	0.0
22:26	48.7	13.0	1.7	8.3
25:00	--	--	40.8	8.3
28:50	--	--	41.7	29.7

$$\int_0^{t_{end,nfc}} E_{g,nfc}\,dt = \int_0^{t_{q,sfc}} E_{g,sfc}\,dt \quad [Js/m^3] \qquad \text{(equation 2)}$$

With:

$E_{g,nfc}$ Internal energy in gasvolume, according to a natural fire curve [J/m^3]

$E_{g,sfc}$ Internal energy in gasvolume, according to a standard fire curve [J/m^3]

$t_{end,nfc}$ Total time duration of a natural fire curve [s]

$t_{eq,sfc}$ Equivalent time duration according to a standard fire curve [s]

Figure 5 shows the percentage of glass fallout related to the energydose in the furnace divided by the equivalent time duration (internal energy in gasvolume in kJ/m3). In comparison to figure 4 this is a better criterion for determining the probability of glass fallout. Apparently the size of the window is more important than the type of glass (double or triple glass). Moreover, it may be observed that the differences in required energydose for glass fallout are minor in the tested situations.

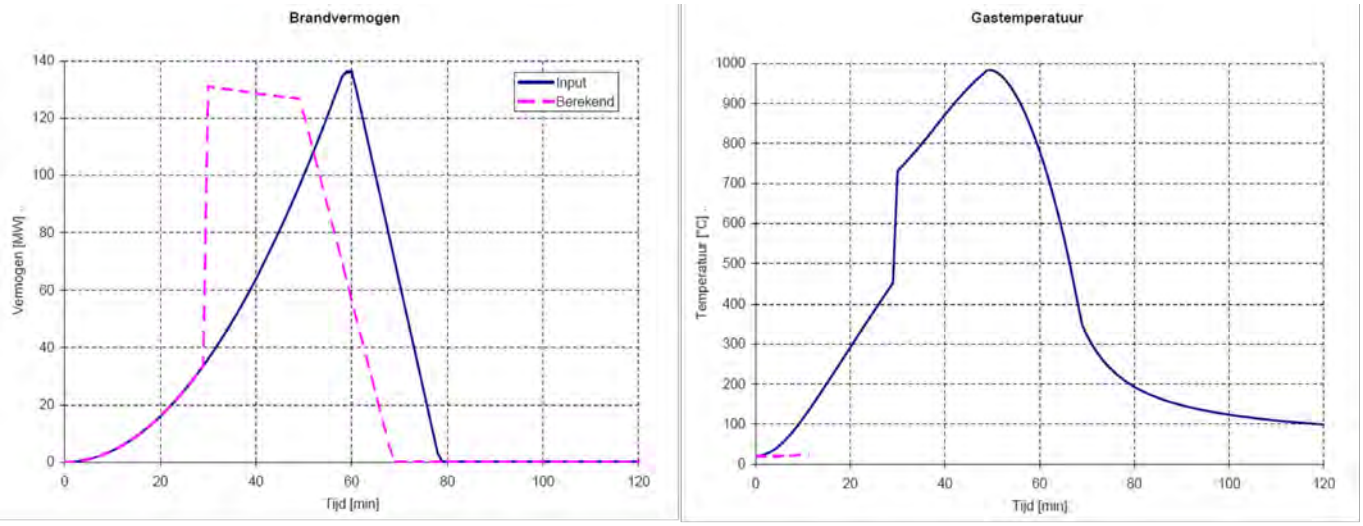

Figure 6 Rate of heat release (left) and the consequences for the gastemperature (right) in a fire compartment in case of a compartmentfire with total glass fallout. The highest temperatures occur in the post flashover fire (flashover at 29 min.)

CONSEQUENCES FOR FIRE ENGINEERING

With the results given in figure 5 it is possible to describe the project-specific interaction between fire and building. In a natural fire concept, the rate of heat release in case of fire depends on both building characteristics and fuel characteristics. The rate of heat release and the building envelope determine the gastemperature in a fire compartment. The highest temperatures are reached in the post flashover fire, see figure 6.

In a natural fire the development of the fire is determined by fuel characteristics and building chracteristics. That means that a different type of glass with a different fallout mechanism will lead to a different rate of heat release scenario and therefore also to a different gastemperature in the compartment. It is possible that in case of a very strong type of glass the percentage of glass fallout is reduced to such level that the fire will not grow to flashover. Instead of a post flashover compartment fire, as illustrated in figure 6, the fire remains local in a smouldering phase (figure 7). In that case the local fire produces toxic and flammable gases like carbonmonoxide (CO). This totally different fire scenario also leads to totally different safety measures.

Of course more experiments are needed to determine the thermal behavior of different types of glass. These experiments fit in the research agenda of the fellowship FSE at the unit Building Physics and Services of the TU/e. With this fellowship the TU/e wants to pay close attention to the behaviour of building structures and building components in case of fire and its consequences for the fire safety of the building and its occupants. With more experiments the results become more reliable. Reliable results can be used as boundary conditions in fire safety engineering.

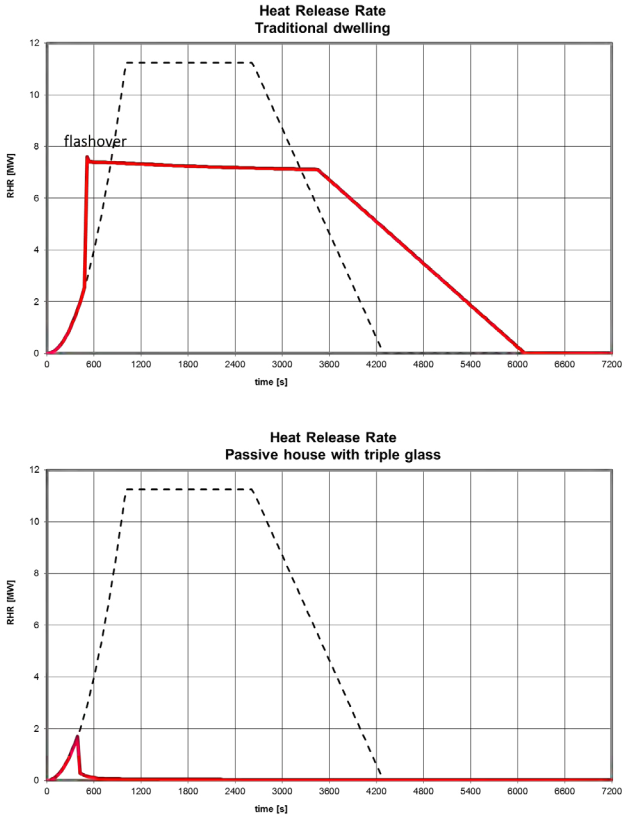

Figure 7 Rate of heat release in a poor insulated traditional dwelling with single glazing windows (left) and in a well insulated dwelling with triple glazing windows (right). Instead of flashover (left scenario) the local fire remains local but becomes oxygen controlled (right scenario: smouldering local fire before flashover is reached).

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Beyond boundaries
A journey to Australia

Written by Karin Conen

Photo's from
TU/e
Bart van Overbeeke
Karin Conen

INTRODUCTION

Let me introduce myself: My name is Karin and most of you probably know me as the Commissioner External Relations and Vice-President from the previous board of s.v.b.p.s. Mollier. Besides a master student like any other at the unit Building Physics and Services, I am also proud member of Solar Team Eindhoven. Together with 30 other students and in cooperation with the university and the industry in Brainport Eindhoven we produced Stella, a four seated electric car on solar energy. Our vision? To show the world that it is not just a dream to drive in a family car that runs on solar energy, but that it can be realized today!

SOLAR TEAM EINDHOVEN

One and half year ago a group of students from the Eindhoven University of Technology had the idea to design and built world's first solar powered family car. Everyone thought they were crazy and that it was impossible to accomplish this in such a short period of time. Looking back I can say that it indeed was crazy: But we did it anyway!

In just a bit more than a year time we designed Stella from scratch, build and tested her, and we even got her approved road legal by the RDW. Finally we travelled to Australia to participate in the Michelin Cruiser Class of the Bridgestone World Solar Challenge 2013: a 3000 kilometer long challenge through the outback of Australia for cars on solar energy. Where the cars in previous editions were only judged on speed, the participants in the Cruiser Class are also judged on the number of people transported, the range of the car and its ease of use.

After finishing the Challenge, a true battle until the end, between Eindhoven, Bochum and Sydney, with an average occupation of three passengers and maximum speeds reaching 120km/h, we had to overcome one more obstacle: the practicality score on Saturday would be added up to the total score in order to determine the overall winner. We had to wait a while for the final results, but on Sunday the 13th of October at 8pm local time it was announced that Solar Team Eindhoven and Stella are the world champions in the first Cruiser Class of the World Solar Challenge!

Figure 2 Stella shining in the Australian sun.

A great sense of relief fell among the team. Team Manager Lex Hoefsloot: "We have set the new standard. After one-and-a-half years of hard work we have not only proved that already today world's first solar-powered family car is reality, but at the same time we've won the World Solar Challenge." World Solar Challenge director Chris Selwood spoke praise for our performances: "I congratulate Solar Team Eindhoven on their innovation, practical design and foresight, to think outside the box and add the extra seats. Stella is a wonderful solar car in a field of exceptional cars and teams."

Figure 1 One of my test days.

Figure 3 The moment we all waited for: Victory!

AUSTRALIA

Anyways, time to tell a bit more on my adventures during this trip of a life time. I experienced this journey as if it was all about traversing boundaries, not only geographically, but also in the field of educational and personal development. My advice, if you are considering an internship or any other project abroad: go for it! Before this adventure, the furthest I ever travelled was to Warsaw with s.v.b.p.s. Mollier. Now I travelled to the other side of the world, through a country that is about the size of Europe!

If you are planning on going to Australia, here are some 'tips': Australia knows many different climates, all very warm and sunny especially during spring and summer. So if you are going to Australia, make sure you pack lots of sun screen and bottles of water, otherwise you might ignite spontaneously. Australia also has a diverse collection of flora and fauna, varying from (very annoying) mosquitoes to spiders, scorpions and snakes. Before stepping into your bed or putting on your shoes, check whether there are none of these animals crawling in your stuff: a huge cockroach scared me to dead one evening!

Figure 4 First encounter with a living koala and kangaroo.

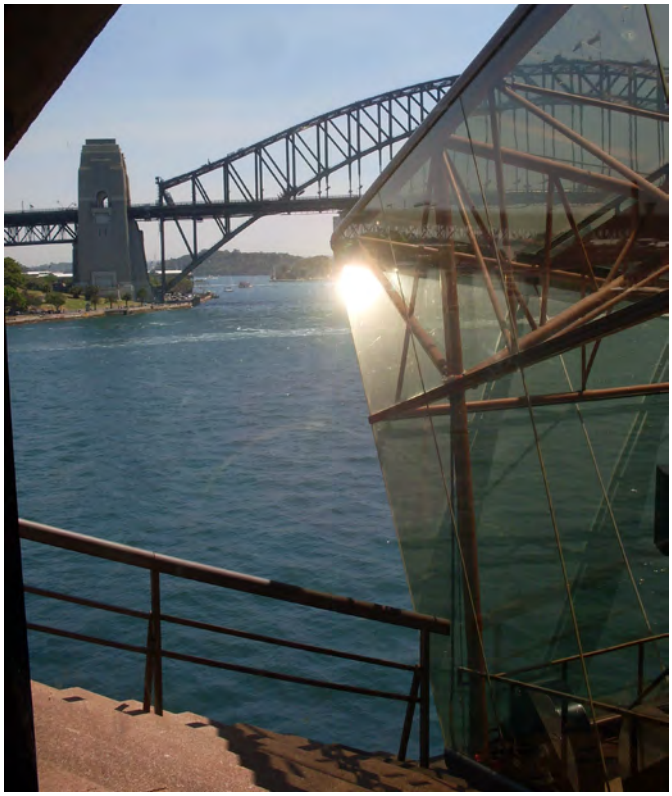

Figure 5 Sydney harbour bridge and bay from the Opera House.

Luckily for us, Australia also has good characteristics: I cannot recall a city where the people did not address me with 'dear' and 'darling' and thank god, Australia also has nice, cute, soft and cuddly animals. If you do not see any of them during your travel through the country -like me- you should definitely visit one of the wildlife parks and feed, pet or try to take with you a kangaroo or koala.

For more stories, come and have a chat with me, but for now: G'day mate, and remember: no worries!

SOLAR TEAM EINDHOVEN / BPS

No clear link between BPS and solar cars? Wrong! Even with a background in BPS there are enough things you can do in the process of designing a solar car. For example: my main task was to design the outer shape of the car: aerodynamics. My motivation: 'What is the difference in investigation air flows around a building compared to flows around a car?'
Well, actually, more than I realized, but together with the other aerodynamics engineers of the team and my team mate working on the solar cells we designed Stella's figure. Besides the aerodynamics I performed a climate research, which was used as basics for the driving strategy, and I strengthened the team responsible for the public relations.
Interested in joining the team for 2015? Next semester the candidate interviews will begin. Stay tuned for more information on how and when to apply!

Figure 6 Camping in the outback.

Ice-breaker

Stefan Wolfs

Though some friends of mine call me Stefka, Wolfie or Swagger (still don't know why they came up with the last one), my real name, as it is written down on my passport, is Stefan Wolfs. I was born and raised in the Southern States of the Netherlands in a small town called Beek in Limburg to be more specific. After living there for more than 19 years I decided to move out to Eindhoven because I was getting tired of all the travelling by train every day. Besides that, I wanted a space that was really my own.

At this moment I'm 22 years old and I'm a 5th year student. I followed my bachelor program, which I finished just a week ago at the time of writing, at the TU/e as well. Now I'm following two mastertracks. Namely, Building Physics & Services and Architecture. I have choosing this because I'm still figuring out what I like the most. Since I joined the Mollier start activity to Lille this year, I found out that there are some Mollier members who have their doubts about this combination because they have a certain opinion about architects in general. To be honest, I don't care because I believe that everybody should do what he or she likes.

Besides studying, most of my time goes to a thing I really love. Namely, music. I'm very much into 60's and 70's music and music from nowadays that is influenced by the old days. I play guitar for more than 8 years and pedal steel guitar for a couple of months now. The latter being one of the, in my opinion, sickest instruments ever but also one of the least known instruments ever. That's because every time I tell someone I play pedal steel the most common reaction that I get is: Heh?.. you play what?!.. Even when I explain to them what it exactly is they still don't get it. For this reason I think it would make no sense at all if I try to explain it here. So I would say, everybody who is curious, just look it up for yourself!

I also play and have played in several bands. At this moment I play in Catawba River Fox. A Southern Folk 'n' Roll band as we call it ourselves. We played in venues like 'Paradiso, Rotown and De Melkweg' and made a record which will be released on vinyl in a month or so. I'm also guitar technician for a band called DeWolff. Since they toured in Australia, played at festivals like Lowlands, Pinkpop and Sziget, I can state that they are getting quite famous. For me this is the

most awesome parttime job I can imagine. Because getting paid for being on the road with friends and tune guitars doesn't sound bad at all! Does it?

Other things I do like are belgian special beers, going to concerts and festivals, good food, hanging out with friends, old stuff like turntables, tape recorders etc. and making city trips. In fact, I'm finishing these words while being on a city trip in Antwerpen!

This is who I am in general. I hope you enjoyed reading this and that the people who didn't know me at all, know who I am and what I do now. Do not hesitate to approach me if you want to have a little chat, get a special beer or make some music!

As I noticed that it's kind of tradition to end with a quote that inspires you, I'd like to end these words with it. I believe that if you want to reach something in life, you really can reach this as long if you go for it. Don't care about what other people say, dare to be different and just do what you want to do. And remember: No guts, no glory!

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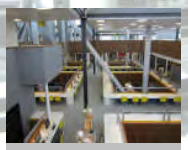

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End activity Leuven

Written by Mark de Waard

Like every year in June, Mollier organized a spectacular end activity to close a long and tiresome academic year. The organisation of this final event was in the hands of the legendary duo: Koen Smelt and Mark de Waard. After considering lots of destinations and changing the budged several times the trip finally went to Leuven in Belgium. How could it be any different, 'the beer capital of Belgium.'

Since many Mollier members do not own a car, it was decided to go by train to Leuven. A group of 15 enthusiastic people still had enough energy at the end of the academic year to attend a final weekend with Mollier. After a journey of almost 3 hours (the Jägermeister distorted the sense of time a little bit) we arrived at the picturesque Leuven. With thanks to the organization of the undersigned, the hostel was within 400 meters walking distance from the train station.

Once in the hostel, the room layout went smoothly and it was time to discover the city centre of Leuven, and of course order a first Belgian beer. The program of the day was straightforward: have a look in the city, go out for a dinner and have some drinks and finally... party till we drop! The first terraces were easily found, since Leuven has a magnificent old market full of terraces outside. Lucky us, the weather did not let us down and the first drinks were consumed under the shimmering sun.

A few hours later, people got hungry and wanted to go out for a dinner. Like a warm city as Leuven, full of bars and restaurants, the organization did not make any reservation in advance. Unfortunately, the group was so big and the restaurants were so small and crowded that it took some time before a suitable restaurant was found. However, at the end of the dinner everyone had filled their bellies, in a delicious spareribs restaurant. Unlimited spareribs demand a challenge: who can eat the largest number of baby back ribs?! This dubious honour eventually went to the treasurer; encouraged by several members of Mollier this young man ate 5 ribs, more than his 'little' body could handle.

Full of food everyone enjoyed the exciting nightlife of Leuven. Many bars were visited and eventually we ended up in a small and shabby establishment with a bar in the basement. Witnessing the pictures and time everyone was leaving, it must have

been an amazing night. Unfortunately, the way back to the hostel seemed to last for hours.

The next morning, the very capable organization had planned an activity that should appeal to every Mollier member; pipes, installations and... beer: a tour through the brewery of the Belgian Stella Artois was on the program. Unfortunately, the times available for this tour were scarce, so everyone had to be at the brewery very early. One of the organizers (apparently, a little bit less capable) and a few other members had some trouble with this very early morning. This resulted in forcing doors and windows and after that, carefully tilting the boys out of their beds. Miraculously, everyone was right on time at the brewery for the start of the tour.

After one and a half hour the tour came to an end and we were treated to what is Stella famous for: beer. Although for some the morning was a little too early, the group did not disappoint the bartender. After this educational morning the other half of the day was free of program, in other words do whatever you feel like. Some people seized this moment to catch up some sleep, others explored the city and the different beers of which Leuven is famous for.

Obviously, after a tiring day everyone ate together. The organization already decided that pizza was a good choice for the second day and searched the best pizza restaurant of Leuven in advanced. As the best restaurants are never in the city centre, it took a little walk through the city before arriving at the pizzeria. Unfortunately, the restaurant did not mention on their website that it was closed on weekends. So, everyone had to take a route back and provided a small Turkish pizza baker to an enormous turnover. After this surprisingly dinner, the ritual of the first successful evening was resumed. No spectacular summary of this evening needed: one picture says more than a thousand words.

On Sunday everyone could sleep a little longer before going back to Eindhoven. Initially, on Sunday there was time for a city tour through Leuven, full of culture, art and architecture. Disappointedly, everyone was so tired of the long nights in Leuven, so it was decided to skip this part of the program and go back to Eindhoven a little earlier. The trip back to Eindhoven went smoothly, so smoothly that all people did switch trains easily except for an individual who missed the next train and had to wait a little longer at the transfer station. However, this moment was used to look back at a successful weekend of Mollier closing the academic year. It will be hard to beat this weekend next year, but one can always try!

Tender als wapenwedloop

Als bouwer succesvol een museum runnen, kan dat? Het Ministerie van Defensie, de Rijksgebouwendienst en Heijmans zijn ervan overtuigd! Daarom kreeg Heijmans vorig jaar de opdracht om het nieuwe Nationaal Militair Museum (NMM) in Soesterberg te gaan realiseren én een kwart eeuw lang te exploiteren. Dit alles tegen een vaste vergoeding uitgesmeerd over de exploitatieperiode.

Geschreven door:
Martin Schellekens
projectdirecteur
Heijmans PPP

DESIGN, BUILD, FINANCE, MAINTAIN AND OPERATE

Op 8 mei 2012 werd in een feestelijke bijeenkomst de zogenaamde DBFMO (Design, Build, Finance, Maintain & Operate) overeenkomst ondertekend waarin alles rond het NMM is vastgelegd. Zo'n geïntegreerd contract is een vorm van PPS (Publiek, Private Samenwerking) die steeds vaker door de overheid wordt gehanteerd voor complexe projecten.

Je moet wel erg zeker van je zaak zijn, wil je zo'n contract aannemen. We willen er immers ook nog een boterham mee kunnen verdienen. En wat weten we bij Heijmans nou van musea? We zijn dan ook zeker niet over één nacht ijs gegaan. We hebben ruim een jaar aan ons plan voor het NMM gewerkt met een team van ruim honderd mensen. We hebben gesproken met allerlei mensen, van experts uit de museumwereld tot en met diverse oud gedienden uit de Defensie-organisatie. We hebben ons laten inspireren door diverse andere musea, soms ook tot ver over de grenzen. Daarbij hebben we vooral goed geluisterd naar onze klant, het Ministerie van Defensie. Uitdaging was om de complexe vraag van onze klant samen te brengen in een integraal plan. Het mooie van deze tender was dat vrijwel alle disciplines binnen Heijmans (utiliteitsbouw, techniek en sport & groen) hebben samengewerkt in dit plan. Daarnaast zijn er nog vele expertisegebieden van buiten Heijmans aangehaakt: van museale inrichting tot en met horeca.

Figuur 1 Artist impression door BMD van de Noordhal.

Figuur 2 Artist impression door BMD van de entree.

In het NMM wil Defensie laten zien wat het belang van de krijgsmacht is en welke rol deze speelt binnen de maatschappij: van internationale vredesmissies tot hulp bij rampen en van het vertegenwoordigen van Nederlandse economische belangen in het buitenland tot technologische ontwikkelingen die we inmiddels onmisbaar vinden. Verder laat het NMM ook zien welke rol de krijgsmacht heeft gespeeld in de ontwikkeling van Nederland als natie.

LEVEN EN DOOD

In het NMM komen de collecties samen van zowel het huidige luchtmachtmuseum in Soesterberg als het legermuseum in Delft (inmiddels gesloten). Defensie verwacht dat het nieuwe museum zo'n 200.000 bezoekers per jaar trekt. Hierbij richt het NMM zich op een brede doelgroep, zoals gezinnen, schoolklassen, defensie-experts en oudgedienden. Ter vergelijking: het Spoorwegmuseum in Utrecht trekt jaarlijks 300.000 bezoekers. Ondanks het streven om een groot publiek aan te spreken, moet het NMM in geen geval een pretpark worden. Disneyficering is uitgesloten! Het mag wel indrukwekkend en uitdagend zijn. Maar het gaat ook om een serieus onderwerp, letterlijk een kwestie van leven en dood, dat met respect zal worden benaderd. Tegenover spectaculaire films in 3D en live demonstraties met tanks wordt ook aandacht gegeven aan belangrijke plekken zoals een stiltetuin, een appèlplaats en een monument voor de gevallenen.

Figuur 3 Artist impression door BMD van het Nationaal Militair Museum.

We zullen het merendeel van de oude hangars op het 45 hectare grote terrein van vliegbasis Soesterberg slopen. Een aantal historische gebouwen zullen we restaureren, deze krijgen een specifieke functie binnen het museumconcept. Het museumgebouw zelf realiseren we van de grond af aan. Het concept blinkt uit in eenvoud. Het gebouw bestaat uit een groot dak van 240 bij 100 meter waaronder vrij indeelbare ruimten en een buitenexpositie worden ontwikkeld. Het gebouw is rondom voorzien van een glazen wand waardoor er vanuit het gebouw zicht is op het prachtige landschap. Om de diverse grote objecten te kunnen huisvesten is de binnenruimte zo'n 13 meter hoog. Ankerpunt voor zowel gebouw als gebied is een hoge uitkijktoren van waaruit je zelfs de Dom in Utrecht nog kan zien. De beleving start voor de bezoekers meteen al bij de entree: omdat je op een hoogte van vijf meter binnenkomt heeft iedereen meteen een spectaculair uitzicht over de collectie. Binnen kunnen de bezoekers thematische tentoonstellingen bekijken over bijvoorbeeld de krijgsmacht en de Nederlandse geschiedenis. Hier zijn veelal ook de wat kleinere en kwetsbare collectiestukken te zien, zoals uniformen en medailles. In de middelenhal staan de grotere objecten zoals vliegtuigen, tanks en kanonen. Op het educatieve eiland leren kinderen meer over de achtergrond van de krijgsmacht. Op deze plek mag alles worden aangeraakt en zijn er veel interactieve spelelementen. Dit alles wordt omlijst met een door onszelf ontwikkeld hospitality concept. Het NMM is een publieksmuseum waar de bezoeker centraal staat.

PRIKKEL

Defensie heeft de ingediende plannen beoordeeld op het gebied van architectuur, landschappelijke inpassing en museale inrichting. Daarbij scoorden we in totaal op 97% van de kwaliteitscriteria. De twee concurrerende consortia lieten we daarmee ver achter ons. Uniek aan deze opgave was dat er alleen maar op kwaliteit kon worden gescoord en niet op prijs. Er was door Defensie een plafondprijs vastgesteld, waarbij aanbieders geen extra punten konden binnenhalen door voor een lagere prijs in te schrijven. Defensie heeft hierbij als klant geen oplossingen voorgeschreven, maar alleen diverse functie-eisen gesteld. Hiermee heeft Defensie de marktpartijen maximaal de ruimte gegeven voor creatieve en integrale oplossingen. De uitvraag was daarbij zodanig vormgegeven dat Defensie, op basis van de biedingen, exact weet wat ze zullen krijgen.

In ons plan leveren we dus een volledig ingericht museum en landschapspark op dat we gedurende 25 jaar gaan onderhouden en zullen voorzien van diensten zoals horeca, beveiliging en schoonmaak. We leveren daarmee niet de spreekwoordelijke 'stapel stenen' (of in dit geval een stalen constructie met glas), maar een 'dienst'. Deze dienst bestaat uit een volledig uitgerust en werkend museum met landschapspark, voorzien van alle comfort en gemakken. We worden ook als dienstverlener afgerekend: we krijgen, na oplevering van het complex, over 25 jaar elke maand een bepaalde vergoeding voor deze dienst. Als we daarbij niet aan bepaalde prestatieeisen voldoen, zullen wij worden gekort op deze vergoeding. Kortom: de klant weet precies wat hij krijgt en wij hebben de prikkel om optimaal presteren over een langere tijd.

Dezelfde werkwijze is natuurlijk ook toe te passen voor andere projecten, waarbij een gebouw of een weg gekoppeld wordt aan een beheer-, exploitatie- en onderhoudscontract. Voor ons is het interessant omdat we als kennisgedreven organisatie niet alleen alle nodige disciplines in huis hebben, maar ook het vermogen bezitten om onze creativiteit te organiseren. Ons onderscheidend vermogen gaat daarmee in toenemende mate zitten in onze kwaliteitspropositie en in het goed kunnen vertalen van klantwensen naar een aansprekend plan.

GOED PLAN

We wisten dat we een goed plan hadden, waarmee we hoog zouden moeten kunnen scoren. Toch bleef het tot het laatste verlossende telefoontje spannend of wij deze opdracht zouden krijgen. Je kent de plannen van je concurrent immers niet. Een tender is een wapenwedloop, waarin alle partijen hun best doen om de ander af te troeven. Dat gaat ver. Zo hadden we ons concept al in een vroegtijdig stadium klaar. Vervolgens hebben we driekwart jaar besteed aan het uitwerken van de detaillering. Het resultaat is een loeizwaar tweedelig boekwerk met 1.200 pagina's op A3 formaat.

Natuurlijk hebben we daar zelf voor gekozen. En natuurlijk wil een klant die flink investeert weten wat hij krijgt. Een kritische kanttekening hierbij is dat er wel steeds een goede balans moet zijn tussen de uitvraag en de wijze waarop je daar in de bieding antwoord op geeft. Alle partijen gaan behoorlijk gedetailleerd in op de uitvraag. Daarmee zijn deze tenders bijzonder kostbaar. We moeten als branche samen met de aanbesteders kritisch blijven om dit proces verder te optimaliseren.

Voor nu: de realisatie van het NMM is in volle gang! In het najaar van 2014 gaan de deuren open voor het publiek!

Figuur 4 Luchtfoto bouwplaats Nationaal Militair Museum. Gemaakt door Heftig Hoogtebeeld op 23 Oktober 2013.

Aquifer thermal energy storage systems: design versus reality

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This article compares Aquifer Thermal Energy Storage system design (performance) predictions with the reality. It is found predictions often do not match with the reality. Next it is discussed whether, and eventually what, changes are necessary to currently used prediction methods, to allow better predictions in the future.

INTRODUCTION

Aquifer Thermal Energy Storage (ATES) systems (Dutch: warmte-koudeopslag, WKO) are a promising and sustainable way of heating and cooling buildings. Theoretically buildings with ATES systems can save 50 to 80% on cooling energy and 30 to 50% on heating energy (Bodemenergie NL, 2012). ATES systems are highly reliable (Dirven, Gysen and Vandekerckhove, 2001), have a short payback period (Snijders, 2000), hardly produce noise (Godschalk and Bakema, 2009), are easy to couple with other sustainable techniques such as solar collectors and energy roofs (DWA, 2012), and can be useful in fighting flooding (DWA, 2011) or cleaning contaminated soils (Siderius, 2010). All in all: an ATES system is a sustainable, multifunctional, technique with a high potential.

The reality is different: installed systems have lots of problems (DWA, 2011) and know efficiencies and energy savings below the expectations (Aan de Brugh, 2011; Hoving, 2012). A lot of these problems can be traced back to the design of the systems (DWA, 2011). Often incorrect or inaccurate estimations are used as input in ATES system design (performance) predictions, resulting in ATES systems that are not accurately dimensioned (Unica, 2012; DWA, 2011) and design related problems that are not or too late discovered.

RESEARCH GOAL

The goal of the research is twofold: (1) provide designers of ATES systems with feedback on their predictions and give them insight in the dealing with uncertainty and (2) determine whether changes/improvements are needed to the prediction methods and/or used input in predictions. Ultimately this will lead to better predictions and more accurately dimensioned ATES systems.

METHODOLOGY

The used research method consists of two parts, being a field study and a simulation study. For the field study four buildings (case #1 to case #4) with ATES systems are investigated. The field study allows to make the connection between design predictions and the reality and to discover the differences. The simulation study determines the sensitivity and influence of different building, building use, and building services design parameters on the heating and cooling demand and related soil energy balance of a building with ATES system. Results will tell what design parameters are important to look at early in the ATES system design process and might be considered in design predictions. The simulation program Vabi Elements is used.

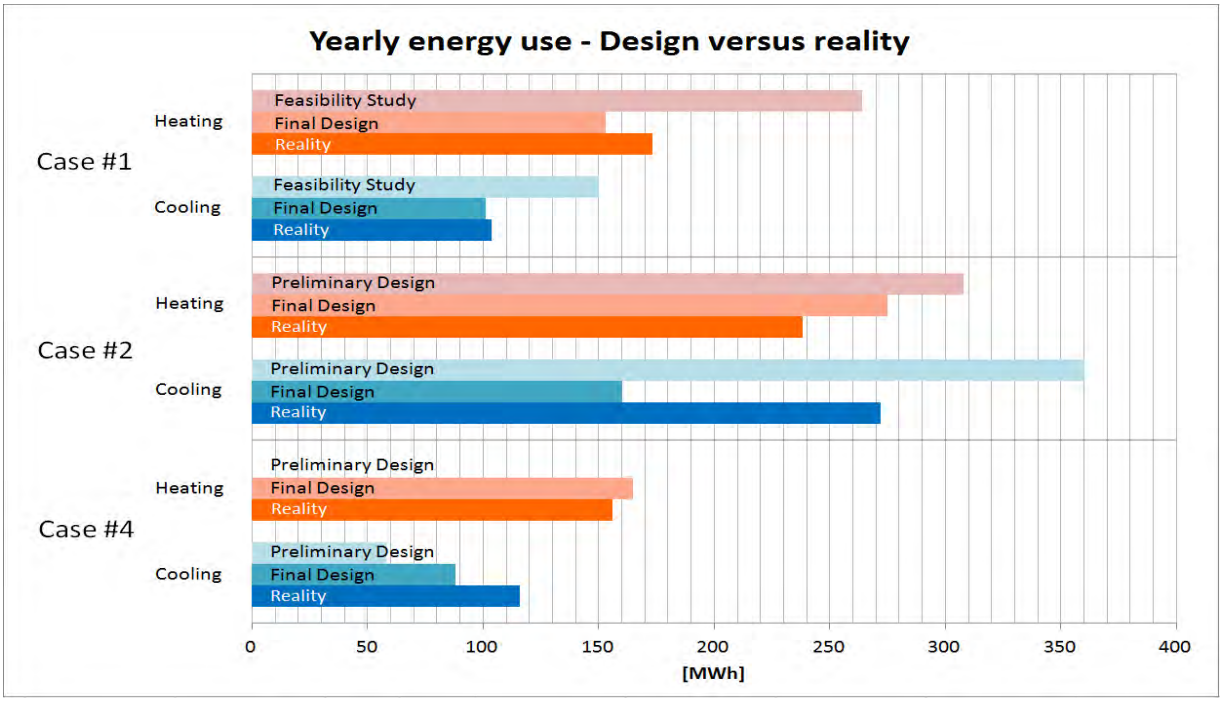

Figure 1 Design versus reality: yearly energy use. 'Reality' bars are multi-year averages.

DESIGN OF AN ATES SYSTEM

Analyses of the four cases reveal the design process of an ATES system globally consists of three stages, being:

1. Feasibility Study: a first check whether an ATES system is interesting for the building and possible at the location of the building.
2. HVAC system design: design of the buildings HVAC system (the ATES system incorporated) by the building services engineer.
3. Well size determination: determination of the size of the well system by the well system supplier.

Note that this is an iterative process: step 2 and 3 may be repeated several times.

During these stages predictions are made of, among others, the energy use of the building, the soil energy balance, and the water flow of the ATES system. In these predictions five so called 'key input parameters' play a large role: the installed heating capacity, the installed cooling capacity or needed simultaneous cooling capacity, the full load hours for heating, the full load hours for cooling, and the ΔT between the wells.

A relatively small number of parameters thus determines the prediction outcomes. Parameters that are difficult to predict. For example: Senternovem (2010) gives a range for the full load hours for heating from 900 to 1,600. Parameters that have changed in value over the years. For example: the climate change has led to higher cooling capacities (see Imsirovic and Molenaar, 2011; Spek and Wisse, 2008). Parameters that are often overestimated. For example: the to be installed capacity is often (deliberately) chosen to high (see e.g. DWA, 2011; Wisse et al., 2011).

Below the energy use and soil energy balance predictions are discussed. Attention is paid to the role of the key input parameters.

FIELD STUDY – ENERGY USE PREDICTION

Figure 1 gives a comparison of the predicted and actual yearly energy use of the investigated cases. The predicted heating demand is calculated as the product of the installed heating capacity and the full load hours for heating (see Table 1). For the cooling demand prediction the installed cooling capacity and full load hours for cooling are used (see Table 2).

The figure shows the heating demand predictions are reasonably accurate and the prediction accuracy increases as the design progresses. Looking at Table 1 it can be seen the capacity prediction is quite accurate and the full load hours prediction is also reasonably accurate. The predicted cooling demands deviate a lot from the reality. Looking at Table 2 it can be seen there is a large range (300 to 700 hours) for full load hours cooling in the reality situation. The predicted full load hours know a smaller bandwidth. This may contribute to the found deviation.

Table 1 Design versus reality: heating capacities and full load hours heating. Installed heating capacity = heating capacity heat pump + capacity gas boiler or district heating.

	Final Design Prediction		Reality	
	Installed heating capacity [kW]	Full load hours heating [hours]	Installed heating capacity [kW]	Full load hours heating [hours]
Case #1	*201*	*761*	*206*	*840*
Case #2	*259*	*1,062*	*295*	*807*
Case #3	*267*	*750*	*258*	*?*
Case #4	*187*	*882*	*174*	*897*

FIELD STUDY: SOIL ENERGY BALANCE PREDICTION

The soil energy balance is defined as the difference in heat and cold injection in the soil. Having a neutral soil energy balance (no heat or cold surplus in the soil) is favorable as a non-neutral soil energy balance may result in a decreased soil condition and reduced system performance (see e.g. DWA, 2011; RIVM, 2011). An accurate prediction is therefore essential. The soil energy balance prediction is based on the, earlier discussed, energy use prediction.

Figure 2 gives a comparison of the predicted yearly soil energy balance and the actual yearly soil energy balance (multi-year averages) of the four cases. The figure shows large differences between predictions and the reality. Three of the four cases have a positive yearly soil energy balance. This means a yearly heat surplus in the soil. This is consistent with a study by IF Technology (2007), which also found most systems have a positive soil energy balance.

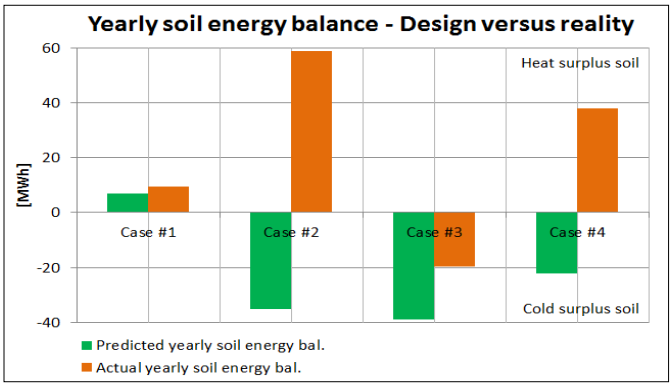

Figure 2 Design versus reality: yearly soil energy balance. 'Actual' columns are multi-year averages.

Table 3 Design versus reality: heat and cold injection in the soil (four cases combined, multi-year averages).

	Final Design prediction	Reality	Difference
Yearly cold injection soil	*27.9 kWh/m2 GFA*	*20.5 kWh/m2 GFA*	*-26.5%*
Yearly heat injection soil	*21.6 kWh/m2 GFA*	*25.2 kWh/m2 GFA*	*+16.7%*

Table 3 gives (multi-year) averages, based on the four discussed cases, of the predicted and actual yearly heat and cold injection in the soil. The table shows, on average, the yearly heat injection in the soil is underestimated, whereas the yearly cold injection is overestimated. Note that the soil energy balance is often expressed as a percentage (see e.g. IF Technology, 2007).

Table 2 Design versus reality: cooling capacities and full load hours cooling. Installed cooling capacity = capacity well system + cooling capacity heat pump.

	Final Design Prediction		Reality	
	Installed cooling capacity [kW]	Full load hours cooling [hours]	Installed cooling capacity [kW]	Full load hours cooling [hours]
Case #1	*?*	*500*	*338*	*307*
Case #2	*?*	*480*	*423*	*643*
Case #3	*?*	*500*	*428*	*?*
Case #4	*?*	*540*	*175*	*663*

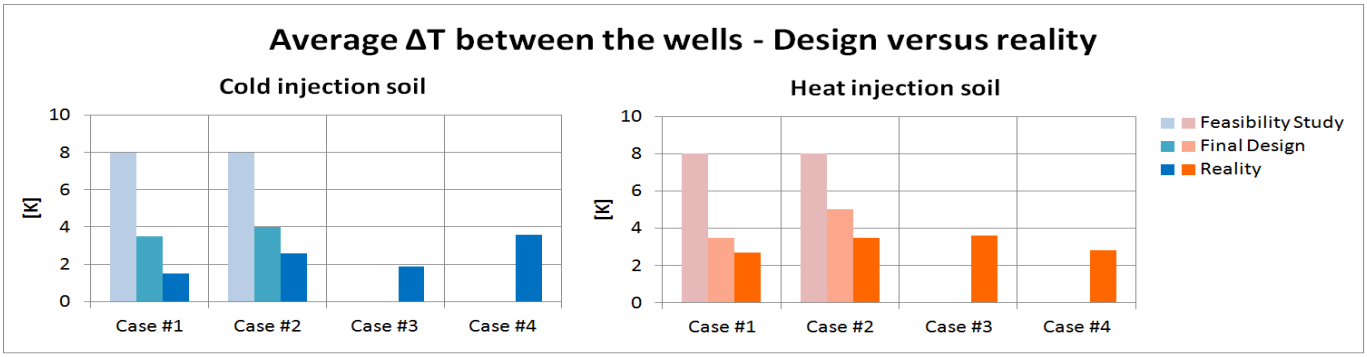

Figure 3 Design versus reality: ΔT between the wells. 'Reality' bars are multi-year averages.

FIELD STUDY: PREDICTION ΔT BETWEEN THE WELLS

The ΔT between the wells is an important characteristic of an ATES system: it greatly influences the efficiency and performance of the ATES system and connected systems. Usually two ΔT's are considered: the ΔT between the wells for cold injection in the soil (during winter period) and the ΔT between the wells for heat injection in the soil (during summer period).

Figure 3 gives a comparison of the predicted ΔT's and the actual ΔT's (multi-year averages). Looking at the figure it can be seen there are large differences between ΔT predictions and the reality. Final Design predictions are more accurate than Feasibility Study predictions.

SIMULATION STUDY

A simulation model was made of case #1 in Vabi Elements. A validation study revealed this simulation model was reasonably accurate (maximum difference between simulation results and reality 12%). Next this simulation model was used to determine the influence of different design parameters on the heating and cooling demand and the related soil energy balance. Figure 4 and 5 show the results. Figure 4 and 5 show, overall, building use design parameters have the largest influence on the heating and cooling demand and the soil energy balance. Specific design parameters with a large influence are: infiltration, temperature set point cooling, glazing characteristics, and equipment heat gain.

CONCLUSIONS

ATES system design (performance) predictions often do not match with the reality. A more extensive prediction method may be necessary to improve the accuracy of the predictions. Current prediction methods heavily rely on five 'key input parameters' that are often predicted (estimated) incorrectly and difficult to predict shows the field study.

To decrease the dominancy of these key input parameters and to spread risks it is proposed to give the following design parameters a more direct and more important role in the predictions: infiltration, temperature set point cooling, glazing characteristics, and equipment heat gain. These design parameters (relatively) have the largest influence on the heating and cooling demand and the soil energy balance shows the simulation study. How their role should look like has yet to be determined. Possibly these design parameters will get a place in design guidelines for buildings with ATES systems.

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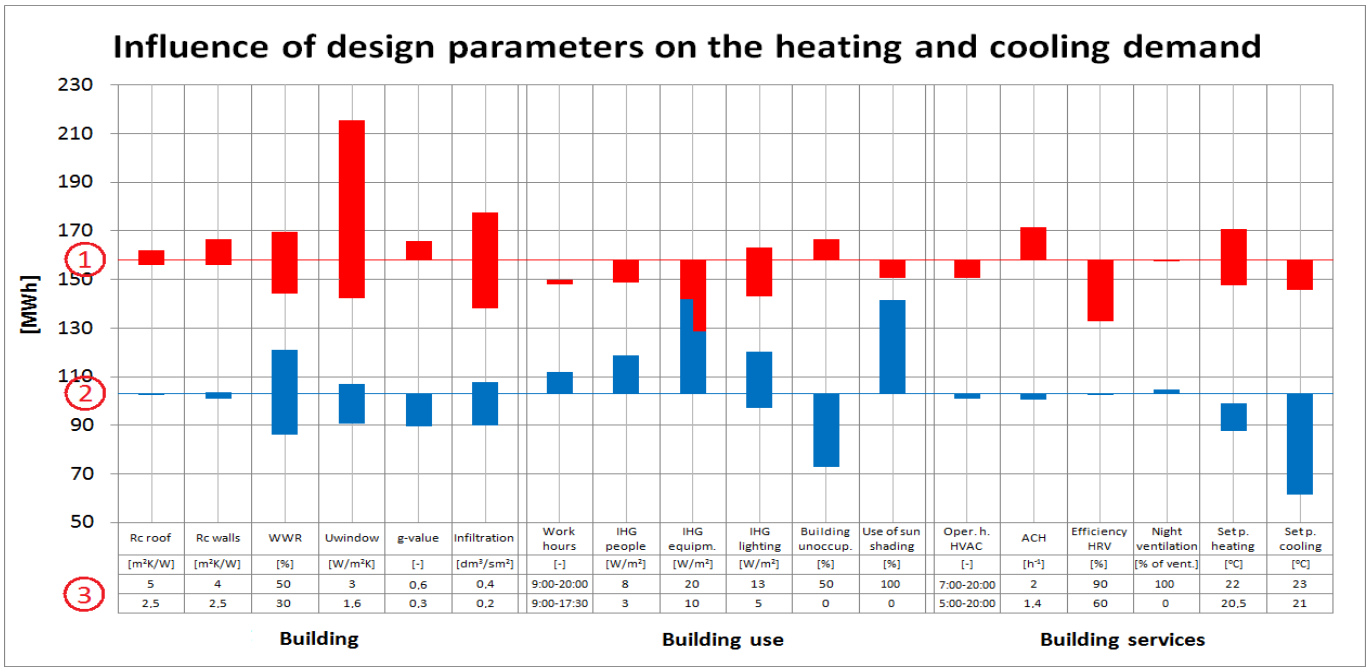

Figure 4 Influence of different design parameters on the heating and cooling demand.
Figure based on the simulation results of case #1.
1) Line indicating the heating demand of the original model (starting point).
2) Line indicating the cooling demand of the original model (starting point).
3) For all design parameters ´typical´ (common, reasonable) ranges are defined. The corresponding heating and cooling demand ranges are shown in the figure.

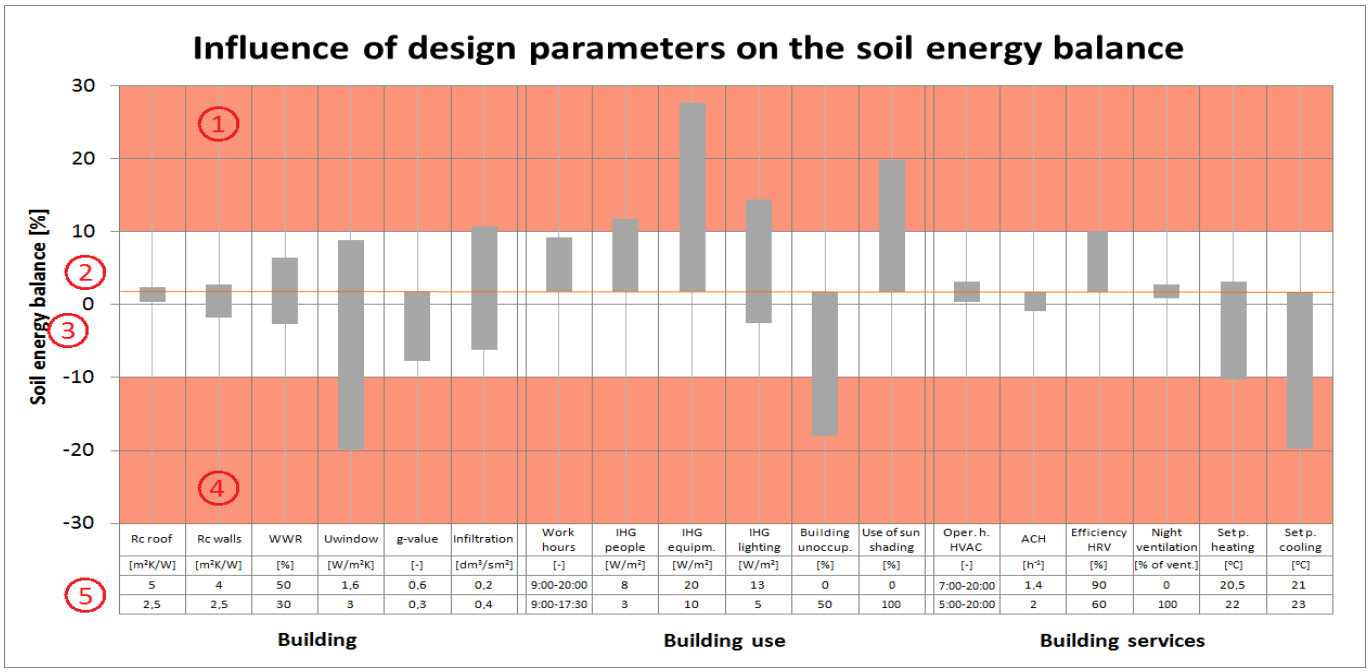

Figure 5 Influence of different design parameters on the soil energy balance.
Figure based on the simulation results of case #1.
1) Positive soil energy balance: soil is heated. > +10% soil energy balance not allowed by law.
2) Line indicating the soil energy balance of the original model (starting point).
3) 0% soil energy balance = neutral soil energy balance.
4) Negative soil energy balance: soil is cooled. < -10% soil energy balance not allowed by law in most cases.
5) For all design parameters ´typical´ (common, reasonable) ranges are defined. The corresponding soil energy balance range is shown in the figure.

Start activity
A weekend to Lille

Organised by:
Dennis Pennings
Franziska Roberz
Jordi van Laarhoven
Sigrid Scheijen

DEPARTURE

On October 4th at 4PM 5 cars with 26 students started driving towards Lille in France for the Start Activity of 2013. After driving more than 200 km and also searching for a parking place, of course including some traffic jams and remarks about driving skills, we finally reached our hostel in Lille at 7.30PM. The hostel were we would spent the weekend was in the north of Lille close to the city centre. The hostel Gastama is modern and of good quality, it also has a local bar on the first floor.

After arriving and some trouble with the payment of the hostel, the start activity comity started cooking right away while the mollier members tried out the local (alcoholic) beverages. A delightful pasta meal was prepared and served not much later.

Figure 1 Mollier and Startactivity committee cooking.

Figure 2 Heavy competition at the music quiz.

Figure 3 A toast while singing the Mollier anthem.

Figure 4 Mollier members getting to know eachother.

A NIGHT IN LILLE

To determine who had to do the dishes a music quiz was prepared, but since all available pans and stoves had been used for cooking and other hostel guests wanted to cook, the dishes already had been done. However the music quiz still went on. To decide which group was first with answering, all the groups were put in a whatsapp chat group and had to answer using this chat. After hearing a lot of different tunes and screams from the groups ("we definitely answered before they did") the quiz was ended with the Mollier anthem.

After the music quiz Mollier decided to explore the nightlife in Lille. No one had any idea where to go, so we just started walking. After asking some people at a café, we found out the places to go out were at a walk of 20 minutes from our hostel. The bars and disco's were located at a long street in the centre of Lille and this is where we stayed the rest of the night.

The next day breakfast was provided by the startactivity committee from 10.30AM. Many members were glad this was not mandatory and stayed in bed a little longer. Eventually at noon we went to the centre of Lille for a quest. The committee had prepared a walk throughout Lille and the route of this walk had to be found with the help of questions, riddles and puzzles. It was a walk of about 2 hours past the cathedral of Lille, the zoo and some other points of interest. Eventually only one group completed the entire route! After the walk members had free time till dinner. Some people went back to the hostel for some more rest while others stayed around the city centre.

Around 6PM we went to a bowling centre. First we would have dinner and afterwards we had a bowling game. Unfortunatly the dinner at the bowling wasn't great and and the english of the french was as good as ... well our french. After the bowling we went to a supermarket to get some drinks and snacks and we went back to the hostel to make our own pre-party in the kitchen of the hostel. Later at 2AM half of the members went to the city for another nightlife experience and the rest of the people talked till the early hours in the hostel.

The next morning there was again breakfast at 10.30 AM which was even less attended and after this we went back home. All together this was a very nice weekend and we all had a great time and got to know eachother.

Figure 5 City quest through Lille.

Figure 6 Bowling and bowling shoes.

Figure 7 Tired Mollier members after a weekend Lille. Thanks to all for joining, we had a great time!

Kuijpers

Kuijpers & Mollier
Resultaat door betrokkenheid

Kuijpers is een professionele technisch dienstverlener met ruim 800 medewerkers en een omzet van 160 miljoen euro. Kuijpers verzorgt alle technische installaties in gebouwen en industrie én zorgt voor het onderhoud daarvan. Hierdoor voldoen zij jarenlang aan de gestelde eisen. Het bedrijf profileert zich met oplossingen op het gebied van milieuvriendelijkheid, energiezuinigheid en veiligheid. Kuijpers combineert zijn sterke klantgerichtheid met de aandacht voor de ontwikkeling en belangen van zijn medewerkers. Resultaat door betrokkenheid is een belangrijke drijfveer. Enkele projecten waar Kuijpers aan heeft gewerkt zijn het Rijksmuseum in Amsterdam, de Aquanura van de Efteling, **de trainingsaccommodatie van Vitesse** en het nieuwe ziekenhuis Bernhoven in Uden. Het 4e generatie familiebedrijf heeft vestigingen in Arnhem, Den Haag, Helmond, 's-Hertogenbosch, Roosendaal, Tilburg en Utrecht.

Binnen Kuijpers zijn er mogelijkheden voor traineeships, afstudeeropdrachten en stageplaatsen en zijn er diverse uitdagende functies.

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Catharina Ziekenhuis te Eindhoven

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MSc and then ...?

Keep growing!

By Peter van Mierlo

It's been already two years since I obtained my Master's in Building Services. Oh, how time flies...

Even though it doesn't seem that long ago, I'm already well-settled into my working life. Since graduating in 2011 I've started working at Valstar Simonis, a consultancy firm, where I'm working amongst other things on building system designs and energy issues.

STARTING UP AND SPREADING OUT

During my first design project I was asked to cosupervise a student at our company, an opportunity which I immediately seized. Even though I was fresh out of university, and found it trying at times, I greatly enjoyed doing it as it brought an extra dimension to my work. Currently I'm supervising my third student and if it's up to me it won't be my last.

Since supervising that first student, my work has continued to grow more and more diverse. I've started getting involved in quality management at our firm, not only cause it provides me as newcomer with a firm insight in the way things are done, but to bring my ideas to the table as well. Even though this brings an additional workload next to my core responsibilities, it also adds to the variation in my job. I realized quite soon after starting my career this diversity made me thrive and is what I need to thoroughly enjoy the working life.

Luckily, this is a mutual feeling shared by my employer. Getting the space to pursue these "extracurricular activities" can be hard if work doesn't allow for it. For a company to realize the benefit for your core activities is a big help. With this understanding and support from the firm I took up a position on an expert panel organized by an industry association. Even I don't consider myself an expert (yet), I am able to put in my two cents, at times with help of experts at the firm.

BACK TO SCHOOL, AND BACK AGAIN

Even though my education at Eindhoven University of Technology had provided me with the theoretical baggage for my job, I found myself struggling with the practical applicability at times. This is not completely strange, when you're coming from an 8-year stint in a mostly scientific environment. Even though I would probably catch up one the practicalities on building systems design soon enough, some additional training wouldn't be a bad idea. After browsing to the myriad of course offered to professionals, I started in late 2012 with a course on air conditioning technology. Even though the theoretical portions were basically a refresher of the material from my Bachelor's, the practical applications proved very helpful in my everyday work.

After finishing and graduating the course this May, I had gotten a taste for education. Shortly after I was already browsing for my next educational challenge, which I found in the subject of project management. So as of last month I've started my second course within two years' time.

FUTURE

Like everyone, I don't exactly know what the future will look like. If it were up to me, however, I'll still be working in diverse and stimulating projects, taking courses, supervising students and more. In whatever form it may come, there are always ways to keep developing. However noticeably or unnoticeable, you continue to develop yourself every day of your working life. I found professional development to take many forms. Be it through education, participation, evaluation or simply practice, I don't think you ever stop learning. Everyone has to find a balance between these elements and combine it with an inspiring work environment to make them not only good at their job, but satisfied as well.

Design of a multi-agent system for optimizing multiple energy flows in buildings

This paper investigates whether higher energy savings are possible when multiple comfort aspects and their interrelationships are taken into account. For this purpose a multi-agent system (MAS) based on AULM is developed. A test case evaluates the performance of the MAS for multi energy flows. The test case consists of two parts. First the control systems for heating, cooling and lighting work independently and are manually controlled by the occupant. Second the heating, cooling and lighting control become part of a MAS and are able to cooperate in a integral way. The results point out that a MAS is able to reduce the energy loads, while maintaining or even improving the comfort in the test room. This paper concludes that a MAS has the ability to optimize multi energy flows to realize energy saving without compromising on comfort for the user.

Written by:
C. M. Chen
M.A. van Houten
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INTRODUCTION

Since buildings are the largest source of global energy demand, cutting emissions in this sector can be a very big step in achieving energy reduction. Heating and cooling systems of buildings account for 30-50% of the global energy consumption (Kharseh, 2011).

This paper investigates whether higher energy savings are possible when multiple comfort aspects and their interrelationships are taken into account. The two fields of temperature and lighting are combined in order to generate a realistic outcome of the possible energy savings in buildings when both the heating and cooling aspects as well as the lighting aspect are considered.

The goal is to realize the combined control with a MAS, while at the same time reducing the energy loads. In order to accomplish this goal, the following research questions are investigated:

- What are the requirements for the heating, cooling and lighting control?
- How to make sure that these separate controls are able to cooperate with one another?
- How does the decision making of this system look like?
- What are the benefits of using a Multi-Agent System?

When making use of a multi-agent system the energy saving for heating and cooling can go up to almost 40% (Wan, 2011) , while the energy saving potential for lighting is even higher and can possibly reach up to 70% (Davidsson, 2005). In all cases every single agent should be prepared to sacrifice their own individual goal in order to achieve a more important common goal. This willingness to cooperate between the agents shows the strength of a MAS.

MAS MODELING METHODOLOGY BASED ON AUML

The MAS development methodology is based on object-oriented technology, which takes full advantage of a large number of graphical notations of AUML. The main steps of the methodology are as follows:

- Describe the system requirements
- Create a Domain Object Model of the system
- Identify use case
- Identifies each agent in the multi agent system
- Design Agents
- Define the role or roles of every agent
- Define the organization of the agents, by defining the relationships between the roles
- Define the capability of the agents
- Define the services of every agent
- Confirm interactions among Agents

One crucial step in MAS development is the understanding and analysis of the user requirements, which is the main activity of Use Case identification and the scenarios that are describing the functionality if the system.

Due to the fact that our objective is twofold: (i) maintaining a high comfort level and (ii) reducing the energy loads and since these two goals are equally important, the MAS is separated into two layers, i.e. a comfort layer and an energy saving layer (Fig. 1). Each individual layer is responsible for only one of the two goals.

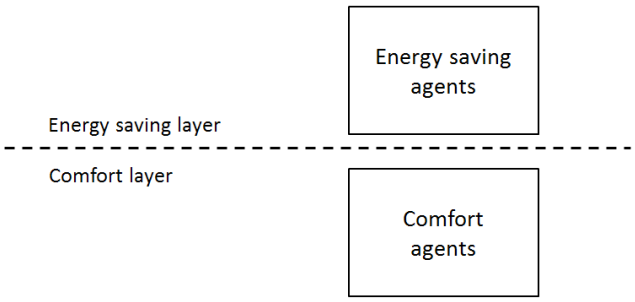

Figure 1 The MAS is divided into two layers, the energy saving layer and the comfort layer (Chen, 2012).

The comfort layer is responsible for providing a good comfort for the occupant inside the room. The comfort layer is divided into three agents, i.e. Heating agent, Cooling agent and Lighting agent (Fig. 2).

The energy saving layer is responsible for controlling the energy loads. Providing a good comfort in a room is very important, but it is also important to keep track of the energy loads and the costs that come with it. Obviously there needs to be some kind of balance between energy saving and creating a high comfort level.

Depending on the energy price the Room agent determines whether energy should be saved and by how much. The agent uses a utility function to calculate the degree of energy saving.

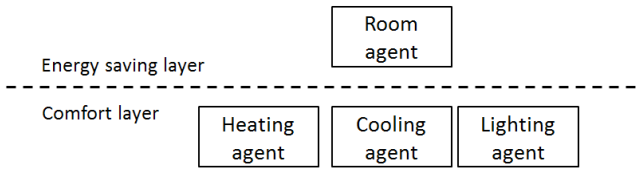

Figure 2 The comfort layer consists of three agents and the energy saving layer consists of only one agent (Chen, 2012)

INTER AGENT COMMUNICATION

One of the important aspects of developing agents is the Inter-agent communication. The communication lines between the agents are modeled with UML sequence diagrams. This communication between the agents is essential for cooperation between the agents. The Room agent is able to communicate with all three agents in the comfort layer.

However, there are no communication lines between the agents in the comfort layer mutually. This means that the comfort layer agents are not able to directly communicate with one another, though these agents certainly are able to indirectly communicate with one another via the Room agent. The reason for this is simple, these three agents do not need to communicate with one another because these agents only care about completing their own individual goals and are neither interested in the goals of the other agents nor interested in energy saving issues. The Room agent, however, does look at the overall performance of the system and hence needs to be able to correct other agents if one does not operate to the benefit of the common goal.

The communication lines between the Room agent and the three other agents operate in both directions. This means that the Room agent is able to send messages to the Heating, Cooling and Lighting agent, but these three agents are also able to send messages to the Room agent. Messages send by the Room agent are generally instructions for saving energy and messages send by the three comfort layer agents are requests to perform an action, e.g. turn on the heating or cooling, raising or lowering the blinds. However, the three comfort layer agents do not need to send a request every single time before performing an action.

Since the agents are autonomous, they are also able to make decisions on their own.

CLASS DIAGRAMS

In order to represent the internal structure of the agents and relationships among their components, a set of classes has been developed, as shown in Figure 4. The first class diagram shows the relationships between the four MAS agents. Also the attributes and methods of each individual agent are shown. The second class diagram, Figure 5, shows the generalization relationships between subclasses and super

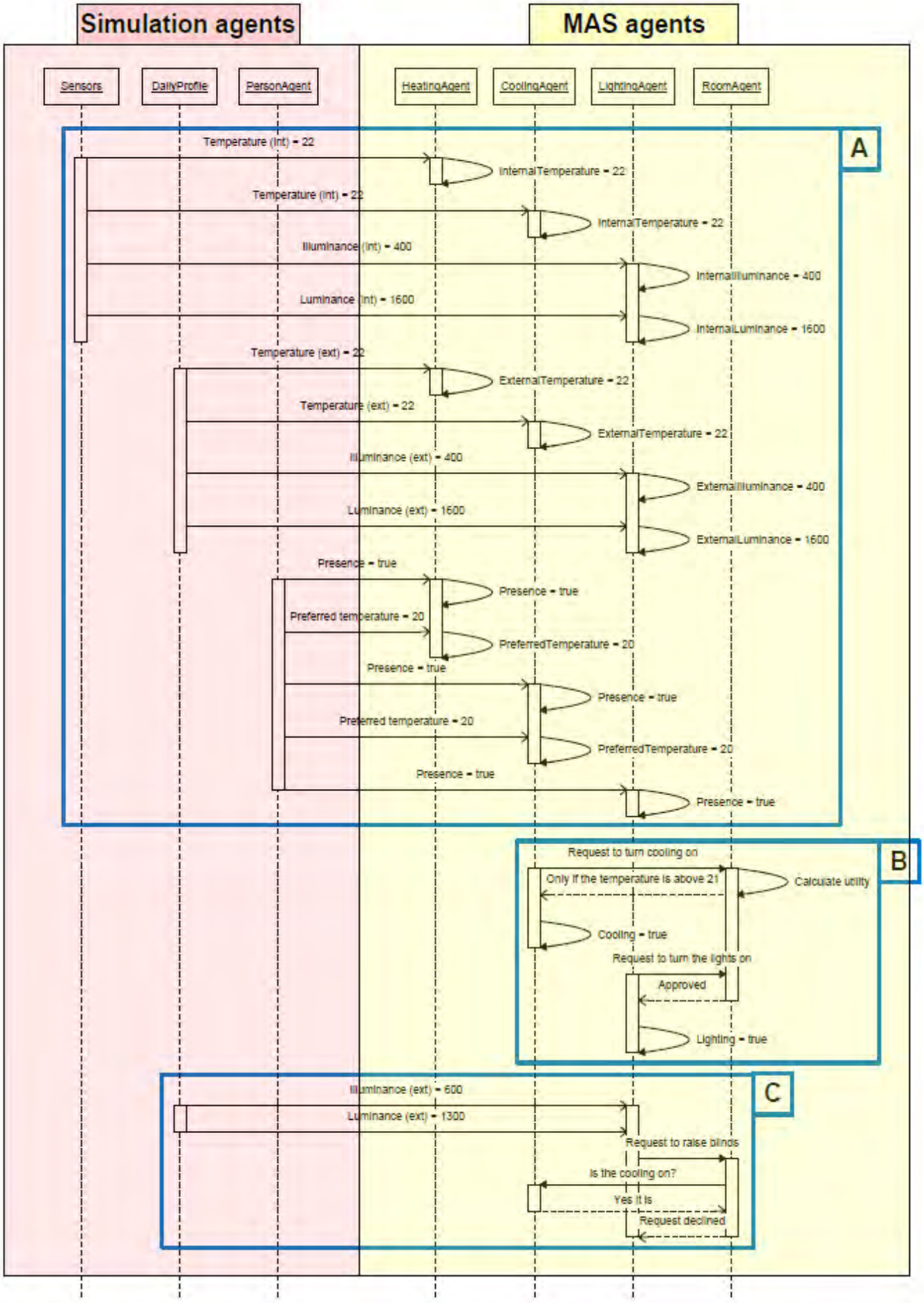

Figure 3 Sequence diagram of cooling and (raising) blinds operations. This diagram shows how the Cooling Agent and Lighting Agent react on the entrance of a person and how the lighting agent reacts on a situation where natural lighting can be utilized (Chen, 2012)

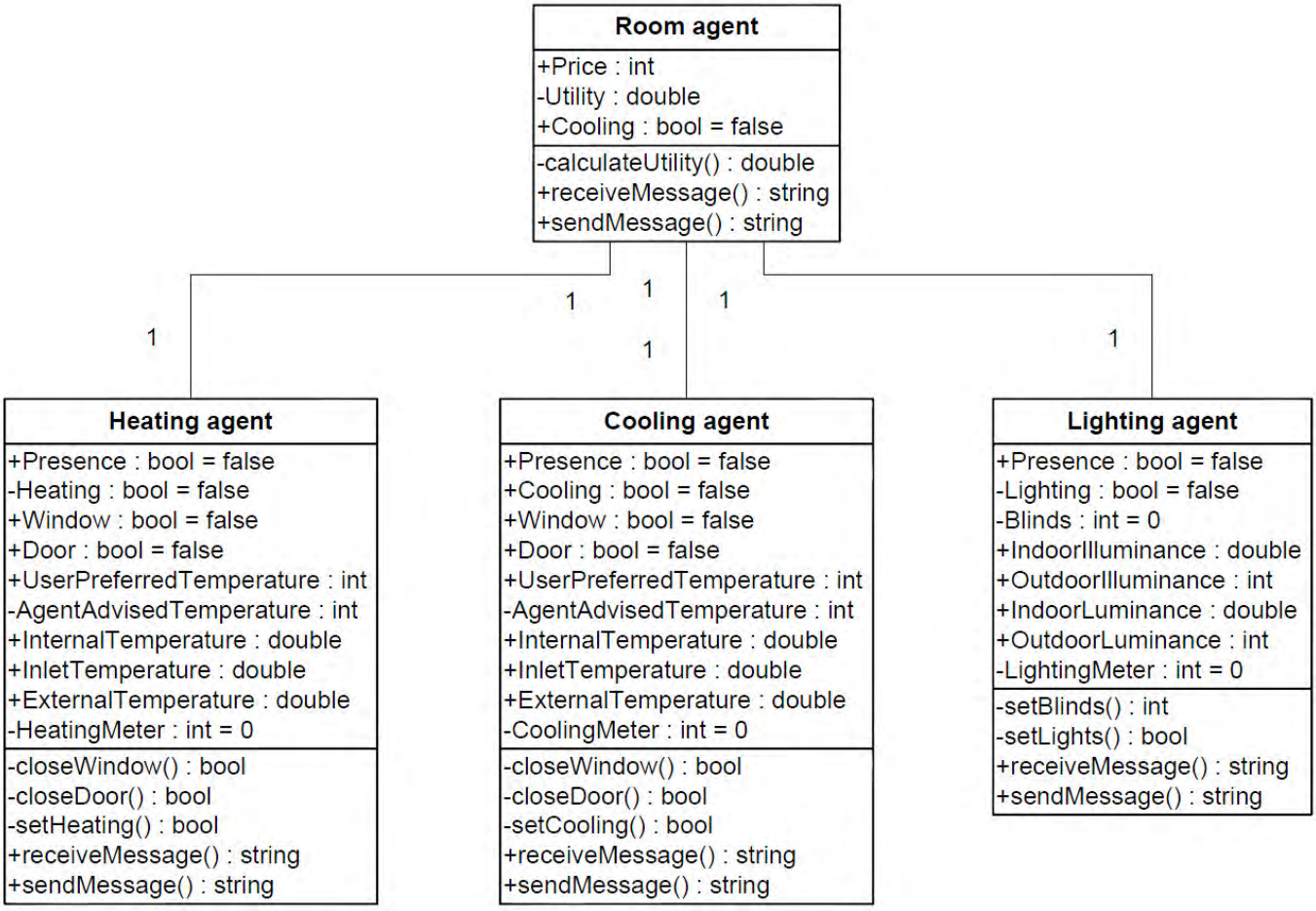

Figure 4 Instance level relationship. All agents have a bi-directional association with the room agent, which means that messages can be send both ways [10].

classes. The other class diagrams show the dependency relationships between classes. This type of relationships shows that one class depends on one or more other classes because it uses these at some point of time.

PLATFORM FOR DEVELOPING THE MAS

A lot of different agent platforms exist that help the software engineer in developing multi-agent systems. However, since agent orientation is a very broad field which covers topics such as agent organization, agent behavior and messaging, most of these platforms focus on specific objectives and therefore cannot address all important aspects of agent technology equally well (Pennings, 2009). In this field a distinction can be made between two important categories of platforms, i.e. middleware- and reasoning-oriented systems. The first category deals with FIPA-related issues such as interoperability and various infrastructure topics like white and yellow page services. This makes agent middleware an important building block from which agent technology can be developed. The second category focuses on the behavior model of an agent where rationality and goal-directedness are important aspects.

Since the categories mentioned above are both important for the development of the MAS in this thesis, an agent platform needs to be found which supports both middleware and reasoning. An existing mature middleware platform which is widely in use is the JADE platform. JADE (Java Agent Development Framework) is a software development framework for multi-agent systems and applications matching the FIPA standards. This platform possesses all the necessary components, e.g. agent development, agent management, debugging tools, efficient messaging, and is also FIPAcompliant (Mahdavi, 2008). Another advantage

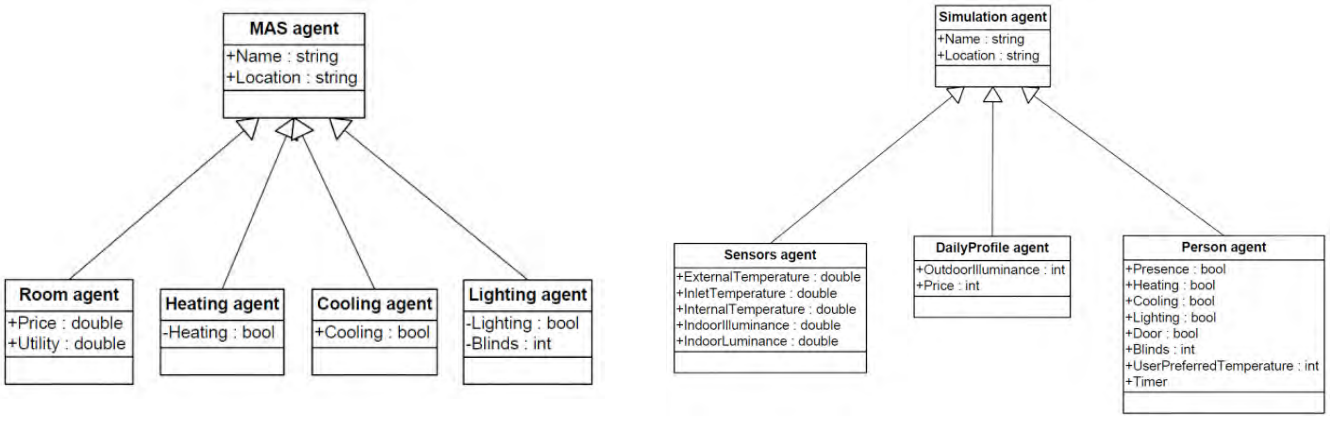

Figure 5 Room, Heating, Cooling and Lighting agent are all four subclasses of the superclass MAS agent. And the sensors agent, DailyProfile agent and person agent are all three subclasses of the superclass Simulation agent (Chen, 2012).

is that the internal agent concepts are not restricted by this platform, which gives developers the possibility to realize any kind of agent behavior.

For the development of agents ordinary Java IDEs (Integrated Development Environments) such as Eclipse can be used (see Figure 6). Eclipse is a programming environment which includes numerous functions those developers otherwise would have to hand code. This platform is managed by the nonprofit Eclipse Foundation, which means the entire development platform is free to use. Also, since Eclipse is built with Java, it runs on multiple platforms.

The designed MAS consist of four different agents: the heating agent, the cooling agent, the lighting agent and the room agent. Three of these agents, which are the HeatingAgent, CoolingAgent and LightingAgent, are responsible for creating a good comfort level for the occupant in the room. The fourth agent, which is the RoomAgent, has no direct connections with the room at all, instead this agent is linked to the three other agents and thus has an indirect influence on the climatic conditions in the room. The goal of this agent is to save energy. Since the goal of this agent can sometimes conflict with the goals of the three other agents, the RoomAgent is provided with a utility function which helps the agent to decide when and how to save energy.

UTILITY FUNCTION

The utility function in this MAS is a function of the room agent to determine whether the heating or cooling can be turned on depending on the actual price of energy. The utility function provides a balance between comfort and energy costs. The utility function consists of two variables, i.e. profit and cost, where profit is an indication of the comfort in the room and cost represents the cost of energy. The aim of this function is to keep the profit variable as high as possible and keeping the cost variable as low as possible. In this respect

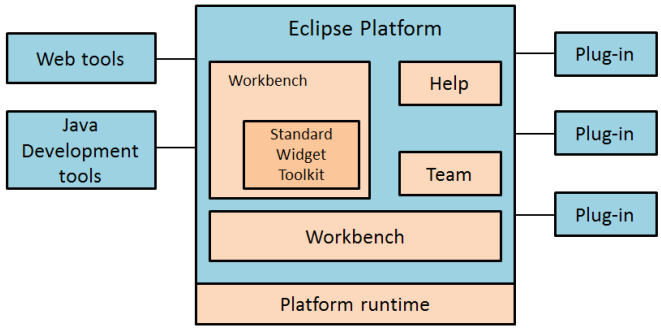

Figure 6 Eclipse platform after the example of David Geer (Davidsson, 2000)

the profit is regarded as a positive variable, the higher the better, and the cost is regarded as a negative variable, the lower the better. This leads to the following utility function:

$$Utility = profit - cost \quad (1)$$

The profit variable is a function in itself which depends on the difference between the occupant's preferred temperature and the actual temperature in the room (see equation 3.2). When ΔT equals zero the comfort variable is at its maximum value, in other words the comfort in the room is optimal. The more the temperature in the room deviates from the occupant's preferred temperature, the lower the profit value.

$$Profit = -2/9\Delta T^2 + 1 \qquad (-3 \leq \Delta T \leq 3) \quad (2)$$

The cost variable is also a function in itself which depends on (i) ΔT and (ii) the price of energy. The ΔT and price are interrelated in this formula. When ΔT equals zero it does mean that the comfort in the room is optimal, but at the same time

this also means that the energy load is at its highest. When making concessions to comfort, the energy load will also go down. The price of energy corresponds to the actual price on the energy market. However, for flexibility purposes in the experiments the price variable in the formula is made up for the different experiments and thus in this paper not coupled to the real price of energy.

Another aspect of the cost function is that it has two variants, one for heating and one for cooling. The reason there are two variants is because the ΔT for heating on the one hand and cooling on the other hand work opposite to each other. A lower ΔT means there is less heating required and thus there will be a lower energy load, while for cooling a higher ΔT means a lower energy load.

After calculating both the profit variable and the cost variable, the outcome of the different ΔT's are compared and the ΔT that leads to the highest utility value is the ΔT that the room agent will keep as guideline for heating or cooling.

$Cost=(100*\Delta T*p)/(1000-25*p)$ (for heating) (3)

$Cost=-(100*\Delta T*p)/(1000-25*p)$ (for cooling) (4)

TESTING SCENARIOS

In order to test the MAS in the test room several experiments are run. These experiments are based on scenarios of regular work days in offices and every scenario is run twice, one time without interference of the MAS and one time including MAS control. The first is based on the thermostat approach where occupants set the desired temperature manually. This method is used in most buildings (Norstad). The latter consists of cooperating agents that control both the temperature and lighting in the room automatically. The agents' temperature set point is based on the preferred temperature of the occupant that is present in the room. The various test scenarios that are tested are:

- Scenario 1: winter day, energy wasting occupant, static blinds (fully down).
- Scenario 2: summer day, energy wasting occupant, static blinds (fully down).
- Scenario 3: winter day, energy conscious occupant, static blinds (fully down).
- Scenario 4: summer day, energy conscious occupant, static blinds (fully down).
- Scenario 5: winter day, energy wasting occupant, dynamic blinds.
- Scenario 6: summer day, energy wasting occupant, dynamic blinds.
- Scenario 7: winter day, energy conscious occupant, dynamic blinds.
- Scenario 8: summer day, energy conscious occupant, dynamic blinds.

During the winter days heating is taken into account but cooling is not and during the summer days cooling are taken into account and heating is not. Also two types of users are considered, i.e. the energy wasting occupant who does not care about high energy consumptions and the energy conscious occupant who tries to keep the energy consumption at a minimum. There are also two types of blinds considered, i.e. the static blinds which are always fully down and the dynamic blinds which can be raised or lowered.

RESULTS

Results of scenario 2: a regular working day in summer. The person working in the room is someone who does not care about energy consumption. The blinds are static and are always fully down. The person enters the room at 9:00, turns the heating and lighting on and never turns these off. The central system automatically turns the heating and lighting off at 18:00.

Results of scenario 3: a regular working day in winter. The person working in the room is someone who tries to save energy whenever possible. The blinds are static and are always fully down. The person enters the room at 9:00, turns the heating and lighting on and closes the door when he is inside. He also always turns the heating and lighting off when he leaves the room.

Since the external temperature of the room, which equals the temperature inside the laboratory, cannot be controlled by the MAS and is always around 24 °C, a summer day is represented by setting the user's preferred temperature to 26 °C or 27 °C and a winter day is represented by setting the user's preferred temperature to 21 °C or 22 °C.

CONCLUSION

A MAS is developed for multi energy control. The MAS reduces the energy loads, while maintaining or even improving the comfort in the room. The agents react appropriately to changing situations and are also able to cooperate with one another.

A general conclusion is that a MAS has the ability to realize energy saving without compromising on comfort for people. This is mainly due to the fact that the agents within the MAS are not only able to work separately to accomplish individual goals but are also able to work as a team in order to accomplish a common goal.

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TU/e more than just education

Welcome to the world of material science

INTRODUCTION

Most people think that Eindhoven University of Technology is just a "large complex of buildings" with thousands of students who follow their bachelor and master studies to learn more about technology. This is partly true, but to be capable of educating all of these students, universities need to stand in the frontline of new developments, so that they can educate their students and prepare them for the "big world" after their graduation.

In order to stand in the frontline, the university develops internally new techniques to become internationally recognized and to get funds, and also broadens both national and international networks. Most of these techniques are developed in cooperation with PhD-students and their my story begins...

As many people know, our TU/e is one of the best universities regarding the cooperation with the industry. Before telling you about the content of my project, I would like to mention that my PhD research/study is funded by STW (De Stichting voor de Technische Wetenschappen), meaning that the funds are granted to develop and extend knowledge which would be applied in the industry. For this reason, there is no project without a user committee including companies that have interest in developing new knowledge and closing the gap between science and practice.

To explain the title, why the university is more than just education, I will shortly introduce my project and show the possibilities available within this "large complex of buildings".

WOOD-WOOL CEMENT BOARDS

My project is focused on the improvement of wood-wool cement boards, in order to make them more environmentally friendly and multifunctional. A lot of people might have seen these boards on ceilings of residential buildings. In case you have no clue what I'm talking about, please have a look at Figure 1.

COMPLETE STAD

To lower the environmental impact of these boards and to keep the same, or improved, properties comparing to the wood-wool cement boards produced by the company Knauf insulation, is quite a challenge. Properties of the wood-wool cement boards are, in fact, already very satisfactory. For example, Knauf boards have low density (450 kg/m3), low thermal conductivity ($\lambda \pm 0.085$ W/mK), can absorb sound and are fire- (B2) and fungi-resistant. Therefore, my project is focused mainly on the improvement of the board from environmental point of view. The production of the cement has a high CO2 footprint, so we would like to replace the cement by other more environmentally friendly materials like fly ash, slag or waste materials. Furthermore, the project will consider other fibrous organic waste materials that currently do not fulfil the existing requirements, and need to be treated before applying them. Eventually, this research will provide a deeper understanding of the wood-binder interaction and lead to the development of a new board with low environmental impact and low costs.

To be able to successfully accomplish this project, it is important to know the ins and outs of the boards. This means knowing: how the wood and cement interact with each other, how the requirements for fire-resistance, acoustic absorption and thermal insulation are fulfilled, how the production of the boards affects these properties, etc. Thus, it is required to know the fundamentals in order to improve the wood cement board properties, and this ranges from nano- to millimeter level.

Figure 1 (L) A wood-wool cement board with ingredients like spruce wood-wool, cement, water and waterglass. (R) Wood-wool cement boards applied on ceiling for sound absorption.

FACILITIES AT THE TU/E

Actually, this is where the fun begins, because our faculty mainly focuses on big-size samples from concrete, wood frames, measuring the mechanical properties, etc. But for the finer measurements we need other equipment, and this is where the research at university is a powerful tool. Other departments like Chemical Engineering, Mechanical Engineering, Applied Physics etc. have labs that can meet these requirements. As for my project, to measure the compressive strength or bending strength, I am using equipment located at Vertigo. To visualize 2D and 3D structures of my samples, I am using scanning electron microscopy and a CT-scan located in the Mechanical Department. Figure 2 illustrates the pore structure of wood obtained by using these techniques. If you would like to quantify the pore structure, you can use Mercury Porosimetry located at the Department of Chemical Engineering, and get results like illustrated in Figure 3. For analysing the interaction between wood and cement I am using the Nanoindenter located at the Department of Mechanical Engineering. This technique is able to push a needle between the hardened cement and the wood to see how strong they are attached to each other. As an example, it can be observed how complex the wood affects the binding between these two materials.

END LINE

To conclude, hopefully you agree that a university is not only an educational institute, but can also be a very nice workplace where people are able to explore their field to extend and share knowledge with different disciplines, to eventually get beyond what is already known.

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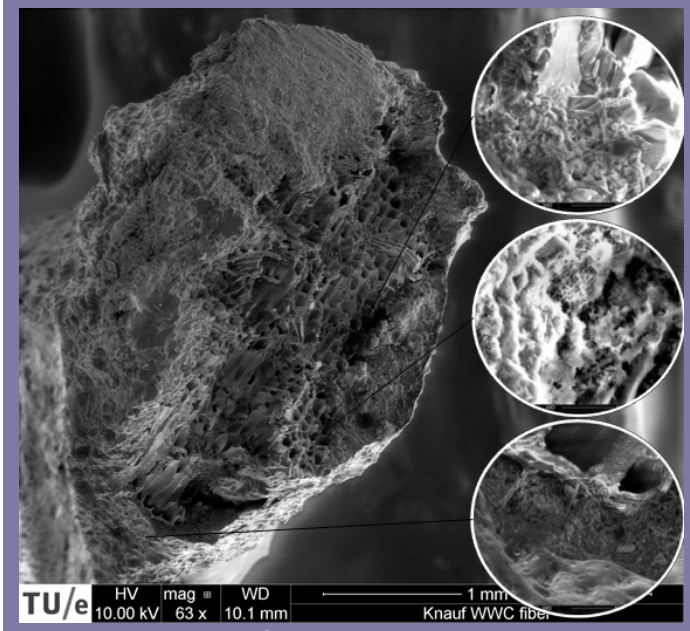

Figure 2a Cross section of spruce wood-wool covered by cement with identified hydration products and interaction zone.

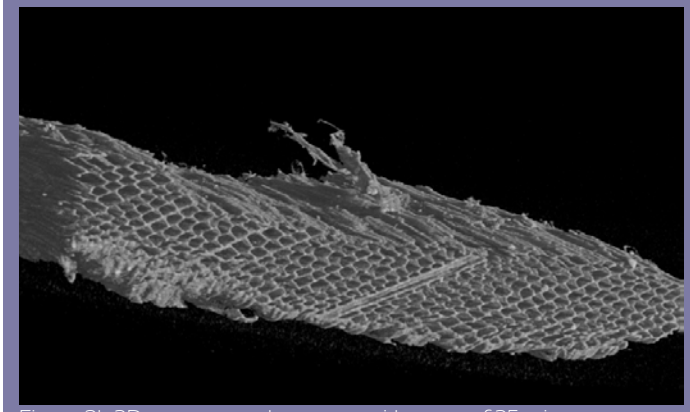

Figure 2b 3D spruce-wood structure with pores of 35 micron.

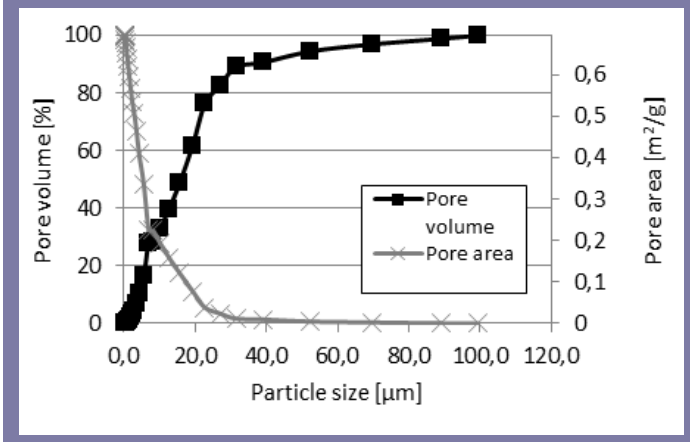

Figure 3 Quantified pore volume of wood-wool fibres and pore area. From this graph you can see that the outer surface area of one gram of wood is 120 cm2 and the total surface area is 6500 cm2.

2nd lustrum alumni association Schoone Leij

Saturday the 30th of November 2013 signified a special day in the history of s.v.b.p.s. Mollier. Not only would this day have been the 150th birthday of Richard Mollier (The Godfather of all members of s.v.b.p.s. Mollier, ever!), this year we also had the great honour and true pleasure to celebrate the 10th anniversary of Schoone Leij, the alumni association for students of s.v.b.p.s. Mollier.

Written by:
Karin Conen &
Peter van Mierlo

Around two in the afternoon a group of 50 people gathered in the centre of Eindhoven to be part of this festive day. Delegates of all classes since the establishment of s.v.b.p.s. Mollier were present: from the very early days of the first board till the current, 18th board. After about half an hour of shaking hands as a reunion between old friends or as introduction towards new members, the official program of the day began.

With a few introductory words from the board of Schoone Leij and after finishing our drinks, groups were formed for the first activity of the day: a quest trough several parts of the city of Eindhoven to test which group had the most knowledge on, amongst others, the history of the TU/e-campus and the old part of town (or simply which team remembered best which pub has which beer on tap). The key question of the afternoon, worth 1000 points: which group would be able to find the highest for public accessible point in Eindhoven centre, based on NEN-norm 2443?

By the end of the afternoon, the race to determine the winner of the title 'ultimate Mollier-member' was not over yet. The groups reunited for a few rounds of laser gaming. In the heat of the battle many of us got exhausted, but this could not ruin the good atmosphere, friendships and mutual respect, as we are used to from Mollier and Schoone Leij.

Hungry from the day so far, a short bicycle trip brought us to Dzjengis Khan, the restaurant where we would fill our stomachs with all kind of Mongolian food and refreshing beverages. With

Figure 1 Climax of the day?


Figure 2 Eat, talk, laugh during dinner and The Great Lustrum Quiz

Figure 3 On a quest (for beer)

Figure 4 Reuniting of old friends

such a large group of (formerly) Mollier members the bottles of Jägermeister got emptied pretty fast and, keeping the tradition alive, the Molliersong got struck up many times.

While eating and catching up on the current employment and other pursuits of many a member, the board of Schoone Leij started the last part of the official program: 'De Grote Lustrum Quiz' (The Great Lustrum Quiz). Questions on the best (and worst) of 18 years of Mollier were put in the spotlight. An example: 'What kind of car does Pierre Leijendeckers drive and what made this car so special?' Where the old members knew the answer straight away, some new members were wondering 'Who is Pierre Leijendeckers?' To prevent overheated brains of some of the readers: Pierre helped found our study association in 1996, and is Mollier's only honorary member.

From all kind of trivia on 'Knotsbal' and beer tasting, study trips, legendary parties, Sinterklaas at Mollier and 'Zusjesdag' (sister day) the evening came to an end, or... was it just getting started in the Irish Pub?

Before I forget, the winner of the title 'ultimate Mollier-member', until the next lustrum:

Stijn Hazenberg!

Figure 5 Laser gaming - let the hunt begin!

Figure 6 Fun at the after party

ABOUT SCHOONE LEIJ

Schoone Leij was founded in May 2003, originally as the alumni association for all the graduated students of the Master Installatietechnologie (Building Services) at the Eindhoven University of Technology. It maintains close contact with Study Association Mollier and its students, which results in the fact that many students from the current fields of study represented by s.v.b.p.s. Mollier -Building Physics and Services - feel at home among the alumni association.

The goal of Schoone Leij is to promote contact between the alumni themselves, as well as with s.v.b.p.s. Mollier and her members. At least once a year Schoone Leij organizes an activity to achieve these objectives. Members of s.v.b.p.s. Mollier can join these activities and become candidate members of Schoone Leij.

For more information on Schoone Leij:

www.schooneleij.nl
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Or join our group in LinkedIn.

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