STUDIEVERENIGING KOers
CONSTRUCTIEF ONTWERPEN

Kersief

EDITION 106
July 2018

Sustainable design

Dear reader,

Sustainability. Everyone has to deal with it. In the grocery store, we will find food with a sustainable production process, we use more and more energy which is obtained from windmills and solar panels, and just separating the organic waste from the general waste is out of date. Over the years, sustainability has changed from a concept into a way of thinking and acting. The balance between the three terms, people, planet, and profit plays an important role in this. In the 21st century, we seek for a bearable, equitable, and viable society. This is reflected in each sector, including the construction industry.

But what makes a building sustainable? A well-known concept is the reduction of CO_2. Among others, we achieve this by an intelligent use of materials and the aim for climate-neutral installations. However, over the last few years, more tools like BREAAM and MPG are developed and in this edition, we want to show how these tools can be used in order to obtain sustainable design methods.

In addition to these tools, you can also read how sustainable goals can be achieved and read about sustainable designs like Tiny TIM, People's Pavilion, and Circl. We hope that you will enjoy this last edition of the academic year and because of this, we made edition 106 a little bit thicker than usual.

New in this edition are the puzzles which you can find on page 53. Two enthusiastic KOers-members made these for you and they will provide the answers at the end of August on the KOers-website!

We wish you all a very pleasant summer!
On behalf of the editorial board,

Caroline Koks
Editor-in-chief KOersief 106

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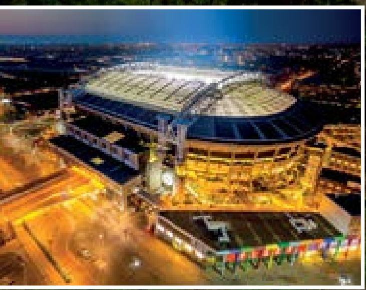

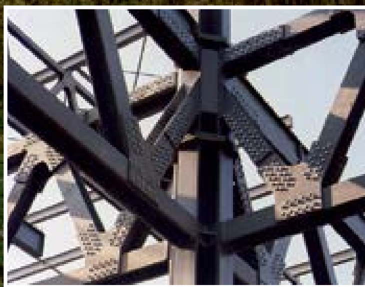

Chairman's note

Dear members of KOers,

It is the end of the year and you are most likely enjoying KOers' end-of-the-year barbecue. This KOersief is released with the theme 'Sustainable design' and you quickly flick through the pages to get a grasp of the content, before you put the magazine in your bag.

Two days later, you open the magazine again and start reading it carefully. You learn about the environmental impact of the buildings you design and methods to improve its sustainability. As a structural designer it is your duty to do something with this information, so you start thinking about ways to implement these methods in the design of your building.

However, It does not stop there, since it is your duty as an intellectual to do something with this information on a personal level as well. So, think about the environmental impact of the barbecue that you are enjoying right now. Maybe one of the principles behind the methods of sustainability can help you to reduce your own environmental impact. To start, it might already help to not eat more than five pieces of meat at the barbecue, but be happy with less meat and more environmentally friendly

food! Since this is the last chairman's note of the year, I would like to thank my fellow board members, everybody who helped organizing our activities, and everybody who joined them for making this year as rememberable as it was. Finally, I would like to thank the editorial board for their efforts in making this last KOersief of the academic year and wish you, the reader, all the pleasure in reading it.

All the best,
On behalf of the 48th board of KOers,

Derk Bos
Chairman of the 48th board of KOers

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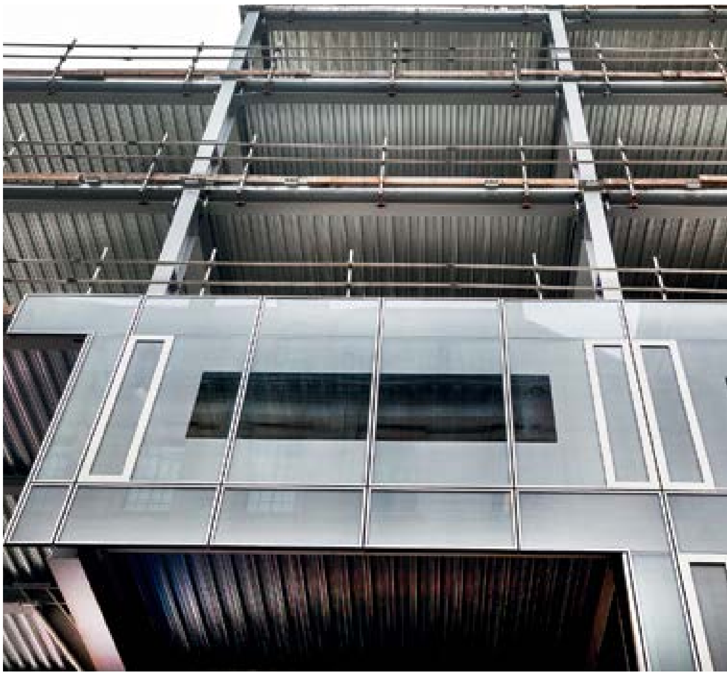

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Agenda

Excursion Van de Laar *March 16th*

Excursion van Rossum *March 28th*

Lunch lecture IV-Group *April 4th*

ENCI Multiple Day Excursion *April 26th-29th*

International Study Trip

July 13th-23rd Japan

This year, KOers will visit Japan, specifically the cities Tokyo, Nagoya, and Osaka. Both cultural and structural highlights will be visited. During this trip a lot of knowledge will be gained about the new culture as well as the different construction methods.

Constitution drink

September 12th SkyBar! Underground, Eindhoven

After the annual General members meeting, it is time to congratulate the new board again and wish them good luck for the coming year. Everyone who wants to support the new board and wants to celebrate that with a drink is very welcome!

Lunch lecture Reijneveld

September 27th Trappenzaal

During this lunch lecture the design of real art will be discussed, like the stage of Lowlands and the official monument for MH17 for example. Feel free to join and listen to this interesting topic while enjoying a sandwich and a cup of coffee (or tea).

Nationale Staalbouwdag 2018

Oktober 3rd 2018 Tata Steel , Velsen-Noord

The Nationale Staalbouwdag is the annual information event for the broad Dutch (steel) construction industry: from clients and designers to steel builders, suppliers, and producers. It is possible to visit this event with KOers. Various projects are highlighted and seminars will be given. Furthermore, the studenten STAAL award and the national STAAL award will be awarded again.

Betondag 2018

November 15th 2018 De Doelen, Rotterdam

For years, the 'Betondag' has been the knowledge day and the meeting point of the Netherlands, concerning concrete. The 'Betondag' will take place in the Doelen, Rotterdam. The date and theme will soon be revealed. Spectacular projects will of course be discussed. Make sure to join KOers on this informative and fun day.

Typical old Dutch games drink *May 2nd*

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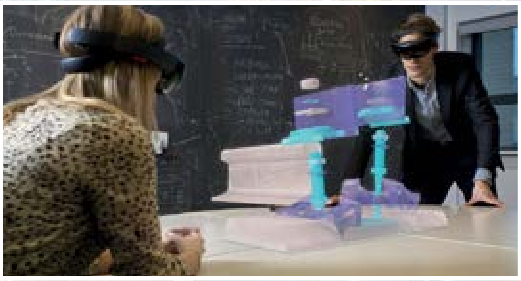

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Building Research Establishment Environmental Assessment Method

BREEAM

By: ir. Jan Willem Hoekstra
Senior Advisor at Van Rossum Raadgevende Ingenieurs b.v.

BREEAM-NL was introduced in 2010, but sustainability has played a role in the Dutch construction and real estate world for at least 10 years. In the early stages, it were the pioneers in particular who contributed greatly and the American sustainability label LEED, which was mainly employed. Now, however, sustainability is a basic part of the design task for new and refurbished projects. This means that it is also important for structural engineers to know something about sustainable designs and to know where they can offer added value.

The nine categories within BREEAM-NL New Construction and Renovation can be broken down as follows:

- Management 12 %
- Health 15 %
- Energy 19 %
- Transport 8 %
- Water 6 %
- Materials 12.5 %
- Waste 7.5 %
- Land use and ecology 10 %
- Pollution 10 %

BREEAM-NL focuses primarily on the building physics and technical installation aspects. The sustainability of a structure can usually be linked to the category 'Materials'. Within the materials category, points can be earned for the use of materials and the origin of the materials (MAT 1 and MAT 5) for which, depending on the environmental impact of the materials, a score is given. The materials chapter does not only refer to construction materials but also to structural materials.

Structural timber results in a high score within the materials category because of the renewable nature of the material. It is important that FSC-certified wood is used. This ensures that the forests where the timber originates from are also managed sustainably and do not lead to deforestation.
A disadvantage of timber construction has always been that, due to a number of material restrictions, the building height of these buildings is limited. The introduction of CLT (Cross Laminated Timber) may change this situation. In

Figure 1: TNT Hoofddorp (now Post NL) LEED Platinum

Amsterdam, for example, HAUT is being built. A 73 meter tall timber framed tower designed by Team V and Arup engineers. Employing a timber structure will inevitably lead to construction costs that are considerably higher than with other materials, which is why the choice is generally made for those other materials.

It is not just timber as a construction material that can contribute to a sustainable structure. The use of recycled aggregates in concrete is another example of this, usually in the form of concrete rubble granulate (according to CUR Recommendation 85). For example, 75% of the gravel in the foundation of the TNT office building (*Header* and *Figure 1*) has been replaced by concrete rubble granulate. In the current market, the use of concrete rubble granulate is also very common; in general, up to 20% of gravel is being substituted by concrete rubble granulate as standard for both poured and precast concrete. For these percentages, the concrete can always be delivered under certificate. This causes slightly more problems when using higher percentages. In practice, it is often difficult to employ high percentages of concrete rubble granulate in precast concrete, certainly with strengths higher than C30/37. The strength of the rubble granulate can sometimes be lower

Figure 2: The Edge inside the atrium

BREEAM is an English assessment method developed by the BRE (English version of TNO) to evaluate the sustainability of buildings, in full the 'Building Research Establishment Environmental Assessment Method'. BREEAM can award a label with a value between 1 and 5 stars to a building depending on the percentage scored, the distribution is as shown in *Table 1*. Examples of buildings with a BREEAM-NL 'Outstanding' rating include: The Edge in the 'Zuidas' in Amsterdam with a score of 98.36% (*Figure 2* and *Figure 3*), Alliander in Duiven (*Figure 5* and *Figure 6*), and also the new Atlas building on the TU/e Campus. The structure of all three buildings is designed by van Rossum.

BREEAM-NL was first introduced to the Dutch market in 2010. This method is currently the most widely used label in the Netherlands for evaluating the sustainability of buildings.

There are four different quality labels within BREEAM-NL and a separate path for projects that do not fall within the four standard quality marks:

- New Construction and Renovation
- In-use
- Area Development
- Demolition and Disassembly
- Bespoke, for projects outside the categories mentioned above

Most of the projects employing structural engineers will usually fall into the category of New Construction and Renovation and, in a few cases, into a 'bespoke' process. BREEAM-NL New Construction and Renovation assesses buildings on nine different sustainability topics: management, health, energy, transport, water, materials, waste, land use and ecology, and pollution.

Table 1: BREAAM labels

Score		%
*	**Pass**	**≥ 30%**
**	**Good**	**≥ 45%**
***	**Very good**	**≥ 55%**
****	**Excellent**	**≥ 70%**
****	**Outstanding**	**≥ 85%**

In addition to BREEAM, there are a number of other methods in the Dutch market for evaluating sustainability; the most important methods are:

- The energy label confers on the building a classification between G and A++, this is the least comprehensive label in the Netherlands.
- GPR building: based on numbers between 1 and 10 on energy, environment, health, quality of use, and future value, an overall figure is assigned. This measure has no certification. This is regularly used by local or national authorities.
- LEED: an American sustainability label in which a greater emphasis is placed on the origin of the materials used, as compared to BREEAM. An example is the TNT office in Hoofddorp (now Post NL) with a structural design by Van Rossum, which has been awarded the highest possible LEED Platinum label (*Header* and *Figure 1*).
- GreenCalc: a sustainability label based on an assessment of energy consumption, water consumption, and the use of materials. The Post NL building mentioned above in LEED is also an example of a building with a Greencalc label.

than the final desired concrete quality. This is one of the reasons why it is difficult to combine precast concrete of a relatively high strength class with a high percentage of concrete rubble granulate. In addition, the applicability of concrete rubble granulate also depends on its availability in the market. This makes it risky to have the BREEAM score depend upon the market situation at the time of construction.

Figure 3: The Edge Amsterdam seen from A10

The same can be done with the reuse of steel, in general a relatively high percentage of new steel profiles consist of recycled steel. The remaining environmental impact can be determined by means of a Life Cycle Assessment (LCA). One step further than the use of recycled materials, is the use of materials that can be found on the building site itself. This can be in the form of an existing building that is being demolished and whose materials are being used in the new building on the same site, e.g. concrete rubble granulate. But it can also be done by the reuse of toilet bowls or sinks. It is even better not to demolish the existing building, but to make it suitable for a new function. The more that can be preserved from an existing building, the more sustainable it will be.

Figure 4: The old complex Alliander in Duiven. Red: demolished, green: retained, blue: given an extra layer, and yellow: added.

An example of this is Alliander in Duiven, where the structure of the existing complex (*Figure 4*) has largely been retained. A limited part of the existing building has been demolished, a part has been retained, a part has been given an extra layer, and a number of buildings have been added. Shown in red, green, blue, and yellow, respectively, in *Figure 4*. The existing buildings were given new facades and placed under one large roof to create a campus. This is also the case with the renovated Atlas building on the TU/e campus, where a very large portion of the existing building has been reused.

A different approach to a sustainable structural design can be to disassemble the structural parts, the aim being that the entire structure can be disassembled and reused as a whole or in parts in order to extend the lifespan of the materials as much as possible. An example of this is the temporary court in Amsterdam by architect Cepezed and structural engineer IMd.

Figure 5: Alliander in Duiven during construction

Within the materials category of BREEAM, points are also awarded for the flexibility of a building (MAT 8). In addition to the flexibility of the installations, the flexibility offered by the structure also plays an important role. Within this credit, the available floor load, the net story height, the column spacings, and the presence or absence of load-bearing facades and walls are important. A structure consisting of a column structure (spacings > 8.1 meters) without load-bearing facades or walls, a large net clear height (> 3.5 meters), and a floor load of 5.0 kN/m^2 yields the most points.

Figure 6: Alliander in Duiven

The search for sustainable structural design is focused on extending the life of the building and/or the materials used, either as a whole, in elements, or in a recycled form. The aim is to limit the impact on the environment as much as possible. This can be done by creating a clever structural design and choosing the right materials. The structural engineer has an important role to play in this, especially as a sustainable structure is not necessarily an expensive one. ◀

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A practical example of the environmental impact of a structural design

'Milieu Prestatie Gebouwen'

By: ir. Pim Peters RO
IMd Raadgevende Ingenieurs

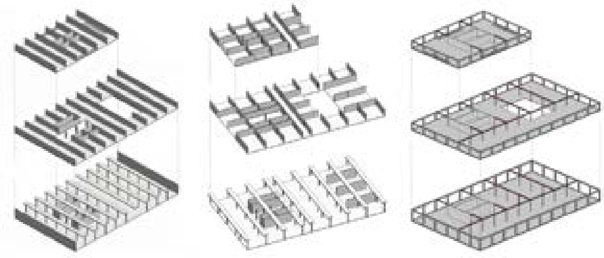
Structural engineers gain a good intuition for structural dimensions during their work experience. When calculating and designing different types of structures they develop a sixth sense for this. With simple design calculations, they are able to check if their preliminary assumptions were correct. Until now, we were not able to determine if the chosen solution for the structure of the building also provided the most sustainable solution. Due to the new calculation rules for the environmental impact (MPG-score) of the materials used in buildings we design, we are finally able to compare the different options considering sustainability. A concrete versus a steel structure, or a steel versus a timber beam. Currently, we are able to determine the optimal structural solution when comparing these materials. However, due to lack of experience, we do not know what the exact difference considering the environmental impact will be. A new challenge for structural engineers has entered the arena.

In order to compare the different structural possibilities, one has to make sure that the functions provided by the structure are the same. For example, if the building is used for apartments, a concrete load bearing wall can also provide the function of a separation wall. In this case, when comparing a concrete structure with a steel structure, one should add a separation wall in MPG-score. Obviously, one can choose the separation wall with the lowest environmental impact as long as it acquires the necessary properties. In the preliminary design stage, there are still a lot of options and choices to make for the structure. During this stage, it is difficult to exactly determine the environmental impact, because of its complexity and coherent connections with architectural and building installations aspects. However, if one can define a representative part of the building, for example, a standard floor of the building, this certainly can give a good estimation for the alternatives in the preliminary design.

For a multifunctional building in Rotterdam (*Figure 1*), IMd recently researched the environmental impact of three structural designs of the building. The building consists of several functions which will be stacked on top of each other; in the basement there will be parking lot, at the ground and first floor will be, still undetermined, commercial areas, a hotel from the second until the fifth floor, and all floors above will consist of apartments with variable square meters. The structural options we compared were (*Figure 2*):

Figure 1: De Pols van Katendrecht building scheme by DeDrie Architects

1. In-situ cast concrete structure with load bearing walls for the hotel and apartments;
2. A prefabricated concrete structure with load bearing walls for the hotel and apartments and prefabricated hollow core floor slabs;
3. A prefabricated concrete load bearing facade with an internal steel structure and prefabricated hollow core floor slabs.



Option 1 Option 2 Option 3

Figure 2: Preliminary structural design options

At first, we only considered the standard apartment floor for the MPG-score. Because the three different options have a great impact on the design of the lower floors, we added the hotel floor and the commercial floor as well. The different functions did not have the same floor area, leading to calculation of the MPG-score for a single square meter and multiply the result with the total amount of functional square meters. Making these simplifications, we were able to determine the environmental impact of the building for the three structural options by only calculating the MPG-score of the three floors.

As a result of the research, the client was advised to use a prefabricated concrete load bearing facade with steel columns and integrated HQ-beams to bear the hollow core floor slabs (option 3). This advice was due to the fact that option 3 had the lowest MPG-score of € 0.18 per square meter. Although the difference with the two other options is not remarkable, it still will have around respectively 28% and 6% less impact (*Table 1*). However, the construction costs of structural option 3 are slightly higher than those of the first two options; still the client did choose the most sustainable solution. But this choice was not only based on the lower environmental impact. The suggested structure also provides much more flexibility for the future function of the building. After all, the separation walls are not load bearing and can be adjusted easily. By investing in the story height of the apartment levels, it is even imaginable that this building, in the near future, can be transformed into offices or a care center.

Table 1: Result MPG-score

Options		€ Commercial	€ Hotel	€ Apartments
1	Tunnelsystem + in situ floors	25,364.82	86,661.85	133,267.88
2	Bearing walls + appartment floors	28,182.43	75,774.37	106,537.48
3	Bearing facade + appartment floor	17,200.25	69,969.45	110,640.12

Options		€ Total	€ / year	€ /m² · GFA per year
1	Tunnelsystem + in situ floors	245,294.55	4,905.89	0.23
2	Bearing walls + appartment floors	210,494.28	4,209.89	0.19
3	Bearing facade + appartment floor	196,809.82	3,963.20	0.18

At first, the flexibility of the structure was not taken in consideration for the MPG-score. After discussing the options

The Bouwbesluit 2012 gave attention to the environmental performance of building materials for the first time and from January 1st in 2013, it was mandatory to add a calculation of the environmental performance for buildings (MPG) to the building permit. A requirement for the calculation had not yet been made, because there was no knowledge about the size of the outcome. As of January 1st in 2018, this has changed and a requirement has been set for the 'shadow costs'.

At first, sustainable design was mainly about limiting energy consumption. By striving to build energy-neutral in 2020, the material-bound environmental impact becomes increasingly important. This material-bound environmental impact is determined over the entire life cycle (Cradle to Grave) of a material, using the Life Cycle Analysis (LCA). This results in a material-bound environmental profile, which contains various environmental effects. To make the environmental impact transparent, it can be expressed in a single number: the total environmental costs associated with an applied (structural) material. These environmental costs are also called shadow costs; these are the costs of the most expensive prevention measures that are necessary to achieve the environmental objectives. There is a shadow price per unit for every environmental effect. The shadow prices have been drawn up by the Dutch government and are based on Dutch prevention measures, so only applicable in the Netherlands.

The product and/or material bound environmental profiles are collected in the National Environmental Database (NMD). The Bouwbesluit 2012 prescribes the 'Determination method for environmental performance of buildings and civil engineering works'. With this determination method, it is possible to calculate the shadow costs of a building per square meter gross floor area per year (€ / m² · GFA per year) with the formula below. The determination method and the NMD are applied in various calculation instruments such as GPR Gebouw, GreenCalc, DuBoCalc, MRPI Freetool, and BREEAM.NL.

$$MPG_{building} = \frac{\sum (shadowprice / kg) \cdot \mathrm{kg}}{lifespan \cdot m^2_{grossfloorarea}}$$

The set limit value for the shadow price is € 1 / m² · GFA for both residential buildings and offices. Currently, almost all buildings, except for some detached villas, will meet this requirement. It seems odd to demand a requirement that should improve the environment, to which almost all buildings already comply. However, just as the Energy Performance Coefficient (EPC), which went from a requirement of 1.4 in 1995 to a future requirement of 0.0 in 2020, the MPG requirement will become increasingly stringent.

with the client, we reconsidered why this big advantage was left out. The calculation of the MPG-score takes two defaults into account for the supposed lifetime of the building. Buildings with offices are considered to have a life span of around 50 years and the ones with dwellings around 75 years. Due to the multifunctional purpose of this building, the shadow costs of the building are supposed to be divided over 50 years. This default can be raised, when a longer lifetime is proven as acceptable. However, there are no approved calculation rules to estimate the life span of a building. In 2010, ir. Frank Tool graduated from Delft University of Technology designing a tool to estimate the service life (ESL-factor) of a building. Taking in consideration the structural conditions, such as the floor span, load bearing walls or columns, the floor height, etc. Independent of this graduation research, ir. Marijn Landman graduated in 2016 at Eindhoven University of Technology on the research of 'Technical Building Properties with the Probability of Elongating the Functional Service Life'. The Landman model gives the probability of transformation in the future, for a building, based on the buildings technical properties.

Table 2: ESL-factor according to Frank Tool

Options	Factor	Percentage	Life span
1	0.745	100%	50 jaar
2	0.941	126%	63 jaar
3	1.116	150%	75 jaar

To see if we could enhance the MPG-score for the chosen structural option, we followed both methods for the three suggested structural options. The outcome was satisfying because the estimated service life of the three options was approximately the same for both methods. With this result, we can assume that the default of 50 years is correct for the structure with the load bearing walls (option 1). However, for the prefabricated wall (option 2) this could be increased to 63 years and even up to 75 years for option 3 (*Table 2* and *Table 3*). When taking these estimated service lives into account, the new MPG-score of option 3 became € 0.12 per square meter. Furthermore, the difference with the other two options changed up to respectively 92% and 25% less impact!

Table 3: The Landman model

Options	Grade	Percentage
1	3.14	100%
2	4.07	130%
3	4.86	158%

The first lesson learned was to really ensure yourself that you are making the right structural design choices when considering the MPG-score for the entire building. Secondly, when considering multifunctional buildings, this actually means that the influence of the structure, for all the different functions should be taken into account. And last but not least, one should always check the estimated service life of one's structural design. Let us design the buildings for the future today! ◀

Figures:
Header,1 DEDRIE architects

By: ir. Marijn Landman
IMd Raadgevende Ingenieurs

In addition to my job as a structural engineer, I fulfill the role of sustainability coordinator for IMd Raadgevende Ingenieurs. Within this role, I keep track of achieving our sustainability goals and increasing the knowledge among my colleagues of this subject. The main goal that IMd set for itself is making structural designs with a minimal environmental impact by using MPG-calculations and sustainable materials. IMd developed the DuCo-tool (Duurzaam Construeren) in collaboration with Bouwen met Staal in order to easily compare structural designs and their components.

In order to reach our sustainability goals, IMd pioneers in circular building. An example of this is the project Hoogstraat in Rotterdam. Here, steel beams are used which were obtained from a field with steel scrap ready to be melted down in the steel ovens. *Figure 1* shows connections with new steel columns and the old beams that were reused. When using second hand materials, you have to work with what you get. In *Figure 2,* this can be seen by the different profiles that were used to make one beam.

Programs such as BREEAM-NL and GPR-Gebouw give more insight into the environmental impact of our decisions in the design of the building and the materials used. Both are influenced by the length of the functional service life (FSL) of the building during its life cycle. The higher the life span, the more the environmental impact of the building will decrease.

Figure 1: Construction of a steel connection at the Hoogstraat

My interest in sustainability developed during my studies at Eindhoven University of Technology. I graduated on the subject of the potential of buildings to be transformed or reused based on their building properties. The fourteen technical building properties that have an influence on the probability of elongating the functional service life are:

- Structural stability principle
- Segregation of the facade
- Demountability of the facade
- Demountability of the facade elements
- Reachability of the facade connection with the structure
- Adjustability of the facade
- Horizontal expansion possibilities for the service elements
- Demountability of non-loadbearing walls
- Reachability of the floors (entrances)
- Usability of the floors caused by the structure
- Free ceiling height (in meters)
- Reachability of the stairs connection with the structure
- Horizontal distance between grid lines (in meters)
- Variable loadbearing capacity of the structural floors (in kN/m^2)

The final result of my graduation research is the Landman model, an analysis tool that predicts the chance of a (design of a) building to be transformed or reused in the future, based on its building properties.

Figure 2: Structure with reused steel beams

I am convinced that we need to change our design process to one considering the environmental consequences of our decisions during the entire life cycle of the building and its products. When improving the adaptability of the structure and facade of buildings, in order to elongate the life span, a higher score on sustainability levels will be achieved. Adaptability is the new flexibility! ◀

IMd
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IMd Structural Engineers (1960) is an independent engineering firm. Over 50 structural engineers put their expertise in service for developers, builders, and architects for smart, efficient, but most of all; economic structures which make buildings feasible.

IMd often collaborates with enthusiastic and ambitious students and starters. Therefore, we are always looking for new IMd employees, whom take self-initiative. In the meantime, we now have a long-term collaboration with KOers, the study association of Structural Design at Eindhoven University of Technology and U-BASE, the student association of Civil Engineering at Delft University of Technology. Regularly, we give lectures at universities and other knowledge institutes.

In the vision of IMd, a successful design heavily depends on the design process and the importance of integrated design within this process. In complex projects, the collaboration in the design team is essential for a good design. Working together in a BIM model supports this process.

IMd has extensive experience working within BIM environments. At the IMd office, a BIM-room is set where design teams can work together on the BIM model. By performing clash controls mistakes in the model can be prevented and the failure costs during construction are significantly reduced.

IMd sees it as her duty to make projects feasible. This means a proactive, guiding attitude in the design process. A 'designing' engineer can be of great value for all parties if he contributes to the design right from the start. For each project, IMd makes a study on an alternative design. Unnecessary costs can be avoided by continuously testing the influence of choices on the costs.

Each project at IMd has its own project team that consists of a consulting engineer, project manager, engineers, and draftsmen. Throughout the entire process, the consulting engineer and project manager are the contact persons for the internal as well as the external project team.

Furthermore, IMd uses a shadow team during the entire process. During each phase of the project, the shadow team performs internal reviews of the work by the project team. The advantage of this 'additional' team is the possibility of replacing someone from the project team by someone from the shadow team. This fulfills the four eyes principle of the Compendium Approach of Structural Safety, which is integrally incorporated into the Code of Conduct NEPROM Structural Safety.

IMd is located in a special office, made inside a sixty year old former steel plant at the Maas river in the Feyenoord district, Rotterdam. IMd was closely involved with the redevelopment of this former factory. In the meantime, the high architectural quality office enjoys a lot of attention of the national, as well as the international, architecture scene. The office building at the Piekstraat was awarded with the BNA Building of the Year 2012 Delta region.

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A better interaction between parties involved in soil, road, and hydraulic engineering

Achieving sustainable goals

By: M.E.M. (Maarten) Schäffner MSc
Sustainability manager at Witteveen + Bos

The Dutch construction industry faces a huge transition challenge in the coming years. A transition from a fossil era, towards a sustainable era. Worldwide, the construction industry consumes over 40% of all the raw materials. In the Netherlands, this adds up to around 250 million metric ton of raw materials per year such as stone, concrete, and wood for infrastructural, residential, and non-residential constructions. Minister Eric Wiebes (Economic Affairs and Climate) will present a national climate agreement next month, in which the carbon emissions of the Netherlands need to be reduced by 49% in 2030. Agreements such as the international climate agreement of Paris, but also national climate agreements, are leading factors in this transition. Achieving the goals goes with small steps, because a cultural change has to take place in the entire building industry. Clients need to communicate their sustainability ambitions more clearly and extra efforts by parties in the supply chain need to be rewarded. We need a more proactive behavior of parties to take sustainability a step further and activate the strength of supply chain collaboration. In order to get things moving, a long-term approach is needed with an intrinsic motivation to become more sustainable.

Ambition

The first step, in order to, achieve sustainability goals in the construction supply chain is to have a clear vision and the guts to show a high ambition. Each transition comes with a lot of uncertainties, and thus courage is required as to which parties take their role and responsibility in the transition. An achievable target is not really an ambitious target. This applies for both clients and contractors. All parties in the construction chain will autonomously become more sustainable because of the international tendency of everything becoming more sustainable. Even companies without any serious ambition will have a greener energy mix in five years because the standard electricity mix will become greener. New company cars will generate less emissions in five years than they do today. However, with this passive attitude we do not achieve the climate and energy targets that are needed to protect future generations from negative climate and environmental consequences. If a client says he wants to become climate-neutral within ten years, this will give a certain ambitious signal to the market. The signal that sustainability is important, without knowing exactly how to achieve ambitious targets. The ambition level is too often set based on the technological knowledge level of today. However, the innovation of tomorrow will generate a sustainable acceleration in the future. Rijkswaterstaat has the ambition to become energy-neutral in 2030 and climate-neutral by 2050. It also has the ambition to work circularly in 2030 and to no longer generate waste in 2050. Because they are not sure how to achieve these goals exactly, one can speak of an ambitious goal.

Attitude

The construction sector can be seen as a relatively traditional branch in which materials such as concrete and stone are used. These materials were already used by the Romans and since then relatively few sustainable alternatives have been developed. Cement has a large impact on climate change. Concrete is the most widely used construction material, and is responsible for 5% of all carbon emissions (*Figure 1*). Making the supply chain more sustainable can ensure that Dutch carbon emissions will be reduced by 1.3 million metric ton by 2020 [1]. Unfortunately, a 100% sustainable alternative for structural concrete is not yet available. Or for example asphalt, which provides us with great driving comfort. This material consists of bitumen based on an oil refinery by-product, which is, based on its negative environmental impact, not really a product of the future. Therefore, it is not surprising that the companies working in the construction supply chain, in relation to companies in for example the IT sector (where much more innovation is present), have a fairly traditional view of the building process. Within the construction industry, companies complain that clients do not reward sustainability sufficiently, which means that investments are insufficient. Sustainability is often also considered vague and insufficiently specific. A different attitude is desired in which parties take responsibility for their negative impact, set up better chain cooperation, share knowledge, and be transparent about sustainable goals.

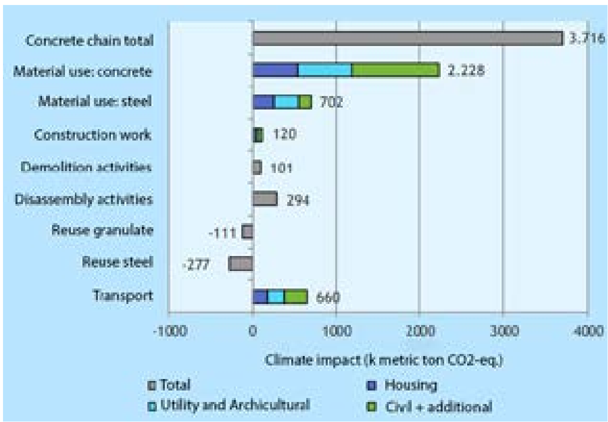

Figure 1: Climate impact construction supply chain the Netherlands 2010

Chain collaboration

Chain parties lack a part of communication with regard to sustainable measures. A troublesome dilemma is that the initiator in the supply chain does not always benefit from its own sustainable measure. The initiator (or investor) is then not rewarded for his effort.

Example: dredging works in a port
The current technology of dredging ports emits a lot of carbon dioxide from diesel consumption. A new carbon reduction invention by dredging company X reduces 80% of the emissions. However, the dredging company in question does not benefit from the climate benefits. The client does not ask for any climate impact optimizations, so the dredging company is not 'triggered' to invest. The dredging company expects that a proactive implementation of this sustainability measure would not be appreciated by the client.

In the example, the dredging company assumes that the client does not want this carbon reduction innovation. Clients, however, are explicitly looking for the impact areas on which environmental benefits can be achieved. Because the contractor does not address his innovation, the client is not able to oversee which activities can be optimized. Suppose the dredger is really intrinsically motivated and proactively offers this carbon reduction innovation to its client. This would contribute to raising awareness by the client about the opportunities and impact areas. Perhaps the client will standardize the sustainable measure in a subsequent tender, which will give the dredging company a head start over the competition. And perhaps because of this, young starters would rather work for this innovative dredging company compared to other traditional dredgers. In this case, there is an (indirect) profit because of proactively addressing sustainable opportunities to the client and optimizing the supply chain.

Contracts and tender procedures are generally not yet arranged for the sustainability transition. In general, for most of the contracts, it holds that different parties work on the project before and after the tender. This always brings some kind of loss of knowledge. Innovative building processes in which (all) parties are selected in an early stage of the project (e.g. 'bouwteam model') are seldomly used. After all, innovations can hardly be tendered on command. This requires a certain amount of trust in the supply chain that needs to be built up over the entire process. One cannot expect from parties which are only involved in a certain phase of the process (e.g. only design, construction, or management) to make additional investments in sustainability.

Chain analysis
Because the supply chain is often insufficiently transparent, it is hard to see where most sustainability gains can be achieved. In the context of the example mentioned earlier, the dredging company already knows that the largest climate impact can be achieved by optimizing the dredging engines, while the client may think for example that smarter transport routes of the vessels will have a higher impact. By carrying out a chain analysis (*Figure 2*), it is possible to determine the environmental impact of an activity or product over the entire life cycle (extraction of the necessary raw materials, production, transport, use, and waste processing). For parties that are certified in accordance with the CO_2 Performance Ladder, they are obliged to make two chain analyses. In the context of the above example, it would be interesting for the client to carry out such an analysis. When the chain analysis has been performed, the emission data can be presented in a pie chart, so that the areas that are responsible for the most impact become visible. It may turn out that the client thought that smart transport routes have a major impact on sustainability, but that in reality it appears that this only generates a few percent of the total emissions.

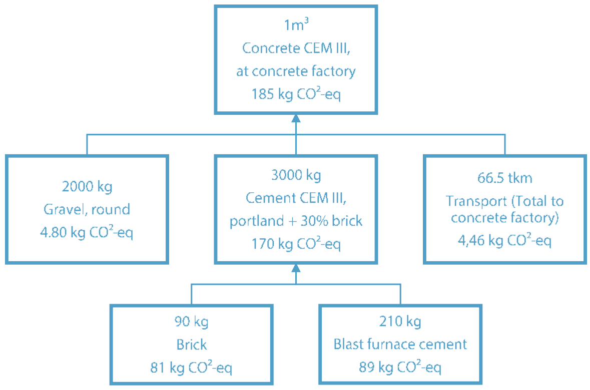

Figure 2: Example of a chain analysis

Communication
Finally, it is important that the results of the chain analysis are properly communicated with the parties involved in the supply chain. This gives all involved parties an insight into the sustainable opportunities and which parties are on the 'critical path' for a more sustainable supply chain. It is important to discuss who should bear the costs and how the benefits of sustainable innovations can be fairly distributed over the supply chain.

Summary:

- Clients need to be ambitious.
- Contractors must fulfill the client's ambitions through a proactive and transparent attitude.
- Chain analyses are needed to determine what the largest impact areas are (e.g. for carbon emissions). This is an obligation for parties that are certified in accordance with the CO_2 Performance Ladder.
- The transition towards a sustainable construction branch is a quest for all involved parties. The exchange of knowledge in the supply chain is crucial. The competitive position between parties does not have to be an obstacle. It can contribute to a positive image (and become an example).
- Discuss the chain analysis results with the parties involved, and discuss which impact areas need to be optimized.
- Discuss who should pay for the costs of supply chain optimizations or innovations, and how the benefits of sustainable innovation can be fairly distributed.
- Develop the right instruments, contracts, and ways of cooperation to communicate about sustainable measures in the supply chain. ◀

References:
[1] *https://mvonederland.nl/sector/bouw*

Figures:
1 *CE Delft*
2 *Witteveen + Bos*

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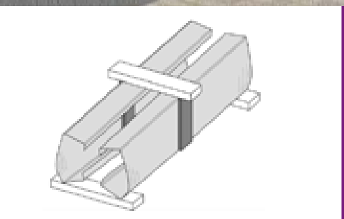

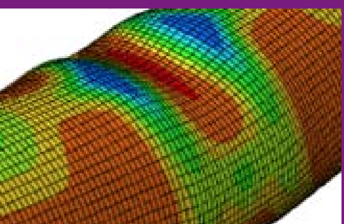

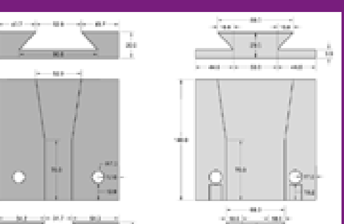

Students graduating between 31 July 2017 and 1 August 2018 are invited to participate in the studentenSTAALprijs (student STEEL award). Projects that may be eligible are: architectural design, structural engineering, research, product development and/or a combination of these in which steel plays a key role. The prize is divided in the categories: Bachelor and Master. In order to encourage architecture students to participate, an extra category is added: Master architecture. In each category there is a first prize of 500 euro and a second prize of 250 euro. Beside the regular prizes the jury may grant two additional prizes: the Van Bentum Prijs (special award for steel strip) and the ECCA-award (special award for prepainted metal).

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Interview with the architect, circularity advisor, and structural supplier

Circl, the circular pavilion at the Zuidas

By: Eline Dolkemade
Editor KOersief

The first attempt to a Dutch circular building was opened on September 5th, 2017. This initiative by ABN AMRO is called Circl. The main ideas of circular design are that both the construction and the exploitation phase are waste-free and that as little as possible raw materials are used. The wooden floors are old wooden frames cut into parquet and the floor tiles are made of crushed recycled concrete. In the ceiling, discarded jeans of bank employees have been processed as insulation material. Even the name does not have any waste, the E is not necessary as it is not pronounced. In addition to this, Circl is a social living lab where everyone with good ideas about sustainability and circularity is welcome.

The ABN AMRO pavilion was already under construction when the bank realized that the building should be more sustainable. In collaboration with TU Delft, de Architekten Cie. wanted to bring it even further and the pavilion should be circular. Construction was stopped and a new design was made. The general form was maintained, yet altered. Other aspects that were changed include the structure, functional design, climate design, etc. Three years ago, circularity was still new for all parties, yet a new design had to be made in three months.

Figure 1: Large stairs at exterior of Circl

The architect - de Architekten Cie., Hans Hammink
"When we realized that we were going to build circular, I was immediately enthusiastic. The actual design of a building with a principle of which little is known was difficult. On the other hand, the nice thing about this is that a lot had to be reinvented, which I really experienced as pioneer work. Time pressure has also helped in little choice doubts.

"The principles were clear: as much use of raw materials and energy neutral as possible, and everything demountable. But how is this constructed in practice?"

For an architect, choosing the right grid, for flexibility, and choice of materials are the most important. Integration with other disciplines is even more important in circular construction than usual, especially with the installer.

Figure 2: Interior of Circl

Together with the structural engineer, we came up with a structure where the installations could be integrated into the structural layer. In this redesign, the choice of materials has also created a different atmosphere and aesthetics."

Together with all disciplines, a building passport has been created after completion. All parts are given extra information about the materials and conditions in a BIM model. This digital information can be transferred to the building manager or ultimately used when the building is dismantled and materials are reused.

The circularity advisor - TU Delft, Luuk Graamans
"Circularity in the built environment consists of three important aspects: the first is to minimize the required amount of materials through smart design, the second is to design for the direct reuse of these materials and the third is to ensure a low CO_2 footprint for these materials. At the start of the project, the approach to circular construction was still unclear. This is why we advised to place a high emphasis on the disassembly of each and every element. This would allow for the reuse of materials at a later stage.

For the structure we investigated how we could minimize the CO_2 footprint and incorporate materials produced in the Netherlands. We quickly arrived at a timber structure. Due to difficult shapes, which were set by the architect, a concrete structure would require a lot of on site casting, which is detrimental to disassembly. The architectural design and requirement of a demountable structure limited our option for a construction method. For a demountable structure, the options typically focus on steel and timber. Steel has a much higher CO_2 footprint than timber and raw materials are not produced in the Netherlands. The choice for a timber structure is the result of its low CO_2 footprint. Additionally, at the moment, we were not able to find any companies that could guarantee the return of steel structures after their functional lifespan.

The timber structure was also quickly picked up by the architects, due to the aesthetics, and by the installers. For us as an advisor, it mainly concerned the environmental impact (which can be determined via Life Cycle Analysis). As an extra, there was already experience from the BAM in the area of residual value determination of timber structures, by the town hall in Brummen."

Figure 3: Circl at the Gustav Mahlerplein

By: Jacqueline Cramer
Professor of sustainable innovation at Utrecht University

The need to build circular is fortunately more and more recognized. The construction sector is in fact a major consumer of raw materials. An estimated 50% of the total raw materials consumption in the Netherlands can be attributed to the building industry. By reusing raw materials and recycling materials at high quality, we can significantly reduce raw material consumption and also reduce the associated CO_2 emissions and energy consumption in the chain.

Building circular is about making the entire chain circular. A priority order can be made in the chain. At the top is raw materials prevention (do not use) and - reduction per unit of product. The next step is to (re)design in such a way that the circularity of the building or object in the entire chain - from cradle to cradle - is guaranteed. The next step must be to keep a building or part of the building in the cycle for as long as possible, unless this is not better for the environment or otherwise not beneficial. Think of how many buildings will not be demolished if they can have a second or third life and possibly fulfill another function (such as housing). The recycling of, for example, steel or aluminum facades or concrete slabs also offers environmental benefits. Only when reuse of the product is no longer possible there should be switched to high quality recycling. Recycling of building materials is already happening on a large scale, but the applications are low-grade, for example as road foundation. If we demolish circularly, we can not only separate building components, but also materials that are suited for recycling into new raw materials for construction. It would be ideal to aim that hardly any material remains that has an ending lifetime.

All practical examples show that circular demolition and construction can not only produce environmental-technical but also economically and socially positive results. The condition is that parties in the construction chain work together, distribute the costs and benefits in a balanced way across the chain, and are prepared to involve people who are lagging behind in the labor market. It is not the technical possibilities that form the bottleneck to build circularly. It is mainly a question of courage to dare to change and come up with new revenue models together.

Not only disassembly, but also the possibility of reuse is important in circular construction. Throughout the project, the design team investigated potential strategies for the reuse of materials after their functional lifespan. This has also been done to investigate what is involved and which contract forms are part of this. There is not yet a fixed date on which the building should be removed, but it is designed in such a way that when there is a demand the entire building is able to be disassembled and rebuilt somewhere else.

Ideally, the future reuse (next life scenario) of all materials had been fixed in contracts in advance. In this structure, the material could even remain the property of the manufacturer, e.g. through leasing. Sadly, the construction sector was not prepared for these types of financing and ownership of structures. Additionally, the project time span was insufficient to broker such agreements. The ownership of the building and the materials in general therefor still lies with ABN AMRO. It was noticeable that installation suppliers are closer to a lease construction, because they already have service contracts. With traditional building materials, this was a lot more difficult and a return guarantee was the highest achievable option. A certain return guarantee has been concluded for most building elements and the lighting is leased.

"For the engineer, circular construction is mainly the technical feasibility of making a building demountable. It is a challenge to ensure that all materials that are enclosed in a building can actually be recovered for reuse."

As another improvement point, Luuk wanted to apply more technological developments, for example in the facade. Glass facade panels are often already demountable, so there is less to achieve at that level. Several new (non-proven) technologies, such as an algae facade or a fully automated Photo Voltaic cell facade, could also serve as a showcase for the people who walk around in the Zuidas. They generally would otherwise have little exposure to the developments in the construction industry. Unfortunately, this proved to be infeasible in the short remaining time span.

The search for the right timber manufacturer started after the timber structure was selected. Five parties were interviewed on their perception of circular construction and how they felt that they could contribute to this project. After making a quotation and a plan of action, Derix Glued Wood Constructions was selected. Together with BAM Bunnik, they designed the structure.

Figure 4: Entrance stairs to public roof garden

The supplier - Derix Glued Wood Constructions, Johan Paul Borreman

The Derix factory is located close to the Dutch border in Germany, where they produce laminated and cross laminated timber. Thanks to their own production and location, they were able to offer Dutch timber, which had been set as an important starting point for circularity.

Figure 5: Main entrance of Circl

"An intention was expressed for the return guarantee, because circularity was a new concept for us. There is no concrete stipulation that the material will be returned after a certain amount of time for amount X, as a company we were not yet ready for it."

Derix produces project specific products that can make it difficult to re-apply them directly elsewhere. However, the timber keeps its value and it should be able to market it again on a second hand market. Taking into account inflation, depreciation, and possibly abbreviation. It is stipulated that the timber should still bring in 60% of today's market value.

At Circl, the timber elements are connected with screw connections. The ambition was to develop details especially for this project that would not damage the timber elements. A piece of development had to go before that, but did not taken place due to time-constraint. In the end, traditional detail solutions were chosen, which may result in the elements to be cut off at the location of the connections for reuse. For future projects, more attention should be paid in the area of detailing in which the timber and the wood fiber are less affected.

The production and assembly of the Circl structure were not very different from other projects. The big difference was in the process, such as transport. For example, wooden elements are normally transported in plastic film to protect them from moisture. In order to prevent waste on the construction site, the elements were not transported in foil and attempts were also made to prevent unnecessary transport.

In spite of the difficulties, this project has given all parties much more than just a nice project. Almost everyone involved has learned to look differently at their own business and way of working. And almost everyone is inspired in his own way to do business in a different, sustainable way. This means that at least a small part of Circl's target has already been achieved. ◄

Figures:
Header, 1-5 Ossip van Duivenbode

People's Pavilion: 100% borrowed

The architect's point of view

By: Peter van Assche
Architect at bureau SLA

From 21st to 29th October the Dutch Design Week (DDW) – the largest and most important design event in Northern Europe – took place in Eindhoven (NL). Last year, DDW and Design City Eindhoven launched the first edition of the World Design Event (WDE), which provided a platform for future makers from all over the world. The People's Pavilion, a design of bureau SLA and Overtreders W, stood in the heart of the Dutch Design Week.

The pavilion was a design statement for a new circular economy, a 100% circular building where no building materials were lost during construction. The designers of bureau SLA and Overtreders W have accomplished this with a radical new approach: all of the materials needed to build the 250 m^2 building, were borrowed. Not only materials from traditional suppliers and producers, but also from Eindhoven residents themselves. And to be clear, it is not 70% or 80% or even 95%, but 100% of the materials. Concrete and wooden beams, lighting, facade elements, recycled plastic cladding, even the Pavilion's glass roof, all of which will be returned completely unharmed – with one special exception – to the owners following the DDW. The exception? The striking colored tiles that make up the Pavilion's upper facade, made from plastic household waste materials collected by Eindhoven residents, which were distributed among the same residents at the end of the DDW.

100% borrowed means a construction site without screws, glue, drills, or saws. This, in turn, leads to a new design language. The People's Pavilion reveals a new future for sustainable building: powerful designs with new collaborations and intelligent construction methods.

Program
The People's Pavilion was the main pavilion of the World Design Event. It was used as a meeting place and hang-out for visitors and served as a venue for music and theater. The Pavilion was programmed for two weeks during the days and evenings with events like the Age of Wonderland, the award ceremony for the national Who Cares competition, a TEDx try-out, the Making of Your World readings, and a Climate Action debate. The pavilion accommodated 200 seating or 600 standing places and was open to all: entry tickets were not required.

Figure 1: People's Pavilion under construction

Design outline

The base for the People's Pavilion was a structure of 12 concrete foundation piles and 19 wooden frames, designed in collaboration with Arup. The frames consisted of unprocessed wooden beams with standard dimensions, held together with steel straps. Concrete piles and frames were connected with 350 tensioning straps, creating an eight meter tall primary structure for the 250 m^2 building. The glass roof was constructed using a system that is commonly employed in the greenhouse industry. The pavilion's upper facade consisted of colored plastic tiles, made of recycled plastic household waste, collected largely by the inhabitants of Eindhoven in the summer of 2017. After the Dutch Design Week had ended, every inhabitant who contributed, received a plastic slate to take home. The glass facade on the ground floor was a leftover from a refurbishment of BOL.com's headquarters and will be used for a new office space after the DDW. The podium consisted of borrowed concrete slabs. For the furniture, church benches were borrowed from the Keizersgracht Church in Amsterdam for two weeks and black chairs were borrowed from Vitra Circle. The latter is a webshop in which Vitra sells restored showroom models and second-hand copies of its furniture.

Process

The process for realizing the People's Pavilion was particularly interesting, because it questions traditional building methods. In a 'normal' building process, the architect designs a building and a structural engineer elaborates the structural design. Depending on the complexity of the design other consultants are brought in to advice, for example for installation, building physics, acoustics, sustainability, construction costs, and so on. The result of all this advice is an as complete as possible design. A contractor can estimate the price really well, after which the execution, in the ideal case, runs exactly according to the set design. In this sequential process, the responsibilities between the disciplines are strictly separated and contractually well established. This is no longer the case in a more circular approach such as with the People's Pavilion. The process is no longer sequential, but parallel. After all, we as designers were completely dependent on what the market wanted and could lend us. The structural engineer also had to take into account the given dimensions. Traditionally, the manufacturer supplies the products that the architect and structural engineer prescribe, but in this case designers, structural engineers, contractors, and suppliers had to consider the optimal solution with the available products.

Figure 2: People's Pavilion during night time

Figure 3: Zooming in on People's Pavilion

Our experience is that this working method will become more important. In a traditional building process, the product supplier has a catalogue from which you as a designer can or cannot choose products (a bit exaggerated). The supplier is a product seller. With a circular model this is no longer the case. The producer, but also the consultants and builders, are called upon their experience. For the design of the People's Pavilion, we gathered a group of producers around us at a very early stage who, each based on their own expertise, thought about the realization of the building. For many suppliers, the early joining of the process was a relief. For us as designers too. It turned out that combining professional knowledge leads to more intelligent designs. In a society that is moving towards a circular economy, this new intelligence is needed. After all, there is not yet a good definition for circular construction methods: you cannot (yet) write or design a general specification for it. More experimental building processes are required for research, in which parties do not primarily monitor their own discipline, but rather dare to bear joint responsibilities. ◀

Figures:

Header,1 Jeroen van der Wielen
2,3 Filip Dujardin

People's Pavilion: no gluing, no screwing, the story of a borrowed pavilion

The structural engineer's point of view

By: Joost Lauppe, Edwin Thie, and Mike Aurik
Structural Engineers at Arup

The People's Pavilion was constructed for the Dutch Design Week in Eindhoven last year and was entirely built from borrowed materials which had to be returned undamaged to their rightful owners once the festival was finished. With this article we want to take you with us in our journey on how it was built and will take you into a new chapter in the built environment: from conventional to circular. The project showcased the possibilities of using timber as a fully circular building material and presented the challenges involved in designing and building a fully demountable timber structure without using glues, screws, or bolts.

Circular economy
The circular economy is an economic system that aims to minimize virgin resources, waste, and energy leakage by creating closed loops.

Moving towards a circular economy in the building industry will have a big benefit for the environment. A change of societal mind-set is fundamental for the circular economy to flourish. This shift requires a different way of thinking about how we design our structures.

When designing for circularity, standard detailing does not always apply. In case of the pavilion, the challenge was to create a safe structure without using any glue, screws, or bolts. This required careful consideration of how loads are transferred between elements and how overall stability is achieved.

Figure 1: People's Pavilion on Strijp-S during the Dutch Design Week

The structural design of the pavilion was conceived with circularity in mind from the outset. All materials were borrowed and the owner expected to get his materials back without loss of value. This meant that all the connections had to be completely demountable without leaving lasting traces on the building elements.

In order to create the large spans required by the architects, standard 75x200 millimeter, spruce C24 timber planks of different trade lengths were combined to larger composite beams tied together with steel straps that rely on a combination of friction and push-pull mechanisms to transfer moments and shear forces (*Header*).

The composite timber beam elements make up the chords and verticals of 3 meter deep frames which are tied to the columns, using ratchet straps. These 9 meter tall frames provide the overall stability and stiffness of the structure. For the columns, prefabricated foundation piles were used. They act as counter weights to the relatively light frame, keeping the structure firmly on the ground. Horizontal forces are transferred in friction to the underlying concrete prefabricated bearing slabs.

Figure 2: Materials used in the People's Pavilion

Detailing

Inspiration for the detailing of the dry connections came from knots commonly used in climbing, canyoneering, and sailing. An adaptation of the Prusik knot was used to attach the bracing via the ratchet straps to the timber frame. This way of connecting elements meant it could be done quickly on site and braces could be pre-tensioned on site. Around 350 ratchet straps, each with a capacity of 50 tonnes were used in the pavilion: they tied the timber frames and columns together. The downside of using ratchet straps, however, is their relatively high elasticity. For this reason, a limited number of demountable steel connection details were developed that, combined with steel cables, assured a sufficiently stiff structure against horizontal wind loads.

Construction

The pavilion was built in the course of three weeks. The structure was fully 3D modeled to define the position of the joints and the straps in the timber beams.

As the pavilion was conceived as a kit of parts, the building process remained relatively simple. Assembly of the composite beams was all done on site. The fact that the concept did not allow any screwing, meant that elements did not require processing before arriving on site. They remained in their raw unaltered state throughout.

The pavilion has demonstrated a new way of designing and building a circular structure in timber. After the event all building elements were disassembled and returned to the owners. This means the pavilion had virtually no carbon footprint besides transportation emissions.

Considerations in relation to structural analysis, detailing, and construction made this pavilion different and unique compared to conventional timber buildings. The pavilion has been praised for its architectural and structural qualities and received extensive coverage in the national and international media.

Acknowledgement

We wish to acknowledge the help of Eindhoven University of Technology in conducting the structural tests and the timber experts in the Arup Amsterdam office for designing the structure. As well as the architects Overtreders W and bureau SLA who came to us with their beautiful design and challenging ambition. ◄

Figures:

Header, 1 Filip Dujardin
2 bureau SLA

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Making cement production sustainable

By: ENCI
Subsidiary of the HeidelbergCement Group

Five billion metric tons. That is how much cement is produced every year. It is not surprising: housing, infrastructure, and workplaces must be created for over 7.5 billion people – using concrete. The HeidelbergCement Group is assuming its responsibility to produce its materials as sustainable as possible. And certainly in the Benelux we have already been a frontrunner in this for years.

In 1999, the world's largest cement companies set up the Cement Sustainability Initiative (CSI). Its purpose? To collaboratively improve the sustainability of cement production and limit its environmental impact. The CSI proposed a very specific plan in 2010 – a roadmap to reduce the CO_2 emissions from cement production by:

1. making kilns more energy efficient;
2. replacing primary fuels by alternative fuels;
3. replacing clinker by alternative raw materials;
4. capturing and storing carbon dioxide, or making effective use of it.

En route to 4 out of 4

ENCI and CBR, the Dutch and Belgian subsidiaries of the HeidelbergCement Group, are already well along in three out of those four objectives today. We use only dry raw materials in our kilns, which costs less energy than the wet processes that were previously used. The kiln is 85% fueled by alternative fuels and the cements consist of only 50% clinker. The other 50% consists of alternative secondary raw materials. By way of illustration, the European average lies at 25% alternative raw materials. We are of course continuing those efforts. And in the meantime, we are going all-out towards the fourth objective – and the greatest challenge for our sector: capturing the CO_2 that is unavoidably released and using it effectively. A European pilot project in our Belgian cement factory in Lixhe demonstrates that the HeidelbergCement Group is a pioneer in sustainability in this area too.

Capturing CO_2 in clinker production

The technology company Calix developed the Direct Separation Calciner for the LEILAC project (*Figure 1*). This allows the CO_2 from the clinker production process to be captured and removed. The CBR factory in Lixhe has been selected to build a demo installation.

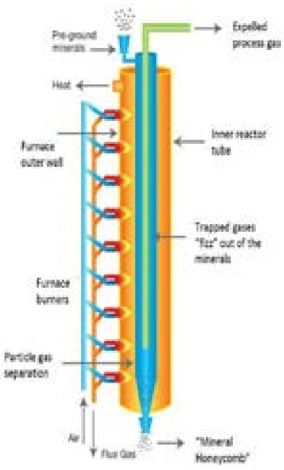

Figure 1: Direct Separation Calciner

LEILAC stands for Low Emissions Intensity Lime And Cement. It is a consortium that consists of representatives of the lime and cement industries such as HeidelbergCement, research institutes, and leading suppliers of technology and engineering. It is focused on demonstrating a revolutionary technology that should enable the European cement and lime industry to drastically curtail its CO_2 emissions.

How does it work? The exhaust gases from the kiln have no direct contact with the limestone. In an indirectly heated reactor, the heat from the exhaust gases is transferred to the ground limestone via a special steel partition. Consequently, the CO_2 that is released from the limestone can remain separated in an almost pure form – a unique step that intercepts the emissions without significant extra energy consumption (*Figure 2*).

Figure 2: Omegagreen runway

CO_2 has its uses

Researchers from HeidelbergCement grew microalgae at three locations (Sweden, Turkey, and France). Their findings were unanimous; when flue gas is injected into the bioreactors, the microalgae grow significantly better. Moreover, the microalgae meet all the criteria that make them suitable as livestock food or as food for fish farming. The HeidelbergCement Group has already studied the optimal conditions for applying CO_2 conversion commercially. The group is currently making preparations to grow these microalgae on a large scale in Morocco.

Do you want to find out more about the steps that ENCI and CBR are taking to reduce CO_2 emissions from cement production? Then read our 41st Answers sustainability edition: enci.nl/nl/klantenblad-answers. ◀

A smart and sustainable alternative to student housing

Tiny TIM

Interview with: Hans Peter Föllmi
Co-founder and designer Tiny TIM

By: Monique Morren
Editor KOersief

Many of the present day students are probably familiar with the problem of housing shortage in urban areas and especially housing that one can afford. A few years ago, this problem got the attention of architect and landscape photographer Hans Peter Föllmi when his son Dante Föllmi, student Future Planet Studies, experienced the problem of finding appropriate housing as a student in Amsterdam. Together with friend and architect Jurgen van der Ploeg, Hans Peter started to brainstorm about a next project and the idea emerged to develop a sustainable solution to this housing problem on empty sites near city centers, so called Waitlands.

Through a project by architect Jurgen van der Ploeg, the opportunity came forth to obtain six office units that otherwise would be demolished. Hans Peter and Jurgen put together a team with Dante and 12 fellow students. Forming this team in 2015 would later be the start of Tiny TIM.

On a construction site in Amsterdam, the project team started to transform the office units in more sustainable potential tiny houses. The goal was to make a mobile and autarkic design, this means completely self-sufficient and off the grid. Unfortunately, not long after starting these activities, the owner of the site threw a spanner in their work and the project had to be stopped. The property owner did not realize the project team needed his property as temporary facility and was anxious about rental of the unit's on his site. The office units were sold and got a new sustainable purpose, so the delivered work of the team did not get lost but the project team was left empty-handed. However, much was learned from the first step to a sustainable solution to the housing problem in urban areas.

The office units turned out to be less mobile than hoped for and this would result in high transportation costs. With the gained insight, Hans Peter Föllmi and Jurgen van der Ploeg together with three motivated students Waas Thissen, Abe van der Woude, and Dante Föllmi started again from scratch on a new design.

The project team was still determined to strive for an autarkic design. By making a design off the grid, so independent of local water and electricity services, you hope to lower the threshold for municipalities to make empty sites available for this type of housing because after doing this their contribution is minimal. A building contractor offered a space to build the first prototype of the new design during Christmas and the first Tiny TIM (Timber Independent Mobile) was created.

From a sustainable point of view, it is chosen to build Tiny TIM for 90% of sustainable produced timber. For the structural integrity, a SIP (Structural Insulated Panel) structure is used. These elements are a combination of OSB panels with an EPS insulation core. The panels are recyclable after disassembly of the two materials and form a strong structure for the house with high thermal properties. It is also a lightweight building structure that is important for the mobility. Stability is obtained from a steel frame on which Tiny TIM is built. The facade is also made of timber. By using the network of architect Jurgen, the team got to know of the traditional Japanese technique, Shou Sugi Ban, literally 'burnt cypress' in which coniferous wood is burned on one side and it is no longer necessary to treat it with environment polluting paint. The project team designed an interior for Tiny TIM inspired by the practical program of a sailboat (*Figure 1*).

Furthermore, Tiny TIM consist of many innovative elements to make a successful independent design. One of these special elements is the green purifying facade wall (*Figure 2*). Tiny TIM is supplied with a 2,500 liter water tank. This water constantly circulates within your own household. All water used in the bathroom, toilet, and kitchen is purified through the green facade wall. The water board has tested the quality of this water with a sample that appeared to be very pure. In order to generate sufficient energy, hybrid PhotoVoltaic Thermal (PVT) panels are used that gain both electricity and heat. Tiny TIM also has a heat pump and warm water can be stored in a 160 liter tank for sanitary water. The project team also did research on the implementation of windmills to the design. During optimization of the first prototype, this element is taken out of the design due to unfeasible return on investment.

Figure 1: Interior Tiny TIM

The mobility of Tiny TIM was a challenge. The starting point was to build the house on a trailer. However, all innovative elements to make Tiny TIM autarkic resulted in much weight. Despite the fact that the water purifying green wall was designed to be transported as a separate unit, it turned out that it was not possible to build a complete autarkic Tiny TIM on a trailer due to limitation of dimensions. The project team well considered the choice to eliminate the trailer from the design, because it will be less mobile which is one of the main goals of this concept. However, the continuous costs of a trailer are much higher than the costs of relocating by renting a crane and truck. Not to mention insurance costs, when you are driving with a trailer that is transporting your own house.

The project team learned a lot since the first ideas in 2015 and now has finished an improved design of Tiny TIM. The tiny house is no longer built on a trailer, to be able to realize an autarkic design. This made it possible to increase the roof area and generate more energy by the PVT panels. This mainly turned out to be a challenge in the first design during winter time. Another aspect the project team ran into while working on innovations is that you will face problems with some regulations that have not been set or adjusted. This is also the case for tiny houses regarding the building codes. However, the project team managed to make some final changes to the design in order to have the improved Tiny TIM comply with the building codes.

For example, the insulation thickness has been increased. Also, by increasing the size of the house to make an autarkic design feasible the minimum of 18 m^2 of required free space can be fulfilled. Innovative elements are sometimes not yet officially classified. This was also the case for the facade. The burnt timber does not have an official fire class but with a mix of certified wood the current design now complies with the building codes. This also reduces the cost of the expensive burned timber facade. Finding an affordable and sustainable facade system is still an improvement that the team is looking for.

Meanwhile, the first permits have been issued in the municipality of Haarlem to locate 10 Tiny TIMs on Waitlands. Tiny TIM has signed a contract with the municipality of Haarlem that says these 10 tiny houses will be guaranteed of a location for the next 10 years. When construction plans for the sites will be made, the municipality will provide a new location within these 10 years. The goal is to realize three tiny TIMs before summer 2018.

A mortgage cannot be applied for tiny houses yet, but for two Tiny TIMs in Haarlem private investors make it possible for future owners to purchase the house through a rent-buy construction so after 10 years the house will be theirs. A housing corporation has also joined the project and makes it possible for young people to rent a Tiny TIM. This brings the concept back to the main goal of the project team to develop a sustainable solution on empty sites near city centers to the housing shortage for students.

Figure 2: Green purifying facade wall

During the process, the project team learned that the demand for the Tiny TIM concept not only comes from students but also from other groups in society. This also results in realization of a Tiny TIM in Rotterdam as a meeting place on a roof garden at a shopping center. The Tiny TIM team continues to develop ideas and with the ever-growing housing demand, the team hopes to get support of more municipalities that want to contribute to a sustainable solution to this problem. ◀

Figures:
Header, 1,2 IC4U © Hans Peter Föllmi

A collaboration between Wessel van Geffen Architects and Superuse Studios

Waste for waste disposal

By: Denise Kerindongo
Editor KOersief

Oogstkaart is the Dutch platform for professional reuse of residual materials. This organization aims to provide insight into available materials, elements, and components and offers these for reuse. Oogstkaart is a platform developed by Superuse Studios and fulfilled a creative leading function for the waste disposal station in The Hague, which was made of 'waste'. This station is intended for the intake of leftovers and for further processing of materials. With this building, the municipality of The Hague created a new procedure for reuse. It thus marks an important step towards a circular future.

With a professional and driven team, a wonderful example is realized. The architect made the design, the contractor carried it out, Superuse Studios connected parties and materials, the waste processor was the supplier, and the municipality tested the project on strict requirements. This project has lifted reuse to a new level with regard to the scale and risk management.

'Not building with new materials, but with waste and residual materials'. In the past, this idea was perhaps something for idealists, but nowadays it is becoming mainstream. The waste disposal station, that is made from waste, is a perfect example of that. The building is also energy-neutral, it collects and uses all rainwater and is covered by a green roof (*Figure 1*).

Figure 1: Green roof with solar panels

The waste disposal project is all but ordinary: the building materials were supplied by the car industry. Their waste was reused and so instead of an investment for disposing their waste, a profit was made. The municipality developed a calculation method to make reuse suitable for a European tender and Wessel van Geffen architects directed the design process. Superuse Studios has been given a linking function within the whole, in order to connect the design and the product development. This building makes a modest but proud contribution to the transition to a sustainable society.

For how long have materials already been recycled and what does the future bring?

Recycling started in the 1970s already, but nowadays reuse of materials and waste prevention are gaining ground, given that recycling is much more energy-intensive than reuse. The EU's sustainability agenda and our National Raw Materials Agreement point to a political change. Governments are increasingly aware of the benefits of a circular area development, as the municipality of The Hague currently does in the Binkhorst. There is plenty of experimenting with good results. China is a country that is dealing with raw material scarcity for example, and companies such as Superuse Studios are a wanted partner. The circular economy association in China plans to create 200 circular industrial estates in 2020. The waste disposal station is located in the center of The Hague. This sets an

Figure 2: Different locations for different types of disposal

unusual high requirement for appearance and architecture for an environmental waste stream, but also for issues such as sound insulation and fire safety. The fact that the facade of the building consists entirely of waste materials shows the high standard that can be achieved with reuse. The use of waste for the facade gives the residents of The Hague an idea of what happens inside and where they can dispose of their extensive waste (*Figure 2*). The visual quality of the facade panels provide an attractive image, but those who look closely, recognize cutting residues from the car industry in the perforated steel plates. The building displays useful reuse of residual materials, and that is exactly what was strived for.

How does the earning model work for the reuse of steel cutting residues?
The steel plates are reusable and thus have a larger sustainable value, the waste processor earns from transport, the creative experts earn from mediation and design, and the contractor saves purchasing costs. More is earned and the environmental impact is less, compared to conventional building processes. In the end the client gets a unique and affordable building.

The outline of the building was developed by the engineering firm of the municipality of The Hague. Another part of the team was able to make some smart improvements, such as the distinctive shed roof shape. The focus of Wessel van Geffen architects, supported by Superuse Studios, and the contractor Van Boekel Zeeland,

Figure 3: Open space without columns

was mainly to elaborate the facade well. Chosen is for a vertical emphasis of the facade with timber beams. Due to this, the length of the building is split into parts and provides a constant size for the steel contour. The design of the entrance includes an expressive canopy, resulting in plenty of daylight for the employees and is also used as a roof terrace. Thanks to the large column less interior and the modular facade structure, the building is perfectly adaptable for possible future developments in both use and in the urban environment (*Figure 3*).

For Wessel van Geffen architects, this project meant a different design trajectory than the office is traditionally used to. The spatial design is largely determined by the requirements for a reuse collection station. The design of the final appearance did not start with the concept of the desired materialization and coloration, but it started with the choice for a particular residual material. The final design showcases the expressive qualities of the chosen reused material (*Figure 4*).

Figure 4: Close-up reused facade

The used components are placed in such a way that the resulting composition not only refers to the waste that is collected in the building, but also subtly refers to the facades of the houses that the building is faced to. In this way, the waste disposal station is convincingly mixed within its complex urban environment, while at the same time it is a self-conscious statement about the possibilities of reuse.

The choice for reuse brought the project many extras. The building expresses its function. When looking at the costs, the used materials are of a higher quality than new materials and meet the high demands that are made by the municipality. What this building shows the most, is that circular buildings can look convincing and attractive too. ◀

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[1] *Karola van Rooyen, Superuse Studios (2017). Persbericht - Den Haag opent vandaag een nieuw afvalbrengstation van afval.*
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Figures:
Header,1-4 Superuse Studios

A technology to save CO_2 emission by re-using cement from concrete waste

SmartCrusher

By: Alef Schippers
COO at SmartCrusher B.V.

SmartCrusher aims to improve the business processes of its customers and wants to improve their competitive position by supplying SlimBrekers with accompanying peripherals and services. The SmartCrusher systems and services are focused on the separation of heterogeneously composed products and waste materials in pure raw materials suitable for a subsequent application. Therefore SmartCrusher enables its customers to make a significant contribution to CO_2 savings in the production of raw materials and, moreover, to participate in the circular economy. Concrete recycling with SlimBrekers creates environmentally friendly concrete for sustainable construction.

It is a well known fact that the production of Portland cement releases a massive amount of CO_2, because of the chemical composition of limestone: the CO_2 in the limestone has to be removed from the limestone. Limestone consists of $CaCO_2$, that has to be split into 56% CaO (the useful part) and 44% CO_2. This is the main reason that producing one kilogram of cement causes one kilogram of CO_2 being emitted in the atmosphere. That causes that the cement industry produces three times the amount of CO_2 that the air traffic sector produces.

A lesser known fact is that only about 50% of the cement in concrete will be 'activated' by the water. This is caused by the process that only the outer area of a cement particle is reached by the water; the inner part is 'protected' by the part that has been activated. So, in concrete (waste) still half of the unused cement is present.

When working on recycling concrete, Koos Schenk was thinking of ways to free this unactivated cement. Knowing that concrete consists of very strong particles (gravel, sand, and cement, having a strength of > 200 MPa), but concrete itself only has a compressive strength of 40 MPa. He thought of a way to attack the concrete's weakest point, and created a device to crush the concrete into its primary parts: gravel, sand, unused cement, and used cement (called 'cement stone' or 'cement hydrate') (*Header*). This device, the Lab-crusher (*Figure 1*), proved his thinking to be right, and the results were validated at the TU/e.

Next, he patented this technology and sought for a partner company to scale up the process and build a full scale machine together with this waste processing company. When this was finished, for some obscure reasons, the collaboration was ended and the machine shut down. A lot was learned to design an improved machine, that would separate the cement-hydrate from the bigger particles.

Figure 1: Lab-crusher

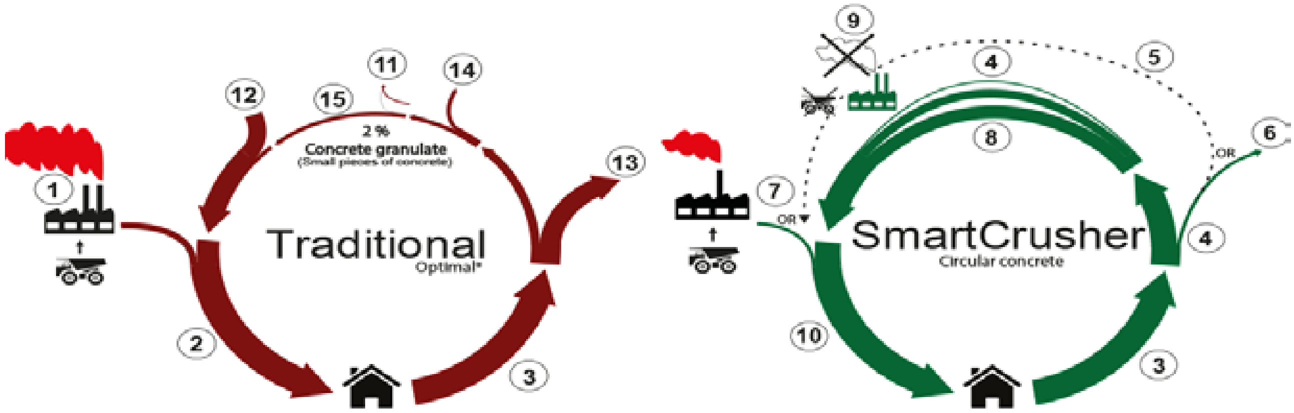

Figure 2: Concrete lifecycle traditional versus smart

The secondary gravel and sand can be applied in new concrete without compromise: it performs even better, because of the chemical 'fingerprint' on the particles. The secondary cement is free from gypsum (the material present in normal cement, that retards the reaction of the cement, so there is time for processing). This lack of gypsum allows to control the hardening time by adding the right amount of retarder. Because of this, the secondary cement is very well suited for 3D concrete printing, where today, only three layers can be printed in one go. Then a waiting time is needed for hardening, before the next layers can be printed. With the secondary cement the hardening time can be controlled such that it is optimal for the product being printed.

The cement hydrate can be used as a filler in concrete (to smooth the paste), as activator for steel slag or fly ashes, or could be fed into a cement oven. SmartCrusher is working on a way to (electrically) heat the hydrate up to a point that it forms a new binder. Using electrical energy as the source, the process can be done CO_2-neutral. When this latter step is implemented, we can make concrete 100% circular!

Over the past years, together with Alef Schippers, a lot of time is put in informing about this promising technology and convincing the market this should be the future, including showing the very profitable business models for customers. Luckily, last year the awareness for circular economy did grow, which resulted in municipalities now actively looking for ways to be more sustainable. Given this trend, SmartCrushing is a very attractive solution, but

Figure 3: Complete setup

seemed to be risky for many partners, given the interests of the traditional industry, see the comparison of the concrete lifecycle traditional versus smart (*Figure 2*):

1. Making one kilogram of Portland cement from marl/ limestone leads to 1 kg of CO_2 (five billions metric tons in 2017).
2. For concrete construction, roughly three times as much CO_2 is released than in the entire aircraft industry.
3. In all the concrete rubble is still roughly 50% new, reactive cement.
4. SmartCrushers free unactivated new cement is made of concrete rubble and is immediately usable again.
5. The cement (cement hydrate) is a CO_2-free marl substitute for the production of new cement.
6. The cement can also be worked up as a binder or mixture improver.
7. SmartCrushing: no marl quarry is used and new cement and concrete is created dust-free and without harmful emissions.
8. Sand and gravel from SmartCrushers is directly on location and ensures better concrete with less cement!
9. SmartCrushing reduces roughly one billion metric tons of CO_2 per year.
10. Urban mining with SmartCrusher halves the cost of new concrete!
11. Worthless sludge by washing.
12. Large amounts of valuable sand and gravel with a lot of CO_2.
13. Downgrading as road foundation.
14. Worthless crushed sand.
15. Concrete granulate in concrete requires more cement.

Fortunately, there are entrepreneurs that want to be front-runners in sustainability and willing to finance the realization of a SmartCrusher 2.0.

The Rutte Groep from Amsterdam showed their commitment and became co-founder which started a process of completing the mechanical design and control hardware and software of the Smart Crusher 2.0, and turning it into a machine that is ready for full scale production. Recently the improved machine was completed and now is being commissioned and tuned. The first results are very promising. Within a couple of weeks we expect to start producing circular concrete somewhere in North Holland (*Figure 3*).◀

PATCH22, Amsterdam | Beeldmateriaal: Luuk Kramer

Concrete Canoe Race 2018

By: Lieneke van der Molen
Day Commissioner of the Concrete Canoe Race Organization 2018

This year's edition of the Concrete Canoe Race was organized by members of Study Association KOers. The event took place in the weekend of May 25th till 27th and the location of the race was E3-strand in Eersel, a 20 minute drive from Eindhoven. Here, we welcomed more than 300 participants from 17 study associations or companies with either national or international roots.

The organizing committee was formed in the beginning of October 2017. Many arrangements were made in order to start with the preparation of the event's location. On Thursday May 24th, suppliers brought their material and equipment, after which the whole terrain could be furnished. The last preparations were done on Friday morning after which all was ready for a great weekend!

Figure 1: Weighing the canoes and jury judgement

On Friday, the participants arrived in the beginning of the afternoon. The first teams arrived 1.5 hours earlier, so the event started during the last preparation. Half way the afternoon, the jury, consisting out of Simon Wijte (TU/e), Marco Hutteman (BouwQ), and Marjolein Humme (Betonvereniging), started weighing the canoes. They also judged the boats for the special awards: The BouwQ 360 Quality Award, the most innovative canoe, the heaviest and lightest canoes, and the unluckiest canoe. Once the jury left, all participants had dinner and returned to the campsite to chill out.

On Saturday, the races started early at 9:00. Three races were organized: a 100-meter, a 200-meter, and for the first time a surprise race, all raced by man, women, and mixed teams. During the surprise race the participants started on the beach, had to run to their canoes and collect inflatable monkeys, flamingos, bananas, ducklings, and a parrot from the water to collect points. In a five minute period, the animals were collected and the score was written down. The highest score won the round and went to the finale, after which another race was done and the highest score then would win the race.

Figure 2: The start of the 200 meter race

After the races, the awards were handed out, including the ones based on the jury's judgments. The B-invented team built the most innovative canoe and the BouwQ 360 Quality Award was handed out to HTKW Leipzig. The unluckiest canoe award was handed out to SV Construct from Enschede, because one of their canoes already broke on transport, while the other one broke at the beginning of the first race on Saturday. The lightest and heaviest canoe where respectively built by TU Dresden and Utrecht University of Applied Science. The best canoers came from Leipzig (100 meter men, 100 meter mixed, 200 meter men), Twente (200 meter women, 200 meter mixed), and Regensburg (100 meter women and the surprise race).

Figure 3: Sprint to the canoes for the surprise race

Once the awards were handed out, some teams started loading their canoes, others went swimming, or they slept at the campsite or on the beach. The day ended again with a nice party. Sunday morning, after breakfast, the rest of the teams had to load their canoes and other stuff. Once that was finished, everyone left on his or her way back home.

Figure 4: The organization and volunteers on Saturday

The organization of the Concrete Canoe Race 2018 would like to thank their partners, volunteers, and participants for all their effort to make this event a success! ◀

Figures:
2-4 *Ivo van der Velden fotografie*

Innovative canoe of KOers

The PneuKano

By: Lars Hogenboom
Member of KOers' Concrete Canoe Race committee 2018

Just like every year, KOers had a participating team at the Concrete Canoe. This year it was organized by KOers, and therefore the match was close to home. They participated in the races with three of their traditional Canadian canoes and a very special innovative canoe.

With the great success of the first 3D printed concrete canoe of all time in Enschede and Cologne in our mind, the Concrete Canoe Race committee had to come up with something different this year. Most participants of the Concrete Canoe Race of last year in Enschede will still remember Lia, paddling away in her canoe, without having any chance to win the race, but no one actually cared. The canoe worked! The plan of this year was quite the opposite. Instead of some heavy machinery printing the 3D canoe in detail, this year's invention should be able to function as formwork but should be as light as possible.

Figure 1: The KOers racing team

So, how to come up with something new and make people forget about the canoe printed with that heavy piece of art in our laboratory? The brainstorm started as most students would do it, by drinking beer. Could a piece of fabric be inflated to form the inner shell of a canoe and function as a formwork? All Structural Design students have followed the course Lightweight Structures, so this canoe should be a piece of cake, right? The actual start was to make a Grasshopper model with some basic adjustable parameters. Since the first Grasshopper models where merely shaped like bathtubs, these adjustable parameters were not such a bad idea after all.

After finishing the 3D model with Grasshopper, it was time to overthink the actual construction of the canoe. What kind of mix must be used? How to shape an inflated canoe formwork out of one large piece of fabric? How can the formwork be inflated anyway? The used concrete mix was a mixture of the regular concrete components of the previous canoes. This special ingredient is fiber, creating a fluffy and cuddly canoe. No reinforcement net was used, because of the inflatable concept of the canoe. However, the canoe had to offer some additional tensile and shear strength, and therefore fibers where needed.

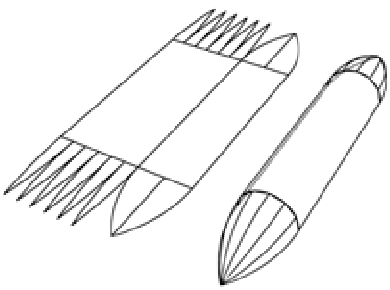

Figure 2: Grasshopper model of the PneuKano

Thanks to Grasshopper, again, the inflatable canoe formwork was divided in several flat pieces to create the double curvature without creating flaws. These flat pieces were easily cut out of the of the piece of material by a guiding paper. Afterwards, the pieces were ironed together. The edges where sealed to a timber frame, also for structural integrity, creating an airtight inflatable formwork. Although, it was supposed to be airtight. In practice, this was very hard to achieve, so the solution was quite pragmatic, equal the input to the output of air. The air was blown in using a valve, constantly creating the pressure needed to keep the canoe formwork in shape.

Figure 3: Lubrication of the PneuKano

Since this was the first year an inflatable formwork was created, lots of improvements can still be made. The formwork should at least be airtight, so we can inflate it without having to check whether the formwork was still functioning. Needless to say, but it was an exciting experience combining some basic theories with practice, which is where the Concrete Canoe Race committee stands for! ◀

Figures:

1 Ivo van der Velden fotografie

By: Cement
Knowledge platform about concrete structures

Quality Mark for reliable origin concrete
The Concrete Sustainability Council (CSC) has developed an international quality mark for sustainable concrete. With the CSC certificate, suppliers provide assurance to clients about the reliable origin of the raw materials used, an optimal production process, and recyclability. The system must lead to the acceleration of the sustainability of concrete and socially responsible processes within the cement and concrete sector.

Figure 1: Hospital Bernhoven with use of partly, 100% recycled concrete

The Concrete Sustainability Council (CSC) has captured the requirements and conditions within the CSC certificate in the Sustainable Concrete Manual. Therefore, the certificate also has an international status. There are four levels: bronze, silver, gold, and platinum. The certificate can be awarded to both concrete producers (prefab and concrete mortar) and suppliers to the concrete industry, such as cement, sand, and gravel suppliers. In the Netherlands, CSC-NL (from the Betonhuis, sector concrete mortar) is the regional system administrator of the scheme. The actual certification is carried out exclusively by independent certifying bodies: Kiwa, SGS, and SKG-IKOB. The Netherlands is a leader in the CSC system. After the launch of the CSC certificate in January 2017, more than 70 certificates were awarded in our country within one year. At the beginning of 2018, the CSC-NL certification system was officially recognized by BREEAM as a quality mark. The certification applies to the credit MAT 5 – Well-informed origin of material. With CSC-certified concrete of all available levels (bronze and higher) a score level of 5 points can be achieved.

3D concrete printing in the desert
In the desert of Dubai, the first on-site printed utility building in the world is realized: the R & Drone Laboratory. Especially for the project, a mobile 3D printer was transported from the Netherlands to the emirate. The R & Drone Laboratory has a footprint of 12 by 14 m^2. On a concrete slab supported by a strip footing foundation, hollow wall elements that form the facade of the building were printed using a 3D concrete printer. The wall concept consists of a coupled outer and inner shell with hollow space in between. The couplings function as a stiffener and offer support to the outer shell. They are realized with two fully connected print tracks.

Figure 2: Printer of the R & Drone Laboratory in Dubai

Because the building must also offer sufficient safety in the case of an earthquake, ductile failure behavior is a requirement. This is not the case with unreinforced concrete. That is why a hidden reinforced concrete column is included in every 3D-printed concrete wall element. After the printing of the elements, reinforcement cages were lifted from the top into the middle part of the wall, after which the cavity was filled with concrete. The printed wall element functioned as a formwork. The facade is subdivided into 24 separate wall elements. These walls include a dilatation in order to allow shrinkage and thermal action. The wall elements are 3.75 meters high and have a maximum width of 2 meters. The wall thicknesses vary from 330 millimeters to 1,200 millimeters. The wall elements are curved in horizontal and/or vertical direction. As a result, they all have a unique geometry. The economic realization of this design was only possible by using 3D printing technique. The wall elements carry the roof floor composed of hollow-core slabs and provides the overall stability of the building. On top of the roof floor, 3D printed concrete wall elements have been placed that form the balustrade. In total, 51 elements were printed within three weeks. ◀

More about these topics can be found on
www.cementonline.nl/...
[1] /...duurzaamheid
[2] /...3d-betonprinten-in-de-woestijn

Master's thesis

Constructing lightness

By: Bas Rongen MSc
Supervisors: dr.ir. S.P.G. (Faas) Moonen, dr. J.C.T. (Jacob) Voorthuis, dipl. -Ing. T.W.A. (Torsten) Schröder, ir. A.P.H.W. (Arjan) Habraken

Can architecture contribute to a just and sustainable world? That was the question of the "Architecture, Justice, and Sustainability" graduation studio that was combined with a graduation in structural engineering in this master's thesis at Eindhoven University of Technology.

The premise of the graduation studio was that justice and sustainability are reciprocal concepts. Sustainable design is necessarily just and fair, and just and fair design is necessarily sustainable. It is true that they can be enforced by the will of those in power, those who have conquered, it is for that reason that it is desired that people at all levels of power act justly. Architecture can inadvertently make society incredibly unjust and the building industry is still one of the most unsustainable industries around. To investigate what this reciprocal concept would mean for an architectural design a case was selected that resulted in the design of a new supreme court of Belgium in Brussels.

Leach, Scoones, and Stirling (2010) describe sustainability as broad and often poorly specified and stress the need to see 'Sustainable Solutions' as a topic that carefully needs to be expanded on a conceptual level in involved qualities, benefits, and flows that are framed in a particular way [1]. This explains why 'sustainability' can have such fundamentally different interpretations.

In this manner, 'being sustainable' would ideally go beyond the bluntly passing of checklists where sustainability measures are crossed out without concerning their benefits, effectiveness, or indirect harm.

The theoretical architectural research observes the contemporary architecture in governmental institutions and concludes that there appears to be a disconnection with society in terms of scale and architectural language. A special case is the Palace of Justice in Brussels by Joseph Poelaert, nicknamed 'The Mastodon'. The Mastodon suggests heaviness, it is proposed to conceive the opposite in the architectural design, an architecture of lightness.

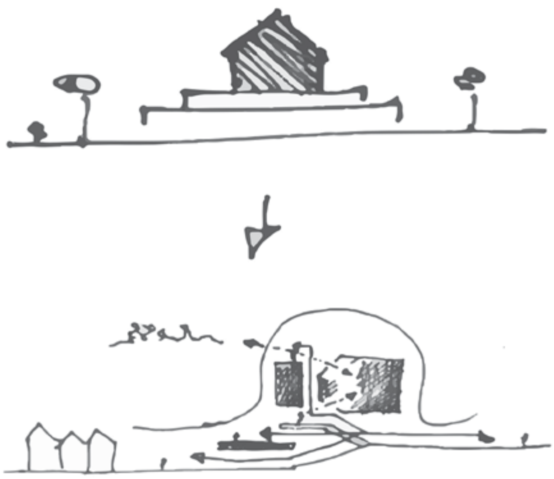

Figure 1: Building concept

The concept of lightness itself appears to be suited for the architecture of the supreme court after theoretical testing. It is suggested here that lightness would go beyond the often suggested 'transparency in law' [2] as it would poise a possibility of interplay between the judicial power and the governmental power, which in fact is real since there is no primate in a constitutional state.

In the design, an attempt is made to give a suggestion of lightness through a set of three principles, this process can be seen in *Figure 1*. Firstly, principles of interaction are used to break down the judicial 'block'. This intervention aims at achieving a higher order of interaction between different types of programs, this is done by bringing programs closer together and in parallel intensifying human interaction.

The result led to a complex spatial and geometrical puzzle in which a subterranean parking garage, tunnel that bridges the height difference between the neighborhoods Marollen and Zavel, supreme courtroom, security entrée zones, public amenities, and offices come together.

Secondly, principles of lightweight design are applied to reduce embodied energy and CO_2 levels. These principles vary from applying 'geometric action' to form spatial load paths (shells and nets) to dismountable components and material selection principles.

Lastly, an architectural language of shape and materials is used that intends to give an experience of 'lightness' for the public. This architectural language also intends to orchestrate and give a sense of unity to the complex puzzle of functions that come together in the design, and intends to fit the design to the surrounding context of the city.

In the final design, the unity from the exterior was mainly achieved by the timber facade and canopy. The facade and roof structure were selected for further elaboration as they possessed most unprecedented challenges from a structural design and optimization point of view.

The timber facade consists of timber ribs that hang vertically down from the steel belt truss at the 10th floor. From the front view, as seen in the main render (*Header*), the facade is materialized in Ethyl Tetra Fluor Ethyleen (ETFE) cushions. The facade ribs itself are designed as scaled up I-profiles where the webs are materialized in glass and the flanges in timber.

The roof part was designed in an iterative process of simulating and designing. In this process, Grasshopper was used as a grid and dome shaping tool in combination with the civil engineering package SOFiSTiK. In SOFiSTiK, a forming analysis (geometric nonlinear analysis) of the irregular double lath grid was performed as can be seen in *Figure 2*. In the resulting post-formed-state of the double lath grid, the residual stresses in the individual timber laths is determined.

After forming, the shell is fixed into place with the use of kinematic coupling conditions and springs onto the

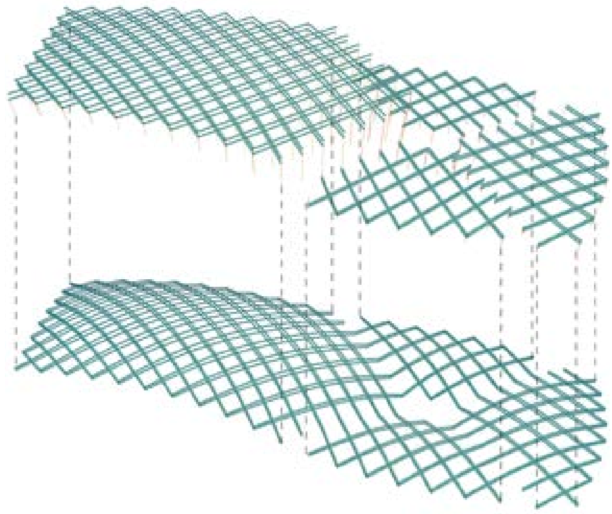

Figure 2: Formfinding of timber gridshell

surrounding structure to proceed to the final construction stage. The edges of the roof are fixed on the facade structure, the upper and lower grid are connected with shearlocks, and finally the rhomboid grid is triangulated with a top layer of straight timber laths which carry the ETFE cushion roof. With the now known residual stress state in the timber lath grid the 'strained' behavior of the grid is simulated for final loading.

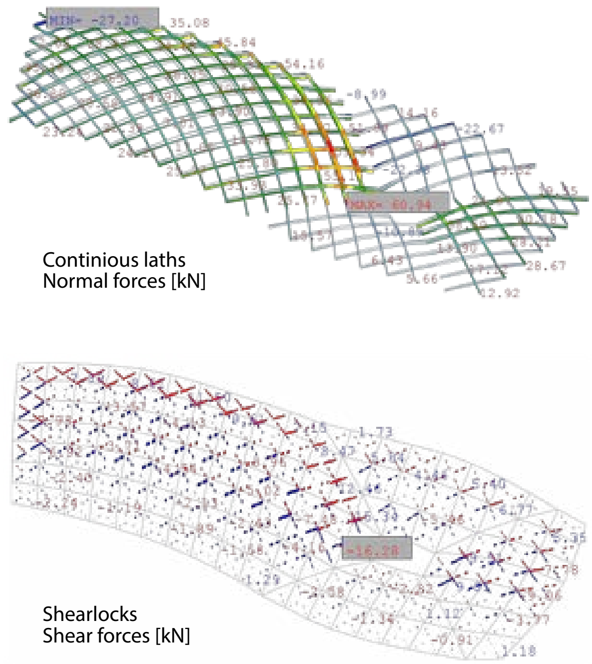

Figure 3: Results from asymmetric wind loading

An example result of the structural analysis in the complete state under asymmetric wind loads can be seen in *Figure 3*. The force graphs in *Figure 3* give a general idea of the force flow in the top and bottom continuous laths, as well as the shear forces in the shearlocks which are situated in between the upper and lower grid. ◀

References:

[1] *Leach, M.; Scoones, I.; Stirling, A. (2010). Dynamic Sustainabilities, Earthscan*

[2] *Broeders, D.; et al. (2013). Speelruimte voor transparantere rechtspraak, Amsterdam University Press*

Five students at BouwQ

Part-time student job of a KOers member

By: Sue-Ellen de Nijs, Jason Al Juma, Nahide Soyal, Steven Dezaire, and Thomas van Vooren
Master students Structural Design at Eindhoven University of Technology

BouwQ is a recognized and independent building inspection office which pursues optimal safety and quality of all kinds of buildings by making goal oriented checks and inspections in all phases and aspects. The last few years, BouwQ has developed a new method for a risk based quality check of design and executions of construction works. This new method is called TIS, Technical Inspection Service. It is already a usual method in civil engineering, but still unknown in structural engineering. Five KOers members are currently working at BouwQ. If you are curious about what they are up to and what they have observed during their work there, read on. They are happy to tell you about it!

Sue-Ellen de Nijs

Sue-Ellen completed her degree in Structural Engineering at Rotterdam University of Applied Sciences and has started a pre-master in Structural Design at the university of Eindhoven. She began working at BouwQ at the beginning of her pre-master program to gain extra work experience. She is mainly involved with housing projects, where homes have to be assessed in both the building permission phase and in the execution phase. Her favorite project so far: the RAI hotel in Amsterdam that will be about 90 meters tall (*Figure 1*). For this project, she contributed to the evaluation of different structural components such as floors. She did manual calculations but also used AxisVM, the finite element method from Technosoft, for this project.

Sue-Ellen de Nijs: "I perform manual calculations and make use of AxisVM to assess the structural elements of a building.

Sue Ellen about her work at BouwQ: "What I noticed during the time that I have worked here is that not everything is self-evident and that everyone has their own way of calculating and interpreting."

Figure 1: RAI Hotel Amsterdam

Jason Al Juma

During his Bachelor's degree, Jason was approached by Jos Rooijakkers of BouwQ to check the structural integrity of various buildings.

Looking back, he says: "At first, I had my doubts, because I felt that I did not have sufficient knowledge at that moment. Now, about a year later, I am very happy that I said yes at the time. I get to learn new things every day."

Figure 2: Risk assessment lattice girder slab floors Eindhoven

Like the other KOers members, he checks the structural aspects of small buildings. In addition, because of the collapse of the parking garage at Eindhoven Airport in May last year, he got together with his colleagues to do a risk assessment on the lattice girder slab floors of existing buildings for the municipality of Eindhoven under the supervision of a senior structural engineer.

Jason Al Juma: "The traditional way of digging through mountains of archive boxes containing old projects was a special experience."

"We were assigned an office in Eindhoven, where we could dig through a mountain of archive boxes containing old projects. A special experience!"

Nahide Soyal

In September 2016, Nahide completed her Master's degree in Structural Design at the Eindhoven University of Technology. After working at a structural design office for a while, she moved to BouwQ. Nahide started out with assessing small construction projects but soon ended up in larger civil construction projects and also in building projects. This required her to gain more civil knowledge, for which she was given more than enough time by BouwQ. She also regularly accompanies the agency's inspector to the construction site.

Nahide Soyal: "It was remarkable to see the difference in reinforcements (used) between a civil construction project and a building project in real life."

She remembers the first time she attended the inspection of a civil construction project: "I already noticed during the assessment process that this was a complicated project, especially for me as a newbie in the civil area. But I was given intensive guidance, even during the actual inspection. We were looking at an underpass below a railway line. It was remarkable to see the difference in reinforcement between a civil construction project like this and a building project in real life."

Figure 3: BouwQ company outing (3th from left Thomas)

Steven Dezaire

Since the summer of 2017, Steven has combined his graduation project in 3D printing at the Eindhoven University of Technology with working one or two days a week at BouwQ. He has carried out various types of structural assessments of building applications: from steel frame structures over timber frame structures to rotating houses. The work is already a real eye-opener for him:

Steven Dezaire: "I was able to experience first-hand how often mistakes are made in relatively easy calculations."

"The assessment branch in the housing sector seemed unnecessary to me given the small size and complexity, but I have been able to experience first-hand how often mistakes are made in relatively easy calculations and how important the role of the inspection is."

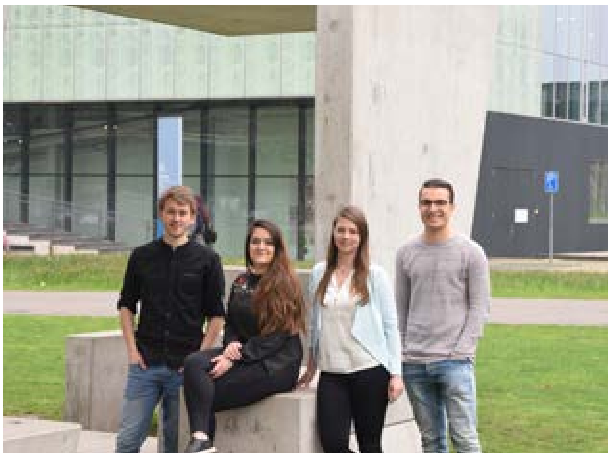

Figure 4: Four of the KOers members (f.l.t.r. Steven, Nahide, Sue-Ellen, Jason)

The most impressive project for Steven was the Atrium in Amsterdam. For this project, he checked the entire temporary strut frame and the floors in the basement parking. He also helped with the inspection of the struts in the construction pit, which were a meter in diameter!

BOUWQ - ASSURING THE QUALITY OF STRUCTURES

The construction industry is experiencing profound changes in the area of quality assurance. Where previously the government had the responsibility for the technical quality assurance of construction works, it now increasingly limits itself to a regulating role. So, BouwQ developed 'Technical Inspection Service' a fundamentally new method for risk based quality control of design and execution of construction works. In the 15 years that BouwQ exists, this method became increasingly more successful. The market volume increases, as does the professionalism and versatility of the service.

Would you like to know more?

Working at a building inspection agency can be very varied, with time spent both on location and at the office. Would you like to know more about BouwQ or apply for a position there? Go to www.bouwq.nl/students

Thomas van Vooren

During his graduation year, Thomas was looking for a job for one day a week that had a link with structural engineering. He was given the possibility to work for BouwQ, where he started by checking design proposals for the municipality of Almere (*Figure 5*).

Figure 5: Housing projects Almere

In the first few months, his activities consisted of checking the weight bearing capacity of the foundations and the stability of the buildings in the building permission phase. After that, more detailed calculations needed to be checked, for instance: connections between steel structures and reinforcements in floors and foundations.

Thomas van Vooren: "I reported back to the inspector that the bearing length was insufficient and the wall indeed showed some cracks."

"A few weeks back, I got an e-mail from an inspector at the municipality of Almere who checks the structure of the buildings on site. He sent me photos of a beam that was supposed to support the first floor of a residential building. The bearing length in practice was much shorter compared to the first calculations made by the structural engineer and according to the calculations I had done myself. I reported back to the inspector that the bearing length was insufficient. A few days later I received a message from the inspector that the wall indeed showed cracks locally due to the short support length and the contractor needed to replace the beam and parts of the wall. This again shows the importance of carrying out a building inspection." ◀


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Master's thesis

Structural behavior of a mycelium biocomposite dome under vacuum pre-stress

By: Shawn Leeflang

In recent years, the use of new and alternative construction materials has been on the rise. The current world is most concerned with the environment. This is also noticeable in the building industry, as engineers and researchers are pushed to shy away from materials that have a large CO_2 footprint like concrete and steel.

In this research, a closer look is taken into the material properties of mycelium bio based composites. Mycelium is the root of a fungus; to use this material in a structural way it must be shielded from moisture. One way to do this, is to inject the biocomposite with natural oils. However, in this research it was decided to use a synthetic membrane to vacuum seal the biocomposite and protect it from moisture. This vacuum sealing also serves a structural purpose, as it provides the biocomposite with a so called "vacuum pre-stress".

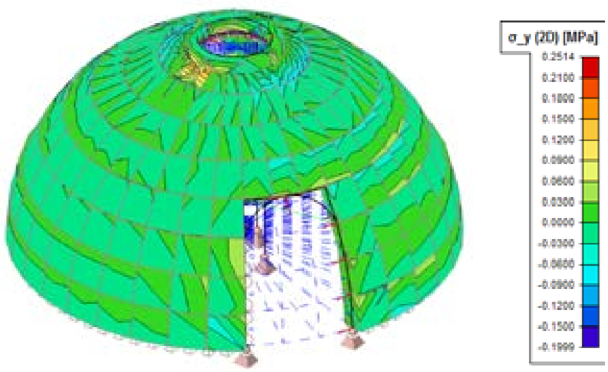

Figure 1: SCIA Engineer simulation of a vacuum pre-stressed dome

To research the possibilities of these structural principles, mycelium biocomposite specimens are subjected to a compression and four point bending tests. To get a baseline, a certain amount of the biocomposites are tested without vacuum and the vacuum pre-stressed specimens are subjected to the same tests. By doing this, a direct comparison can be made of the structural behavior. Using the data from the test, computer simulations will be done in SCIA Engineer to calculate the design possibilities of a vacuum pre-stressed dome (*Figure 1*). Furthermore, extra attention is paid to the design of the connection between elements, as the connections must be able to resist compression forces acting on the dome while still allowing the dome to be easily taken apart and transported.

This research will give insight in the structural behavior of a mycelium biocomposite dome under vacuum pre-stress. ◀

Edge strength of drilled and water jet cut holes in structural glass panels

By: Kay Sanders

The application of glass as a building material made a lot of progress in the past years and continues developing. The variety of possibilities increases rapidly. Nowadays, glass is not only used non-structurally (windows, for example), but also in structural elements. One of the major challenges in structural glass design, is the composition of the connection. This is often done by a through-bolted connection. In this type of connection, a hole is made in the glass panel, and a bolt goes through the hole. The glass panel is, in that case, loaded in-plane (compression or tension).

Until now, these holes in the panels are obtained by using a hollow drill (and a conical drill afterwards). However, a different way of obtaining holes can be by water jet cutting. The comparison of these two methods is the topic of this graduation project. It is possible that different produced holes result in various panel strength. A major part of the project is an experimental part. Samples containing holes obtained by one method are compared to the other method. Other parameters that are considered are hole diameter, panel thickness, in-plane and out-of-plane loading, panel strength (annealed glass and tempered glass), and the influence of eccentricity. Next to an experimental part, the project contains a numerical part. Using finite element modeling, the influence of changing various geometrical properties on the edge strengths can be found. An example of numerical research on holes in glass panels is shown in *Figure 1*.

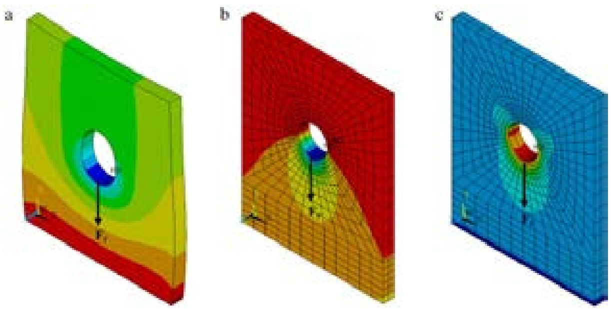

Figure 1: a) deformation due to load, b) compressive stresses, c) tensile stresses

Since glass is a relatively new structural material, a lot of information is still unknown. For example, the information on glass in the Eurocode is more limited compared to steel or concrete. The intention of this project is to deliver a contribution to the knowledge on structural glass. ◀

Figures:

1 *Mocibob, D., Belis, J. (2010). Coupled experimental and numerical investigation of structural glass panels with small slenderness subjected to locally introduced axial compression*

Qiao Ben Zhang

The experience of...

By: Qiao Ben Zhang
Junior Structural Engineer at Adviesbureau Dekker Engineering

In the beginning of summer 2017, I was looking for a job so I applied for a job offer listed at Continu. Soon thereafter, I had a meeting at Continu where they told me they had two companies with interesting job offers. Within a week, I had interviews at both companies. Continu helped me with preparing for these interviews and both companies were very interested in hiring me. A few days later, I signed my contract at Adviesbureau Dekker Engineering. And so, my career began.

I joined Adviesbureau Dekker Engineering in August 2017. It is a small company consisting of 11 people and it specializes in engineering for scaffolds, support structures, and temporary structures; from drawing and calculating to field inspections.

Working with scaffolds and support structures was an entirely new experience for me. I was given plenty of time to learn everything about this field of expertise. The reason for this is because engineering of scaffolds is quite a unique branch in the structural sector.

My daily work consists of making models in SCIA Engineer and ensuring every tube and connection stays within the unity checks. The projects are usually done in a day. From making a SCIA model to writing a report. I get all kinds of different projects, from a simple support structure for floors to a whole scaffold surrounding a church, or even stages for big festivals and events. One of the most interesting projects so far is the scaffolding for Station Blaak in Rotterdam (*Figure 1*) and the Erasmusbrug in Madurodam (unfortunately not the big one in Rotterdam).

Every calculation I do, is based on the European standards and the Dutch guidelines for scaffolds. It all sounds straightforward, except when things get complicated or a client asks for something impossible, then I have to try and find a way to make it work. With scaffolds, you are limited to the material you use. Unlike structural steel or concrete, there is no possibility to use a larger profile or change the dimensions of the scaffolding tube.

A scaffolding tube has fixed dimensions and material properties. There are also different systems for scaffolds with different connections and strengths. Another important factor to consider is the wind load on the scaffolds. Clients often like to put nets or foil on the scaffolds to reduce the wind/draft inside the scaffolds. This leads to higher wind loads and sometimes also stability issues due to the relatively small width (usually around 1.3 to1.4 meters wide) compared to the height which can go up to 20 meters for apartment buildings or 40 meters for churches.

All these challenges make working with scaffolds akin to solving a complicated puzzle, where the right solution should be found and pleasing all parties with the result.

Figure 1: Scaffolding for Station Blaak Rotterdam

I really like that the projects I work on are usually done within a day. This aided me tremendously in obtaining new work experience very quickly; I learn something new almost every day. One of the big downsides of working with scaffolds and support structures is that every project I work on, big or small, regarding scaffolding is temporary and will eventually be taken apart. Now, having worked for almost a year at Adviesbureau Dekker Engineering, I have found my place within the company. I have got the opportunity to work on some very fun projects and learned from some rookie mistakes here and there. I am glad that Continu helped me find what I was looking for and I will Continu(e) to build my way up. ◄

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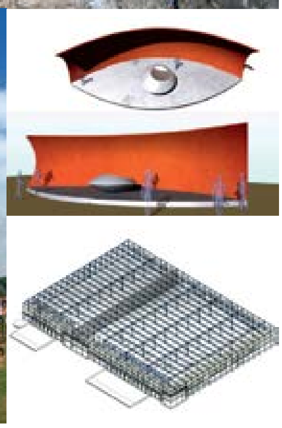

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Passion for a brighter world

Building spatial design optimization methods

By: Sjonnie Boonstra MSc
PhD candidate May 2016 - May 2020

Building design is in its basics an optimization task in which building engineers attempt to reach a number of design objectives while satisfying certain constraints. For example, minimizing the weight of a floor while keeping the deformations below a threshold. Where traditionally this was a human task, today the task shifts towards computer assisted approaches. This shift is caused by the growing complexities in a design optimization problem, i.e. more disciplines arise in the built environment, each of which introduce different objectives and constraints to the optimization problem, making it harder for human engineers to oversee the relationships between all objectives and constraints.

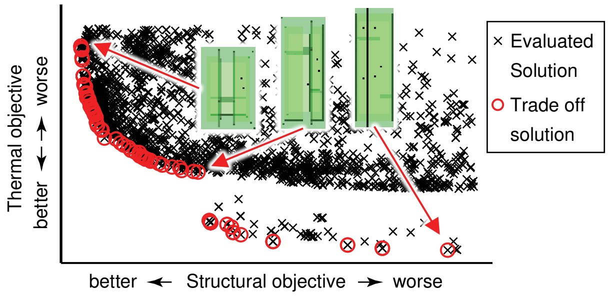

Figure 1: Example result of a GA, typically a trade off front is found. Here, trade off means that a solution must perform less good in one objective in order to improve in another objective.

The PhD project revolves around building spatial design (BSD) optimization. The complete design search space is too large and too complex even for modern state-of-the-art optimization algorithms. An obstacle that was already overcome by human knowledge, experience, and creativity, but which has now become too complex. On the other hand, state-of-the-art algorithms can search design search spaces very effectively. In doing so, these algorithms can find optimal designs and design relations that go unnoticed to human engineers. Both the human approach and the algorithmic approach have clear advantages, and experience learns that the two supplement each other greatly. But, application of optimization algorithms can be a laborious and difficult task for building engineers. This project aims to automate and integrate the two approaches to search for optimal designs quickly and effectively.

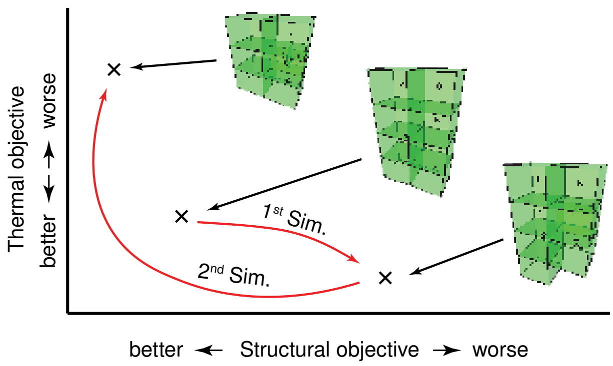

Figure 2: Example result of a simulation of a building design process. Based on previous performance, a space is removed and another is split. Few simulations can already lead to improvements, however, this is not guaranteed.

A software environment, termed toolbox, has been developed for the project. It contains tools like finite element (FE) analysis, thermal simulation, clustering, topology optimization, and building spatial design tools. The toolbox opens a door to a wide variety of research, examples of research that have been carried out so far are: topology optimization of structures in BSDs; structural and thermal optimization of BSDs; automated stabilization of FE models; and generation of optimal structural models for BSDs.

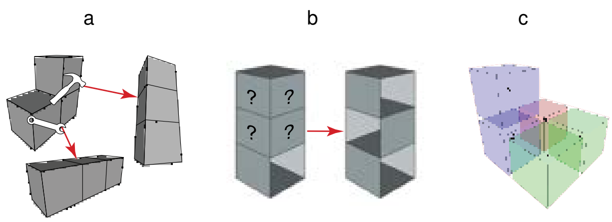

Figure 3: Graduates' work: a) different methods that simulate a building spatial design process; b) openings as an optimization parameter; c) zoning in building spatial designs.

Two PhD candidates work on this project, Koen van der Blom at the Leiden Institute of Advanced Computer Science (LIACS) of Leiden University and Sjonnie Boonstra at the department of Built Environment of Eindhoven University of Technology (TU/e). At LIACS, Koen works on the application of state-of-the-art Genetic Algorithms (GAs) to BSD optimization. At TU/e, Sjonnie investigates optimization methods that simulate building design processes. Together, they work on combining their efforts to search for BSDs efficiently. This, by using GAs to find the best designs in a relatively small design search space, and on the other hand by using the TU/e developed methods to suggest new (small) design search spaces to the GA.

Currently, three TU/e graduate students are working on topics within the scope of the PhD project. Tomas Snel develops different methods – and combinations of methods – that simulate design processes, using design principles that originate from engineering knowledge and experience. Thijs de Goede researches facade openings in design optimization methods. Dennis Claessens investigates methods to find zones within a BSD that are sensible for structural design and works on a stabilization tool for structural models. ◀

The way Octatube uses parametric design

How challenges drive innovation

By: Octatube
Technical design agency and production company

Octatube's customers have a vision, they want the best that architecture has to offer. The complexity of the challenges is enormous and unique for each project. This inspires Octatube to innovate in order to make ambitious architecture possible. As a result, we have developed new smart software.

Technological developments are progressing rapidly. Calculation and simulation at Octatube is performed with advanced 3D models. For these models, an in-house team of clever engineers works closely together with experienced craftsmen. Combining design and construction expertise has proven particularly beneficial when it comes to highly specialized, new, or experimental elements.

Challenge

This was certainly the case for the Capital C project: a free-form gridshell of approximately 45 by 21 by10 meters. ZJA Zwarts & Jansma Architects is responsible for the design and Octatube is responsible for the engineering (the technical design and the structural calculations) of the design. Optimizing the shape in 3D and the parametric design of the gridshell were particularly challenging.

Koos Fritzsche, sales engineer at Octatube (*Figure 1*): "In the initial phase of a project, when Octatube first meets with the architect, advisor, or contractor, the design is usually still being developed. The often complex geometry of the project has only broadly been outlined. Using parametric programs, we provide support in optimizing the design and analyzing variants. These models will later form the basis for the technical refinement of the project."

The basic geometry for Capital C was predetermined but the grid itself was still being developed (*Figure 2*). The grid is the representation of the spatial form and structural elements of the building, schematized as lines. The grid forms the basis, the starting point for the technical drawings and the next phase; the production of the project. The lack of a fully defined geometry raised the following question: How can the project be technically engineered and the production prepared before the basic geometry is confirmed?

Parametric Tool

To meet this challenge, Octatube has developed a parametric software tool in which the wire model of the gridshell, after an optimization study, can be exported to Inventor, a 3D modeling program. Within this program, all the different parts and information required for production, are then automatically generated and file-to-factory produced. This approach allows Octatube to make design changes in the basic geometry until very late in the engineering process. Even when all the parts are already digitally generated, changes can be made to the basic wire-model and automatically updated throughout the 3D model.

The development of the parametric tool for Capital C has increased the efficiency of the engineering process, which has reduced time and costs. The project is progressing swiftly and has reached the production phase. The parametric tool has already proven its worth. In the future, Octatube will further develop the gridshell tool and apply it to a wider range of projects.

Figure 1: Daniel van Kersbergen and Koos Fritzsche in front of one of the parts designed with the new tool

Daniel van Kersbergen, engineer at Octatube: "In all areas, we invest a lot of time in research and developing tools to deal with all challenges presented by the project. The new software and working method allow us to do so. As a result, we have gained a great deal of knowledge in software development, which we will be able to reuse again in the future. Capital C is a great project that has challenged us to develop ourselves further." ◀

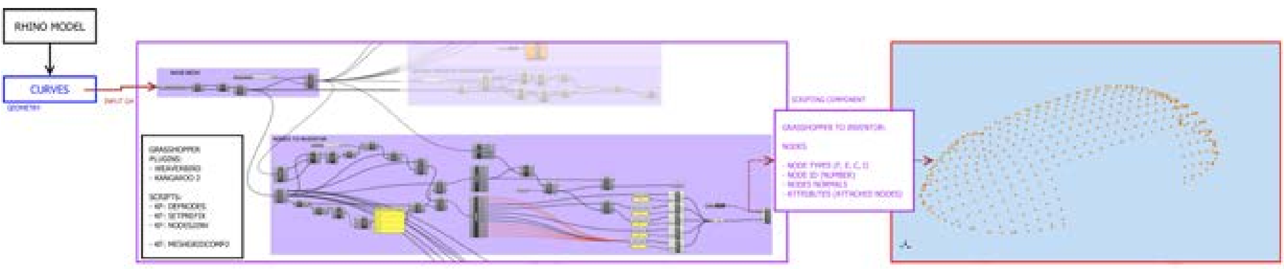

Figure 2: Schematization (part) of the developed parametric software tool

By: Jelme Pennings & Tim Schellekens
Creative KOers members

Two enthusiastic KOers-members made three puzzles for you to solve, they will provide the answers at the beginning of August on the KOers-website! Submissions can be send to: KOers@bwk.tue.nl.

Help! Maisa, treasurer of the 48th board, has a financial accounting problem!
For this year's concrete canoe race, held in Eindhoven, Lia collected the registration fees. For a particular team with 3 members she asked €60,-. Afterwards Lia realizes that this was too much and this team only had to pay €55,-. Therefore, she wants to give the team €5,- back. However, she has no idea how to divide this into three parts, and therefore decides to give only €3,- back and to keep the rest for herself. The team members each paid €19,-, total €57,-. Lia has €2,- in her own pocket, so all together this is €59,-.

At this moment Maisa starts to panic! Where is that one missing euro? Can you help her?

Nonogram
Reveal the hidden picture and discover a nice surprise. ◀

Column clues (left to right):

8	9	2 1	3 1	12	13	14	2 3 1 1	6 1 1	13	12	6 1 1	2 1 1	9	8

Row clues (top to bottom):

Row	Clue
1	1
2	3 1
3	2 2 1
4	3 4
5	9
6	11
7	13
8	2 3 2 2
9	2 3 2 2
10	2 3 2 2
11	15
12	2 3 2 2
13	2 3 2 2
14	2 3 2 2
15	2 11

Derk and the hoop
It is Friday, the sun is shining and Derk has an overpowering urge to stand on a hoop. However, since he is aware of the lateral deflection of the hoop as he will stand on it, he is afraid to fall off. Therefore, he asks Maisa and Denise to help him. They have to push the hoop laterally such that no deflection occurs, and that he will be safe.

The problem can be modeled as shown in *Figure 1*. Since no lateral deflection should occur, the hoop is supported laterally in the points (0,r) and (π,r) by a roller. At the bottom, the hoop is supported by a hinge in (3/2 π,r). The force F Derk is imposing on the hoop, acts in the point (π/2,r).

How large should the force R be, resulting from Maisa and Denise pushing on the hoop, in order to avoid lateral deflection of the hoop as Derk stands on it?

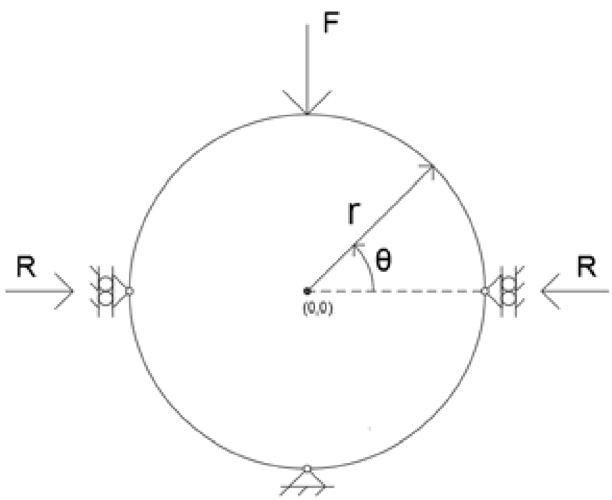

Figure 1: Hoop (perfect circle) with radius r, area A, Young's modulus E, and second moment of area I

TIP – a French physicist and mathematician born in 1768 can help you.

Column

Robust Swedish Volvo

Hans Lamers

Mankind has not been very conserving with earth's resources. With a (still growing) population of 7 billion people we need more land, materials, and energy. Also, the level of individual comfort is still increasing. If all people on earth would adopt our western luxurious life style, we would already need 7 planets. This gives me an anxious feeling in the stomach.

Fortunately, during the last decades there is a raising awareness of global problems. Climate change, extreme weather, extinction of animals and plants, the retreat of coral reef in tropical waters, and melting of the poles. The actual reversal of these negative global processes is difficult and will take a few generations of time. The Paris climate agreement is complex and ponderous and will not solve anything at short notice. Too much politics. Maybe a straightforward technology-based approach may result in a short term gain.

For housing, we need an immense quantity of wood, steel, cement, copper, zinc, aluminium, mineral oil, and much more junk. For a better world, we have to use less materials, use bio-based or renewable materials, expand the product life, and refurbish goods if possible for a second life. In the past 50 years, many promising attempts have already been made in building industry: dismountable buildings, flexible use of space, and adaptable buildings. Structural designers and architects have to think ahead and make it possible to adapt buildings for new users and for new technologies in the future. In my opinion, the simplest solution is often the best one. My opinion, look at the robust Swedish Volvos; buy one and use it for 25 years, just change the battery and tires occasionally. Likewise, build a robust house and use it for 250 years, like the canal houses in Amsterdam, just change the kitchen and the bathroom every now and then.

Colophon
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