STUDIEVERENIGING KOers
CONSTRUCTIEF ONTWERPEN

KOersief

EDITION 114
January 2022

One Million Houses

Top three tips for an excellent kick-off to your construction career

Although the housing shortage isn't a new topic, nowadays it's more relevant than ever. The economy and job market are both booming again after the COVID crisis. Affordable houses have become the proverbial unicorns of this generation. Amazing and creative solutions to the housing shortage problem are popping up all around us. Solutions like tiny houses, container houses and short stays. But still, we need to build almost 300.000 more houses in the Netherlands. And we need to build them now. A challenging and interesting time indeed!

On the other hand, this means unlimited job opportunities for young professionals in the construction business. Which happens to be a situation we, being a job agency in the construction sector for over 25 years, have already experienced several times. So here are our three pieces of advice to make the best out of these challenging times.

Let us do all the work

Do you have a Linkedin profile? If you do, you have certainly noticed the huge ammount of connection requests and job opportunities in your inbox. There are countless jobs waiting for you. So how do you figure out which one suits you best? That's easy, just leave it up to the experts. At Continu Professionals, we've been scouting and mapping the Dutch construction market since 1995. So maybe even before you were born? We know all the ins and outs about most of the construction and engineering companies around. We know their company cultures, their development opportunities and their working conditions. All you need to do is tell us your conditions, ambitions and dreams and together we will find the right job for you.

Show me the money

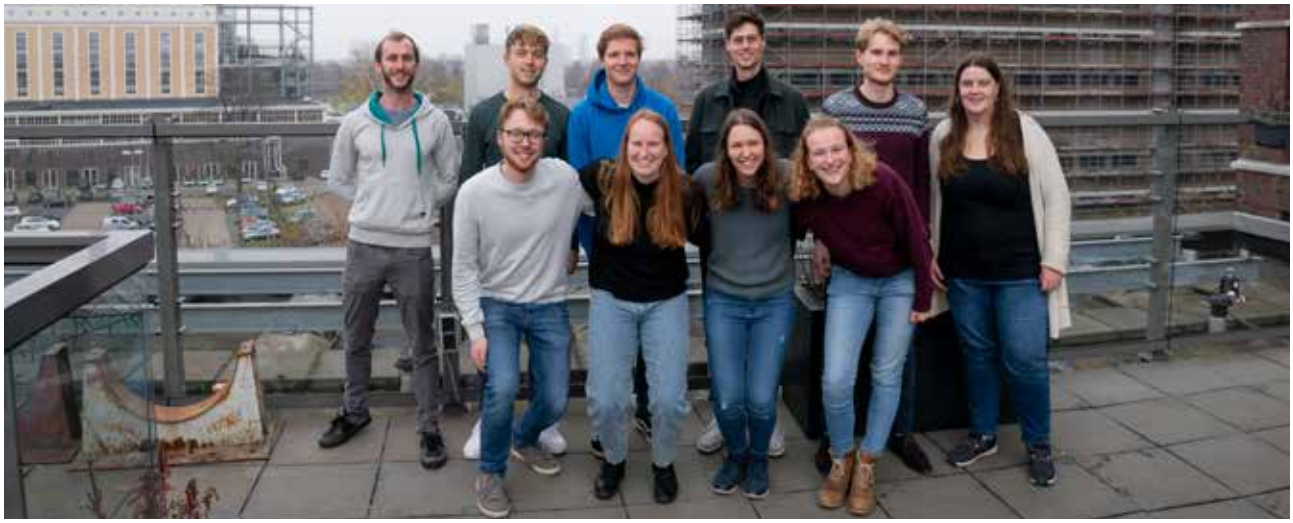
Just like all economies, the job market is all about supply and demand. Right now, demand is very, very high, which obviously affects prices. So don't be afraid to ask for an above average salary. However, don't forget to look around. Yes, you are not the only student are you? Be bold, but never overplay your hand. Aim for a gross starting salary somewhere between € 2500 and € 3000. Don't worry if the thought of selling yourself scares you. We've been there, done that thousands of times and are more than happy to assist you.

Use these easy negotiaton tricks

Sure, your starting salary is a very important working condition. So you should never accept the first offer and open the negotiations at 110% of what you're willing to settle for. However, don't forget to focus on the total package. What if there is little room to increase your monthly salary, but there are several options for additional holidays, education fees or a company car? Secondary working conditions often have a positive effect on your actual spending money. So, do the math.

CONTINU PROFESSIONALS

Editorial



Dear reader,

This edition of the KOersief is called "One Million Houses". An extremely relevant topic at the moment. In this edition, several innovative solutions for the housing shortage problem are presented. These solutions include building factories, modular constructions, tiny houses, and much more. Also, the expert opinions of different professors will be given, as well as the student opinions from different disciplines within the Built Environment. In conclusion, many interesting articles you do not want to miss!

In accordance with the theme, the group photo of the committee is taken in front of the 'Veemgebouw': an old factory building of Philips where new houses are being built on top. The editorial board consists of Pieter van Loon, Thomas Pannekeet, Tom Diks, Maikel Brinkhoff, Lucas van Bemmelen, Leonie van der Molen, Paul Otterspoor, Femke Hermans, Laura Dings and Robin van Steen.

Furthermore, since a couple of years the KOersief has expanded online. There is a podcast 'Kunnen we het maken?' that releases a new episode every two weeks. In each episode, interesting guests will be interviewed on topics related to the structural engineering profession. Furthermore, for this edition we have experimented more with online articles in extension to our physical KOersief. So check out the website of KOers for new interesting online articles. Also, there is a KOersief Instragam with informative posts about the KOersief and the podcast, as well as biweekly quizzes.

Finally, in line with the sustainable goals of the TU/e, it is good to note that this edition of the KOersief is made completely CO_2-neutral. All the paper also bears the FSC certification!

We hope you enjoy this new edition!

On behalf of the editorial board,

Laura Dings
Editor-in-chief KOersief 114

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Chairman's Note

Dear KOers members and relations,

A new academic year has begun, a new board is set, and we are heading for a brand new KOers! For the past couple of years KOers has faced many challenges due to the pandemic. Activities had to be cancelled or done online, which did not stimulate the desired interaction between members as we were used to having. However, that time has ended and KOers will be brought back to their full potential! Before I introduce you to this year, I will shortly introduce myself.

I am Joes Sloots, 24 years old, born in Haarlem and raised in Varsseveld. As chairman of the 52nd board of KOers, I will further improve this great association together with my fellow board members. Next, we desire to further increase the enthusiasm and engagement of KOers members by putting the association in the most favorable light possible.

It has been a rough couple of years for the previous boards, which had to deal with restrictions and uncertainties. As the current board, we are very thankful and lucky that we are once again able to organize real-life activities. And since the kick-off of this academic year, a lot of real-life activities have been organized, like some good old Skybar!Underground drinks, the weekly KOKO's, Timber excursion, a multiple day excursion to Stuttgart, and so on. But, this is just the beginning, and many more amazing activities will follow. Activities like the first KOersSki, a record attempt for the beer crate bridge, the Concrete Canoe Race, and the return of the KIST.

I am looking forward to seeing all of you at these activities! Note that these activities are made possible by the many

awesome members of KOers. Let's hope that the pandemic will continue to be under control to keep this year exciting.

As a board, we also desire to make this year more of you. With the introduction of our idea box on floor 2, multiple great ideas have come forward. Some of them have already been carried out. And we encourage everyone to keep giving more ideas because we will consider them!

To finish my note, I want to thank the editorial committee for creating a top content magazine once again. I wish the reader much enjoyment in reading all the following articles. And of course, stay healthy!

Yours sincerely,
On behalf of the 52nd board of KOers,

Joes Sloots
Chairman of the 52nd board of KOers ◄

KOers will attempt to break the the world record of longest beer crate bridge!

When: May 11th

VeriCon

constructeurs & 3D-engineers

Dé innovatieve partner voor constructief advies en engineering

Variatie
Beton, staal of hout; woonhuizen, hoogbouw of specials, we gaan geen uitdaging uit de weg.
Variatie, daar houden we van!

Totaalengineering
Wij geloven in de kracht van totaalengineering: alle vlakken van constructieontwerp en -engineering. Als integraal ontwerpend constructeur en als engineer voor de uitwerking van alle deelconstructies. Door het verzorgen van constructieve coördinatie voorkomen we fouten en ontstaat een gestroomlijnd en zorgeloos ontwerp- en engineeringsproces.

Parametrisch ontwerpen
Onze parametrische manier van ontwerpen resulteert in snellere, kosteneffectievere en optimale oplossingen voor projecten. Een mooi voorbeeld van een project waarin we parametrische tools hebben toegepast is de 1,5 km lange golvende betonnen gevel met achterliggende staal-constructie van Mall of the Netherlands.

Innovatie
Wij geloven dat innovatie nodig is om samen, efficiënter, betere, goedkopere en beheersbaardere gebouwen te maken.
Modelleren doen we dan ook uitsluitend in 3D. We werken met een uitgebreid pakket aan geavanceerde rekensoftware zoals Grasshopper. Kan er hier iets beter? Dan zorgt ons team van ontwikkelaars daarvoor.

Samenwerken
Met een enthousiast team van ruim negentig betrokken collega's zetten we in een open en zelfstandige werksfeer onze kennis en expertise in voor bouwkundige projecten. Samenwerken is daarbij een van onze belangrijkste waardes.

Kom ons team nu al versterken
Als innovatief bureau heeft VeriCon een nauwe band met de ingenieurs van morgen. We werken veel samen met studenten. Meewerkstages, afstuderen, werkstudenten en duaal-studenten, zowel hbo als universitair. Bij VeriCon doe je praktische ervaring op, waarbij je begeleid wordt door de besten in jouw vak.

Ons DNA
- samenwerken
- ambitieus
- innovatief

Onze expertises
- constructief ontwerp en advies
- civiel ontwerp en engineering
- bouwkundige uitwerking
- BIM-management
- prefabbeton-engineering
- woningbouw
- HSB en CLT
- file to factory

meer weten?

Neem contact op met Ilse van Delst via telefoonnummer 085 086 68 08
of per e-mail: werken@vericon.nl

Kijk ook op onze site: vericon.nl

Agenda

Active members meeting *22 September 2021*

CoBo 52nd *28 September 2021*

KIST *July 2021*

KOKO floor 9 *October 2021*

KOersSki

February 28th– March 6th — France

For the first time, KOers organizes KOersski! KOers takes you to the ski slopes of Avoriaz, at Portes du Soleil. This is located in France. During this trip, we take the slopes during day, and apres-ski at night! The trip will take place during the carnival break, so you won't miss any courses. Subscription is already closed, we're looking forward to it!

Board interest drink

March 16th — TU/e

Are you interested in becoming part of the next board of KOers? Join this drink, and the 52nd board will tell you all you need to know about a board year and the tasks that come with it. Of course, even if you are not interested, you are still welcome!

Bierkrattenbrug

May 11th — TU/e

This year, KOers will try to break the world record for the longest crate bridge! Currently, KOers record of 26,69 meters in length is standing since 2016. Thus, it is time to change that. The committee has already finished the design, only the execution is still in the works. If you want to help build the bridge in the two weeks before the attempt, you can contact the committee via: bkb@koerstue.nl.

BetonKanoRace

May 20th – May 22th — Utrecht

This year, the Concrete canoe race will be held in Utrecht. After two years of cancelation, we hope that this time the event will take place. The goal is, apart from finishing first, to design a sustainable canoe that is also fast. The committee is already working hard to prepare these canoes and their muscles! ◄

SCIA workshop *October 2021*

Introducing the New Board of KOers

Joes Sloots - Chairman

Where are you from? Do you intend to return after you finish your studies?
I was born in Haarlem, grew up in Varsseveld and lived multiple years in Arnhem, Den Bosch and Eindhoven. I have no clear prediction where I will live after my graduation. I would like it to be a surprise!

What did you want to be when you were younger?
As a kid, I wanted to be a superhero! Still working on it…

What is your favorite KOers activity?
Although the last two editions were canceled, I want to believe that the Concrete Canoe Race is the pinnacle of our activities.

What is your favorite beer?
Why of course: the Pauwel Kwak

What is on your bucket list this year?
The BKR and the KIST since both were canceled in the past two years due to COVID-19.

What is the ideal weekend for you?
When my weekend agenda says: "no appointments", then it sounds perfect!

Are you a morning person or evening person?
Both! However, during the afternoon, my energy levels are quite low.

What can we wake you up for at night?
A spontaneous party

Teun van Warmerdam - Secretary

Where are you from? Do you intend to return after you finish your studies?
I'm from the high north of the Netherlands, the city of Groningen. While nothing tops the city of Groningen, I do not see myself moving back there in the upcoming years. I really enjoyed moving to a new place in the Netherlands (Eindhoven) a few years ago, and I would like to experience this at least once more.

What did you want to be when you were younger?
There was an early phase where I wanted to become a firefighter. Although quite quickly after that, I dreamed of becoming an architect.

What is your favorite KOers activity?
My favorite KOers activities are the ones that involve trips, drinks, excursions, sports, or a combination of them!

What material has a special place in your heart?
I have a weakness for textured materials. This could be anything from brushed aluminum to concrete with the timber formwork still clearly visible or structural timber elements themselves.

What is your biggest fear?
Losing my sight.

Are you a morning person or an evening person?
Morning person! While evenings are often really fun because of the activities that are planned in the evenings, there is a mystic ambiance around dawn that is unbeatable and heals the soul.

What is on your bucket list this year?
Beat Timo in a game of squash.

What is an ideal weekend for you?
Spending time outside with a long run or bike ride, taking all the time in the world for cooking dinner, strolling through random cities to look at facades, and spending time with friends, roommates, or family.

What can we wake you up for at night?
Nature wonders like northern lights or sea sparks and for suddenly dropped music by favourite artists.

What is your favorite beer?
Ask me this in a few weeks and my favorite beer has most likely changed again, but for now it's Brewdog's Hazy Jane.

Linda Versteegh - Treasurer

Where are you from? Do you intend to return after you finish your study?
I was born in the city of lights, Eindhoven. However, I grew up in Best, a village close to Eindhoven. After finishing my studies, I would like to stay below the well-known rivers. However, I will go wherever my future job will lead me.

What did you want to be when you were younger?
When I was younger, I wanted to become an architect, I even did a small internship at an architect in high school. However, after graduating high school, I wanted to become an air traffic controller or everything in the built environment, except an architect.

What is your favorite KOers activity?
Definitely the KIST! During my first year at KOers, I joined the KIST committee, but the trip could not take place due to the Covid-19 pandemic. This year, I hope the KIST can finally take place.

What is an ideal weekend for you?
On the perfect weekend, I will have dinner with my parents and brother, have a drink with friends, and win a hockey match with my team!

What can we wake you up for at night?
You can't wake me up for anything, because I sleep through everything. I even slept through a ringing phone that was 10 centimeters from my head. Fun fact: the phone call was from my parents that my little brother was born.

What is your favorite beer?
IJwit, from Brouwerij 't IJ. A white beer with a lovely taste.

Thomas Pannekeet - Commissioner of Public Relations

Where are you from? Do you intend to return after you finish your study?
I am from Geldrop, a village very close to Eindhoven! Since I have spent my entire life in this area, I don't think I want to stay here after my study. I would like to have a change in the living area probably. But you never know what the future brings.

What did you want to be when you were younger?
I never knew what I wanted to become when I was younger, it was always too far away.

What is your favorite KOers activity?
Drinks and excursions, or a combination of both.

What material has a special place in your heart?
Timber, something about the smell of freshly cut timber is special.

Are you a morning person or an evening person?
I'm a morning person. I love waking up early before most people are awake and doing stuff. Also, sunrise over sunset.

What is on your bucket list this year?
Winning the SDE with VIRTUe!

What's an ideal weekend for you?
Going for a long run, spending time with family and friends. Also drinking lots of tea and playing board games is in the ideal weekend.

What can we wake you up for at night?
Very little, I love to sleep. I even slept through a thud nearby, and my sister ringing the doorbell for half an hour.

What is your favorite beer?
I don't really have any. I like to vary with it.

Saar Driessen - Commissioner of Education & Vice-Chairman

Where are you from? Do you intend to return after you finish your study?
I was born and raised in Amersfoort, which I think is a beautiful town. For now, I have no clue where I will live in a few years, we shall see.

What is your favorite KOers activity?
I hope to find out this year! I didn't participate in many activities yet, but this year should definitely make up for that. So ask me again at the end of the year.

What is on your bucket list this year?
Climbing the Puncak Yaya (4884 m) in Papua New Guinea, which will be my fourth mountain of the seven summits.

What is an ideal weekend for you?
It's a sunny and warm Weekend. In the morning we drive to the south to climb on the rocks for the whole day. At the end of the day, we set up the tent and find some dinner. Waking up the next day and start climbing again!

What can we wake you up for at night?
A chocolate chip cookie.

What material has a special place in your heart?
Granite, because it is a beautiful material to climb on.

Are you a morning person or evening person?
I am a morning person, but only after I took the time for my breakfast.

What did you want to be when you were younger?
I wanted to become an architect as I was inspired by an architect redesigning parts of our house, but my high school mathematics teacher told me that it was too easy for me, so I went for SED.

Also interested in a board year?
Join the board interest drink
When: March 16th ◄

Student opinions on how to solve the housing market from different perspectives

Various Solutions to a Complex Problem

To solve the housing shortage problem, a tremendous amount of new houses needs to be built. In this article, we will elaborate on the different opinions from different perspectives by students within the Built Environment.

Construction Management and Engineering

Jelle van Midden

To accommodate the current shortage of housing in the Netherlands, two primary roads can be taken. The new-build path, or the reuse-path. The new-build path allows the use of state-of-the-art techniques to provide future-proof houses. This applies to a lesser degree in the reuse-path, since it encounters its problems mainly on the housing that is already present. In the current supply chain, mainly at the construction site, there is an increasing shortage of both employers and materials. That shortage results in delays everywhere within the supply chain. The most efficient way of constructing would be to use fewer materials and apply simple and easy renovations.

An example is the creation of split-level housing by renovating in-use buildings. Currently, lots of housing that are meant for families are in possession of people, mainly the elderly, whose children moved out. Resulting in a lot of unused space that could be used to house starters. When this would be combined with new housing projects, it could create some space for the market to adapt.

Real Estate

Joep Dirx

It has already been a year, maybe even longer, since the specialist predicted that the housing market of the Netherlands was going to crash, but nothing seems less true. Each quartile, new records are broken concerning the housing prices, the available housing stock, and who knows what. There is no logic in it anymore and there is much disagreement in the search of the problem. Perhaps it is better to call it the driver of current housing market madness. In my opinion, there is not one fundamental issue. It is the combination of insufficient policy, lack of development, and wrong housing culture. However, we do need to start somewhere to solve it. Therefore, I suggest a more life-course-resistant housing market. The flow between life-stages and dwellings is not correct anymore. The elderly stay in their aesthetic paid-off mansions for way too long, which causes congestion in the queue behind them. So, first, get those seniors in some lovely community projects and let the families enjoy their long-possessed mountain of bricks.

Architecture

Demi van Hooff

The current home shortage in the Netherlands is a major problem that architectural solutions can help to solve. From an architectural perspective, the importance lies in constructing suitable housing for specific target groups. This means that housing should be built according to the typological and aesthetical needs in and around the dwelling for different user types. This way, suitable architectural designs can increase residential mobility among users, In other words, both individuals or households adapt their housing consumption to their changing needs. Although starters seem to be the most prominent victim of the housing shortage, it is not necessarily the task of architects to only focus on constructing starter dwellings. Providing suitable housing for all different types of users within our society will create a healthy flow from one residence to the next. In that

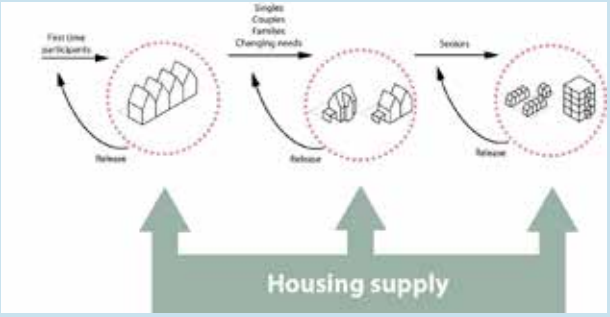

Figure 1: Residential mobility

way, suitable housing will be released at a sound stage in life and result in sufficient and appropriate housing for its users. To visualize this principle, see *figure 1*.

Building Physics

Menno Peijnenborgh

Currently, in the Netherlands, there is a housing shortage because there are simply not enough houses for the people to live in. Building physics has a lesser impact on this matter, since a part of the problem is that not every house is fully occupied. In addition, it is also a matter of space available in the cities. For that reason, building physics focusses more on making housing affordable, since it is also part of the housing shortage cycle. In general, renovating or building more sustainable than the minimum required from regulations should be rewarded higher, because the building will last longer and the initial costs can be reduced. During these renovations, the possibility to divide 'under-occupied' houses should be considered. In addition, high rise buildings are a good possibility as well as ideas like 'The incredible shrinking man'. Of course, the latter would be most effective if it was a real option at all.

Urbanism

Maarten Kamp

Our current housing crisis is often reduced by quantifying dwellings to numbers and financial figures, which nullifies its complexity, importance, ánd possible chances immensely. It is a symptom of a system that has degenerated homes to just mere bricks-and-mortar. An important cause lies with the lack of recognition of the actual significance of the human scale on the one hand and the dominance financial yield plays in decision-making on the other. Realizing that the human scale is both about physical dimensions and the social component is a necessity.

Houses are part of peoples immediate living environment; it has become an essential fixed value in a world where much else is determined by an endless amount of choices and opportunities. Especially considering that many environmental and health-related issues can be traced back to our living environments, and therefore proper action is needed. Designing living environments integrally is the key in achieving resiliency. We have to make social and community design a standard instead of treating it as an extra.

We built for people, communities, and the future. If we embrace this priority as a society, more weight will be put on social design decisions. The discipline of urban design is strongly involved with this, so their role is clear.
A rebalance in values is needed if we want to avoid a situation where everybody has to live in the way J.J. Slauerhoff describes in the following two verse lines: "Alleen in mijn gedichten kan ik wonen, nooit vond ik ergens anders onderdak" - J.J.Slauerhoff. In English: I can only live in my poems, I never found a roof elsewhere.

Not all values can be directly measured in numbers. Social capital is the currency we pay for our future living environment. We have to remember that and treat it with care.

If you like to read more about Maartens, a longer version of this opinion can be found on the website of the KOersief: *https://koerstue.nl/articles.*

Structural Engineering and Design

Laura Dings

To solve the issue of the housing shortage, approximately one million houses need to be built at a rapid pace. Conventional construction techniques include a lot of customization and take a long time. A reduction of on-site actions need to happen. Therefore, the solution will come from modular building systems. Constructing building blocks in a factory will be more efficient and faster. The assembly on-site would only require 'dry' connections, which is quicker and much safer. New digital design tools, such as parametric design, can help create different (optimized) solutions, using the constraints of the modular building blocks as an input parameter. Digital manufacturing techniques can construct customized building blocks.

Furthermore, attention needs to be given to re-using existing structures. When a building has reached its functional or aesthetic life span, the building will be demolished. This is an incredible waste of material, as the structure can often be re-used. ◄

Figures:
Header *John Lord*

Pieters project: Tuin van Noord, Rotterdam, 211 residences
image: © Frank Hanswijk

Pieters project: Dune House, Terschelling
image: © Filip Dujardin

Pieters project: Freebooter, Amsterdam, 2 residences
image: © Michael Sieber

Pieters project: Patch22, Amsterdam, 26 residences
image: © Pieters Bouwtechniek

Pieters project: The Line, Amsterdam, 72 residences
image: © Pieters Bouwtechniek

Pieters project: De Voortuinen, Amsterdam, approx 100 residences
image: © Pieters Bouwtechniek

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The house, its features and potential to tackle two crises at once

Team CASA: CASA 1.0

By: Thomas van der Werff and Camiel Mourisse
members of student team Casa

We are Team CASA, one of the student teams at the TU/e. We are working on designing a Comfortable, Affordable, Sustainable Alternative for the current social housing since 2016. As a team, we work on two very important and pressing issues: the current housing shortage in the social rental sector and the need for improving on sustainability of the built environment. By integrating existing and innovative technologies into the design, we can build the house of the future!

CASA 1.0

This house is not just a house and it has not been given the name of sustainable easily. Besides generating our own energy supply, we also want to be able to store it. By letting water flow through the solar panels, the water heats up thanks to the sun. This heat is used to heat the water in the Seasonal Thermal Energy Storage (STES). This large, insulated water storage, which is placed underground, can store the heat generated in the summer. This energy can then be used during winter! If we have an abundance of electrical energy from the solar panels, we can also use this to heat up the STES. This way you can get through the winter warm and comfortably without having to use the regular electricity grid.

The mere fact that in principle we do not have to use the electricity grid already points in the direction of a utopian home. However, it has another advantage. The number of homes with solar panels is growing and, in the summer, this provides an enormous supply of electricity to the electricity network. Owners of solar panels can often still get money back for this. However, if this number of houses with solar panels continues to grow, the electricity grid will no longer be able to cope with this in the future and you will no longer be able to supply your energy back to the grid. This is annoying, because you will get your investment back much less quickly and, in the winter, you will still be dependent on other forms of energy. That's a shame! When you store the energy yourself, you avoid this problem and provide a truly sustainable solution.

IIn addition, we are conscious of the material that is used for the home. For example, we pay attention to the amount of energy used in the production of the materials, but also to the way we assemble the building. We also ensure that the materials can be reused in the future and that renovation and maintenance can be easily carried out without creating unnecessary construction waste!

Construction update

The house is currently under construction in Brandevoort, Helmond. The STES system has been installed underground and the load-bearing structure with our durable, demountable facade elements has been installed. The end result is becoming more and more visible, and we can already see for ourselves that it will be inhabited. The house has already been completed, but there are still some activities around the house. Our team manager, Antoine, already lives there and is still working hard to complete the house. A great moment to look forward to!

The Future of Housing

The first house is just the beginning. With the current housing climate in The Netherlands, big action is required to address not only the environmental needs, but also the demand of houses. With our first house we showcased, we demonstrated that it is possible to build an affordable and sustainable house that does not incorporate concrete in its structure. The concept of CASA 1.0 can only be expanded upon and will only decrease in costs as the years go on. To add to this, it will be easier to

Figure 1: the construction of the CASA house

integrate the technologies and allow for cheaper prefabrication of the walls. In cooperation with our partners, we are aiming to expand the one CASA 1.0 to multiple CASA houses.

This concept can be expanded and applied to the entire country to provide the citizens of The Netherlands an affordable and sustainable alternative. Currently, the housing market is getting tougher and tougher to enter as a starter looking for a home. What is needed are quick, but proven solutions to provide the people with adequate housing. As stated earlier, our concept does not require the solar energy to be sent back to the grid and thus limits the investment needed in infrastructure if CASA houses are developed. Furthermore, the overall production of cement will decrease saving tons of CO_2 emissions in the process. The development costs will further decline as more houses are being built, and the building process can be streamlined. Once all the houses are built, minimal reliance on existing energy and heat infrastructure (natural gas and electricity) is required due to the houses being responsible for most of its energy production.

All in all, CASA homes have the capabilities to drastically reduce one's ecological footprint whilst simultaneously providing adequate and affordable housing to the increasing masses of people that require it. ◄

Team VIRTUe

Figure 2: VIRTUe house

Figure 3: Podcast hosts and VIRTUe co-developers Bowie and Pim

Interview in the podcast 'Kunnen we het maken'

In addition to CASA, Team VIRTUe has also been busy developing a sustainable and flexible housing. With a large multi-disciplinary team, VIRTUe has worked together for over a year on designing and constructing the building; RIPPLE (see *Figure 2*).

The house can currently be visited temporarily on the KOE field at the opposite of Vertigo. The concept has numerous innovations in the field of materials use, energy use and housing layout. For example, the house is completely made of biobased material, the rainwater is collected and used, and the user has a good insight of their energy consumption. The podcast 'Kunnen we het maken?' visited the VIRTUe building. Co-developers Bowie Steutel and Pim Rijsbergen (see *Figure 3*) answered all our questions and gave a tour in and around the building. Are you curious about their house RIPPLE and how they got sustainability and flexibility in their design? Then listen to 'Kunnen we het maken?' Season 2, Episode 6 via Spotify, SoundCloud or iTunes. ◄

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New Factory to help with Housing Challenge

By: Wendy Hoogeboom-Leenstra
Communication advisor at Van Wijnen

"The new factory and *Fijn Wonen* is our way of making a significant contribution to affordable and comfortable housing for everyone. We will be starting up production in 2022 and over the subsequent years raise the volume to approximately 4,000 Fijn Wonen houses per year. They all come in finished parts from our factory." says Hilbrand Katsma, Managing Director of Van Wijnen Components, the business unit that includes the Van Wijnen factories.

This factory embodies the transition in construction, and is ground-breaking in many ways: in the area of product development, robotisation, digitization and ICT, sustainability, and circularity. The latest technologies come together in this factory on several fronts, which is reflected in the high level of robotization that Van Wijnen uses to solve the scarcity of craftsmen to some extent. That is important, because Van Wijnen need its craftsmen for other wonderful projects besides industrialized construction. The robots will help to accelerate housing construction.

ICT is the backbone of the factory
Floors, walls, and fully finished facades are produced in the factory, after which they are assembled on site into beautiful and varied houses or apartment buildings. The entire process, from engineering to production, assembly, and after-care, is fully automated. Ordering housing is fully digitized too: the factory receives direct inputs from the configurator on the online portal of Fijn Wonen. This end-to-end digitization and the automated production methods are cutting-edge for the world of construction, particularly on this scale.

Lean process
In accordance with the just-in-time principle, equipment, raw materials, and semi-finished products (e.g. door frames, doors, cable ducts) arrive in the factory in the right place exactly on time. The unique aspect is the wide diversity of elements that can be manufactured. From floors to walls, to complete facades in many versions. Then, everything arrives on the construction site at exactly the right time, where the components are assembled in an efficient way.

4,000 houses extra per year, what type of houses are they?
The factory produces low-energy housing that is comfortable, future-proof, removable, but above all affordable. There are also numerous opportunities to give every house, apartment complex, or project a unique look. This produces varied neighborhoods throughout the Netherlands. You can put all of it together yourself with the Fijn Wonen configurator. As Van Wijnen sets itself the objective of no more demolitions for the future and to focus on reuse, these houses can be dismantled. "Imagine a block of flats of 14 floors that can be disassembled and then assembled in the same or a different configuration in a different location."

The factory itself is also sustainable and future-proof
This all-electric factory is modular, uses geothermal heat and cooling, and sustainable materials. The end product, a circular Fijn Wonen house, is built with sustainable concrete with an extremely low CO_2 footprint. This produces affordable housing for everyone, which is future-proof too. ◄

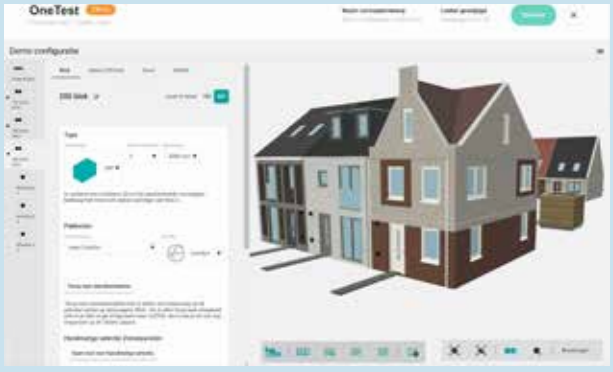

Figure 1: Fijn Wonen configurator with infinite variations.

van de laar
adviseur in
bouwconstructies

Fotograaf: Tycho Merijn, in opdracht van Atelier van Berlo

Rots in de branding in het bouwproces,

meedenkende betrouwbare partner met
duurzame creatieve en innovatieve oplossingen

Adviesbureau Van de Laar is een onafhankelijk ingenieursbureau sinds 1956. Met ongeveer 30 werknemers maken wij vanuit onze ervaring en creativiteit, binnen multidisciplinaire teams, de vertaalslag naar optimale constructies. Door deze werkwijze komen de beste oplossingen tot stand. Open 3D-revit/BIM omgevingen spelen hierbij een belangrijke rol, als coördinerend hoofdconstructeur blijft Van de Laar een stabiele factor in de steeds verder versnipperde rolverdeling binnen de bouw.

We berusten niet in de makkelijkste oplossing, maar blijven altijd “out of the box“ denken en gaan op zoek naar de grenzen van wat mogelijk is binnen de constructie (bestaand of nieuwbouw). Dit om tot duurzame flexibele en innovatieve oplossingen te komen. Oplossingen vinden welke eerst voor onmogelijk gehouden werden maken ons werk leuk en interessant. Zo zijn wij trots op de door ons gerealiseerde projecten en werken we er met veel plezier en passie aan.

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Modular solutions from three different companies for the housing shortage

Modular Buildings

By: Thomas Steigenga, Twan Vrijsen, Charlotte Heesbeen
Business Developer & Project Lead by Sustainer Homes, Marketing & Communications by Barli, Building engineer by MOOS

The building industry is innovating in multiple areas and many different construction methods are being explored. One of these methods is modular construction. This is defined as using prefabricated elements repeatedly in different projects. In this article, three different companies explain their modular construction solutions to combat the housing shortage.

Sustainer Homes

By Thomas Steigenga

There are currently three major transitions in the construction industry: wood, prefabrication (prefab) and digitization. The added value of Sustainer Homes is the focus on the intersection of the three. We could start the Sustainer story from any direction, but most of the time we start with our sustainable driver: wood.

We no longer need to explain in detail the usefulness of wood in construction. The transition has really taken off since the VPRO's Tegenlicht documentary. At that time, Sustainer had already been developing its own modular wooden building system for several years. Every house that is built with our building system, results in a reduction of up to 70 tons of CO_2. This has to do with both the emissions of a traditional building method and the capacity of wood to store carbon. A great contribution to the climate transition!

Figure 1: Placement of the Rabo Groenhuis, Utrecht

Over the past six years, together with a handful of pioneering colleagues, we have proven that you can build safely with wood. In terms of stability, acoustics, and fire safety, wood performs at least as well as traditional building materials. We all know that wood burns well in certain conditions. However, the burning of wood is very easy to predict, and the carbonization of the burnt layer also has an insulating effect on the rest of the beam or column. This makes it possible to say with much greater certainty than, for example, with steel, what is needed to make a building fireproof.

We can only make a real impact if our building system is applied on a large scale. To achieve that, we will have to be cost-competitive. As a material, wood is (at the moment) more expensive than traditional materials. Until wood enjoys the same advantages of the scale on which concrete and steel are used in production and logistics (and therefore becomes cheaper), we will also have to try other ways to reduce costs. This is where the second transition comes in: prefab.

Prefab means that you prepare the work at an external location where the conditions are more favourable than on the construction site itself. As a result, you can produce more cheaply, provided the transport costs are lower than the prefab advantage you achieve. In optimizing both proxies (transport costs and prefab advantage), the design of our module plays an important role, but more about that later.

Prefabrication (or industrialization) also taps into another trend in Dutch construction: conceptual building. Supply and demand are brought together in a number of concepts developed by the

market, so that economies of scale can be achieved on both sides. On the supply side, a completely new project is traditionally set up for each individual house, building, street or district, with project members, architects, engineers, consultants, contractors and suppliers. Conceptual building opens up an approach to product thinking: selling and realizing a building design more than once. Of course, you can still take into account different customer options to make the product suitable for the user and location. This is also how the Rabo Groenhuis was created. You can often choose from different bay sizes and facade finishes. In this way you realize a product with a certain degree of standardization, so that the assembly line in the hall can be optimized accordingly. By going through approximately the same steps for an assembly process, you have plenty of room to learn, to implement improvements and to apply automations. A similar revolution has taken place in the car industry over the past hundred years.

Sustainer's building system called the ".home" system (a kind of high-tech HSB based on Laminated Veneer Lumber - LVL) goes one step further than other conceptual propositions on the market. We set the standard for standardization at three levels: the element (e.g. the facade style), the sub-assembly (e.g. the floor) and the module. By making all the different configurations (in the millions) accessible via parametric software, you can facilitate the entire production chain of detached houses, terraced houses, two-person houses, social rental houses, and apartments with the same building system. And then you have endless flexibility within each category.

Because we use that module so often, we can also put a lot of time and effort into improving that module (including the software and the ecosystem around it) cyclically. Over the past six years we have gone from v1 to v5 in many iterations, of both hardware and software. Taking your product off the drawing board and actively testing it in the field is an essential part of creating a seasoned system. About 100 homes have now been realized in the system and many times more are planned, , see *Figure 1*

In fact, construction proxies come together in the module (besides the transport and prefab proxies mentioned earlier). This creates an integral building block of which you know that it allows each building to largely meet the set requirements, without having to go through a complicated process every time. A selection of the types of problems one might run into: building decrees, fire safety, acoustics, design flexibility, health, environmental impact, detachability, circularity, standardization, easy assembly, construction time, construction steps, transportability, climate regulation, installation integration, constructive stability, use of materials, Rc value, milling margins and operations, product properties, etc. We have a strong team of engineers in-house who carefully consider all these variables with every improvement or expansion of the system.

This brings us to the third transition to which we are responding: digitization. Our digital platform ties everything together. It serves not only as a memory of our building system and easy access to it for every new construction project, but also as an indispensable control of the entire production chain. As mentioned before, prefab thrives in repetitive processes with feedback loops for improvement. For optimal efficiency, different processes are closely coordinated: there is little room for unexpected construction errors. Digital control is indispensable for error-free construction. Our software delivers a 3D model to the assembly hall that is practically 1:1 detailed, including screws, installations, tapes, etc. Each element is matched to every other element to avoid surprises on the construction site. In addition, we attach a lot of data to the 3D model. For example, each element knows what it is, how long it takes to produce and assemble, and in which step it is needed in the assembly line. It also knows who the supplier is, what the theoretical lifespan is, where it is located, to which other elements it is connected, what the environmental impact is, what the weight and dimensions are, and anything else we think of in the future that might be useful. With the help of this data, the work preparation, purchasing and information provision of the assembly line can be largely automated. In addition, it provides a valuable digital foundation for organizing maintenance and reuse in the future.

To wrap up the story, let's make the step to practice. Last summer, developing contractor Koopmans construction group and supplier geWOONhout completed the first four terraced houses in the Sustainer.home system, see *Figure 2*. This is the first step towards large-scale and competitive application of our system, with enormous potential for impact. A plus and minus is that this house is almost indistinguishable from a traditional house. The house plan as we know it today in the Netherlands is largely a result of traditional building methods. What if we could also embrace the modular philosophy in home design? And what if our new housing stock makes optimal use of all the possibilities offered by modular construction in wood? The future will show us!

Figure 2: Houtbaar Huis Concepthouse, Hengelose Es, Hengelo

Barli
By Twan Vrijsen

About 800 homes will be built this year in Uden, barely half an hour from Eindhoven. Not in a new residential area, but inside: in the Barli housing factory. The Brabant company swears by 3D production of modular homes built in wood. And there are very few in the Netherlands who do this on such a large scale, explains director John van der Doelen.

"Last year, just over 800 trucks with more than 600 ready-made homes drove off our site. And in the coming years, we will more than double that," says Van der Doelen, see *Figure 3*. The proof lies in the enormous production halls, with a total area of 32.000 m², of Barli. At this very moment, those halls are filled with homes, ready for transport. Kitchen, bathroom, installations: everything is already in there.

"We have noticed in recent years that our modular and sustainable way of construction fits very well with the upscaling demanded by the housing market," says director John van der Doelen. "For example, for housing associations, who are looking for an affordable solution that is quickly available. Sometimes temporary, but more and more permanent. Project developers are also discovering that you can realize special projects modularly. This is partly because our wood construction method contributes to the idea of circularity and sustainability."

Figure 3: John van der Doelen in the Barli housing factory in Uden

Better environmental performance
The recent report 'Woningbouw in hout' underlines this. Timber construction delivers better environmental performance than other construction methods. With modular building, you also limit the number of transport movements, CO_2 emissions, and nuisance on location. "That report shows very nicely that modular construction as we do it also fits very well with the required quality, speed, and affordability. Comparatively, construction costs are lower, the construction speed is higher, and we also meet all quality requirements!"

The availability of wood is no problem, even if we will build many more houses in wood. This is shown by recent research by Wageningen University & Research. "Every year, one billion m^3 of wood is added, and the harvest is only 600 million m^3/ year. So there is no shortage of wood; the European forest is even growing."

Mass customization
The idea that building with blocks like LEGO blocks leads to straightforward homes is a big misunderstanding, according to Van der Doelen. "Stacking and switching modules makes the possibilities very customizable. In Eindhoven, for example, we will build 45 wooden houses in the OAK Bosrijk project, see *Figure 4*. There are no fewer than 11 different housing types for various target groups; from 70 m^2 to spacious family homes of over 200 m^2." Barli is part of the winning tender team, in which various specialists designed an integral plan. The TU/e is also involved. "Together, we are looking to see if we can make the plan even more sustainable. Almost three-quarters of the houses already consist of circular materials. For example, we make the facades from locally harvested poplar wood. The houses can also be dismantled: we can move them in the future."

Figure 4: OAK Bosrijk project

Data-driven production
Barli's strong growth ambition comes with the necessary challenges, not only in production but also in work preparation and engineering. Based on a digital roadmap, the company is taking significant steps towards data-driven production. Senior Tekla Engineer Bart van der Kallen explains: "Think of the data-technical unambiguous recording of building blocks and construction concepts and more efficient ánd paperless management of our production. But also the automation of engineering processes resulting in validated source data or using a BIM protocol to promote collaboration with third parties. One of the first results is developing an innovative tool in Tekla. With the tool we can automate manual export routines from a BIM model. That saves much time and it excludes possible errors. Within the model it is possible, for example, to live track which elements are already in production."

In the urge to industrialize, one housing factory after another is being built in the Netherlands, often by the traditional building companies. "I can safely say that the developments at those traditional builders are still far from the way we do it ," concludes John van der Doelen. Alluding to the fact that others create mostly 2D elements, whereas Barli chooses to produce 3D elements.

MOOS
by Charlotte Heesbeen

Our world can be a great place to live in, but the truth is that this is not the case for all of us. We are facing severe problems that are threatening our existence. We have to react by radically and structurally changing the status quo of the construction industry. That sounds scary, but with little guts, we can do it! MOOS, short for In The Middle Of Our Street, has picked up the gauntlet to respond to the situation promptly and responsibly. Essentially, MOOS is here to contribute to two enormous social challenges: firstly, the painful shortfall of houses and, secondly, helping to create a circular building environment. The way to get there is by creating a comfortable home for everyone, see *Figure 5*

The MOOS building system is a realistic solution. Realistic, in our eyes, is a technically feasible system at a competitive price and realized at the glimpse of an eye. An answer rooted in industrial and prefabricated production is therefore

apparent. Beyond that, our solution excels at being circular and contains a significant degree of bio-based and secondary building materials. Let us have a closer look at how we aim to combine this in practice.

Figure 5: Comfortable houses for everyone

You can find the key to living up to the expectation in our partner ecosystem, see *Figure 6*. In it, we let go of the traditional top-down hierarchy, headed by a general contractor. Instead, we have realized a unique collaboration of experts in the field. All of our partners have years of experience and are independent builders and advisors. They are similar in having committed to designing comfortable houses. Also, the built solutions will be fit for the entire building lifecycle ánd beyond. An example of a successful collaboration is the choice for recycled concrete floors in an otherwise timber construction. It allowed us to create synergy between multiple factors. To reuse the flow of high-quality building debris and guarantee an acoustically comfortable interior. And also to create a building system that is fit for different building configurations, ranging from two-story gallery layouts to higher buildings arranged around a core.

The process to create our buildings is digitally steered and tracked, from design to the high-quality reuse of resources. We tap from a library of standard and modular units during the design phases to create a customized solution. In the 'initiative' phase, we use a configurator to estimate an optimal solution for a specific location and demand. After realization, we keep track of the building in a digital twin. This way, the information is ready for the reuse of MOOS modules or the repurposing of building materials in comfortable housing that will be needed by then.

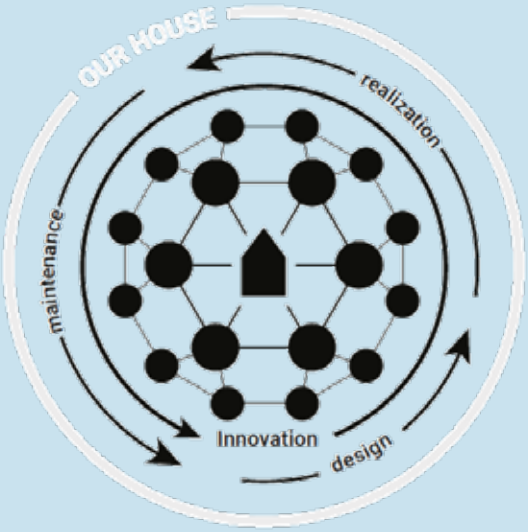

Figure 6: MOOS Ecosystem

Making an impact is not something to do alone. We are continuously looking for innovators and go-getters to strengthen our team. If you are curious after reading this, we are happy to show you around the LAB-house in Zaandam. ◄

Figure 7: The LAB-house in Zaandam

Opinion Article

One Million New Homes – Challenges to get the Construction Started

By: Prof. dr. ir. Marleen Hermans
Managing Partner Brink, and Professor of Public Commissioning in construction at TU Delft

One million new homes, preferably before 2030. That is what the Dutch society needs. Easier said than done. A challenge in many ways. So, what is required to pull off this challenge?

First of all, we need to be more precise in what we need to be built where. What is the exact regional program required and which locations are feasible to answer this regional program? The number of one million represents a wide variety of needs and wishes, regarding the type, number, and quality of houses needed, closely related to the specific regional situation. The current discussion often focuses on the urban needs, and even more specifically, on the needs of the Randstad region. But the demand for housing is nationwide and differs substantially in local needs and shortages. So, the first thing to do is to investigate what type of houses are needed and what possible locations are available or can be made available to build those houses or transform existing buildings into housing. 2030 is just a split second away if we keep the duration of an average planning process in mind. So: which locations can realistically be made available for housing? And is the required land redevelopment feasible? Will it lead to affordable housing? Including all necessary infrastructure and services required?

Studies indicate that inner-city locations will not easily add up to the required one million. Redeveloping inner-city sites will also lead to the displacement of the existing functions to the city skirts. At the same time, rural locations often require more investments in infrastructure and additional services. Current politics seem to systematically overestimate available sites, where figures show that redevelopment is a slow and complicated process. Realism thus is strongly needed to form part of the planning process.

Secondly, how do we get this program going, how do we generate sufficient execution power? Housing is not a standalone product and we cannot decide on housing separate from other policy discussions. Housing requires the availability of many related functions and services, needs a functional energy network, brings on mobility, impacts sustainability goals, etc. As the space available is scarce, housing will require relocation of other existing functions in a densely populated country as the Netherlands. So, where do these other functions go? More and more, housing should be seen as part of an integrated regional program, in which coalition with new partners is essential. For instance, energy companies, water authorities, as well as the existing partners such as municipalities, housing associations, commercial developers, and local and regional infrastructure bodies. Depilation of budgetary streams and funds will be necessary to get the required feasible integral program. A joint program approach is needed on a regional level instead of the current 'area per area' and compartmentalized approach.

Last but not least, where discussions seem to focus on the aims, tasks, and resources for housing, the production capacity available should also be considered. Current figures show a worrying scarcity of construction-related materials, next to the strong desire to transform into a circular construction industry. Even more pressing is the shortage of workforce capacity in the public domain, specifically in municipalities-, caused by the aging workforce among other issues. At the same time, the production sector has great difficulty in interesting students to become the craftsmen we need on our building sites. This adds to a considerable need for standardization and industrialization in the sector to substantially increase labor productivity. We will not be able to produce houses in the future in the way we make them today. There are simply not enough human resources to do the job. Reducing the number of customized programs of requirements and introducing buyer groups, long-term partnerships will help reduce transaction costs and increase innovation options both at the side of construction clients and the supply chain. Thus enabling the one million houses to be built. ◄

Since 2012, Marleen Hermans is a Managing Partner at Brink, a consultant for construction, infrastructure, and real estate. In addition, Marleen is Professor of Public Commissioning at the Department of Management in the Built Environment at the TU Delft. Within her function as professor, Marleen is intent on giving substance to the subject of commissioning in the construction industry, in both research and education.

Much-Needed Migrant Workers Lead to Much-Needed Mid-Range Housing Production

By: Dr. Harry Boumeester
Assistant Professor in Management in the Built Environment at the TU Delft

You do not necessarily have to be working as a professional in the housing or mortgage market to know that the Dutch housing market has been performing far from optimally for the last two years. Housing is back in the political and social debate. Almost daily, an item in a newspaper or magazine or a current affairs program on radio or TV pays attention to the current housing market. A significant housing shortage, substantial price increases in the owner-occupied and private rental sectors, and enormous queues for social housing even result in headlines such as 'housing shortage'.

We have known for some time that the housing market is not really a market in which supply and demand come together through price formation. However, we have not seen the current discrepancy between housing supply and demand in recent decades. The Dutch population has grown by approximately 100,000 people per year in recent years and is expected to continue to grow substantially over the next ten years. Striking is that the migration balance is currently responsible for about 75 percent of this growth, while until 2015, natural growth still accounted for the majority of the increase. The outflow of the baby boomers from the workforce requires more and more workers from abroad. This also means that the growth of the population is less 'natural' and takes place predominantly in the age groups that are already further along in their household and housing careers.

It is expected that, on top of the current housing shortage of approximately 300,000 homes, there will be an additional demand from 600,000 households for new homes in the upcoming nine years. This additional demand can be met by splitting homes and converting (office) buildings into houses to a limited extent. Nevertheless, on an annual basis, a new construction production of at least 80,000 houses will still be required to house the migrant workers. In the past two years, the production has already increased but remains stuck at approximately 70,000 homes. The housing shortage is therefore growing.

For that reason, it would be necessary to build considerably more, despite all the now-familiar bottlenecks such as shortage of labor, shortage of (and currently too expensive) construction materials, and the nitrogen and PFAS problems. Moreover, the approach to the building process should differ from that of the past. The Dutch housing market can be characterized as a through-flow market: a boom in the housing market and the economy will lead to the construction of new homes in the more expensive, higher-quality market segments. Through relocation chains (in Dutch: verhuisketens), a more appropriate distribution of housing between households can then take place.

Above, we noted that the surplus of demand is now enormous and that it is primarily focused on the middle segments of the rental and owner-occupied sectors. This means that, despite the current boom, we do not have the time to hold on to the flow-through principle. More than in the past, new housing production must be 'directly' linked to the current and near-future surplus demand: more housing in the affordable to the medium-price range and more housing near the current and future concentrations of jobs. In other words, more new construction of apartments and houses with ground-level access in and on the outskirts of the cities, but certainly not with too strong an emphasis on the (expensive) central urban residential areas.

Harry Boumeester is a teacher at the faculties of the Built Environment and Technology, Policy and Management at the TU Delft. Harry is active particularly in the research areas of housing market (development), housing choice and housing preferences, with an increasing focus on the owner-occupied housing market.

Naturally, we cannot expect such a turnaround in thinking about new housing production from private, commercial investors, project developers, and construction companies. Therefore, a much clearer and directing guidance by the municipalities and central government is indispensable. In the past, the Netherlands often faced significant housing shortages. These shortages were overcome by national government policy: reconstruction after the Second World War, growth cores policy in the 1970s, and the Vinex policy in the 1990s and early 2000s. Back then, the housing corporations also turned out to be very reliable partners. The Dutch housing market is not a real market, so market forces will not be able to solve the current housing shortage. ◄

Two visions on the development of the Eindhoven area

There is Work to be Done; Build more Houses

By: the board of EHVXL, Wilbert Seuren, and Jos Hüskens
member of the board of EHVXL, members of the Henri van Abbe foundation

Recently, the 25 largest building associations in Dutch housing construction published a statement expressing the need to build no less than one million houses in the Netherlands by 2030. A significant part of this production will likely be realized in the Eindhoven area. What does this mean for the development of the city? For this article, EHVXL and The Henri van Abbe Foundation (HvA-foundation) share their vision on the future of Eindhoven.

The housing production in Eindhoven, like the rest of the Netherlands, has reached a low point in recent decades. Far fewer homes have been built than planned. Therefore, Eindhoven wants to accelerate the housing production in the coming years. This so-called 'building offensive' aims to build an average of 3.000 homes annually. But where should all these homes be built?

EHVXL

EHVXL is an organization that focusses on the urban development of the Eindhoven region. The organization is run by citizens from a large range of disciplines. By providing input to the municipality, informing citizens of Eindhoven of the latest urban developments, and facilitating the debate, they try to shape Eindhoven into an attractive metropolitan and inclusive city.

One solution that is often proposed is to build these new houses on current agricultural land on the outskirts of the city, expanding the city into rural areas. As EHVXL, we think this is not the right way forward. Since the end of the Second World War, there has been considerable pressure on the countryside. The high demand for housing, industry, and food production, among other things, has led to a degradation of the landscape and a decrease in nature. As a result of the building policy, large parts of rural areas have been transformed into spacious monotonous neighborhoods and industrial areas. In the past decades, the limited space in our country has been arranged inefficiently. We need to develop a 'smarter' method of using this space, especially in 'Brainport Eindhoven'.

According to EHVXL, the greatest opportunities lie in the inner-city area. The built-up area of Eindhoven has a relatively low density, especially in comparison to cities like Groningen or Amsterdam. Because of that, there is a lot of potential to increase the density of the built-up area in the city. Hundreds of promising locations exist in Eindhoven where homes can be added: think of vacant lots, inefficient plot-use, and untapped potential of current structures. Densification is not only about adding housing but also about adding value to the city. When more people live in close proximity to each other, this can lead to a strong basis for other functions like public transport, restaurants, and entertainment. It also creates opportunities for greening and renewing the public space, for example, the development of the VDMA area, where a city forest is created alongside some new residential buildings, as shown in *Figure 1*.

New layers

Adding more mixed-use, mid-rise, and high-rise buildings is an opportunity to add more value to the city. Densification does not always mean a new standalone residential tower. Topping up existing buildings or adding structures to rear areas can also contribute to the building offensive. Winy Maas, the building supervisor of Eindhoven, has formulated two concepts of interest: the 'Eindhoven layer' and the 'Brainport layer'. Both describe a possible way of adding new layers to the existing city. With respect to the existing structures and floors, houses can be added with setbacks. This is already being applied in practice, but we would like to see more of this.

Figure 1: Aerial render of VDMA location with the proposed 'micro forest' that will replace the current parking lot.

Infrastructure

The construction challenge also affects the infrastructure. More people in the city means more (travel) movements. Mobility also has a tipping point, in which we move from a car oriented city to a bicycle and pedestrian oriented city. Other forms of (sustainable) mobility are becoming increasingly commonplace. This means that broad-based car structures such as the Fellenoord, for example, will have to be used in a completely different way from a 21st-century perspective. This offers enormous opportunities for densification and additional homes. According to the plans of the municipality, the Fellenoord area will be transformed into a new city district called 'Knoop XL'. The proposed plans are shown in *Figure 2*. Several other large-scale city developments are on their way and we are looking forward to what the future holds in store!

Figure 2: Birds-eye overview of the potential Knoop XL district. The TU/e campus is visible in the bottom left corner.

The Henri van Abbe Foundation

The Henri van Abbe Foundation (HvA-foundation) is committed to heritage in Eindhoven. It is about what we inherited from our predecessors and what we leave to our children, both in terms of art and architecture. For us, architectural heritage specifically entails the urban monuments, characteristic buildings, the parks and nature around the city, and the urban layout that keeps our neighborhoods livable.

Architectural heritage is an essential element of a livable city to us at the HvA-foundation. The notion that a monument is a delicate object that has to be guarded against the general public, has been luckily outdated for decennia. Furthermore, whenever new development is needed, it is no longer simply put to replace the old, but somewhere appropriate. We have to look at monuments through the lens of livability. Because of this, the neighborhoods of Eindhoven all have their unique character. The pre-war areas of Den Elzent and the White Village consist of architecture from the Amsterdamse School and Delftse School. Eckart stems from just after the war when the Netherlands was faced with a huge housing crisis. One of its prominent characteristics is the spacious setup, which currently quickly leads to the thought of densification.

Densification

Densification entails more than transforming the city so it can house more people. It should account for more functions in close proximity: shops, leisure, green space, water, public transport, and no increase in car traffic. It is also important to keep the spatial character of the densified neighborhood in mind. Is high-rise a good fit? Most streetscapes will not benefit from a 10 or 30 story flat. It will rob the neighborhood of its character. Not only wind and shade play a role, but also safety around such a large anonymous building. As far as we are concerned, project high-rise only in carefully designed urban compositions.

When densifying the historical center, an additional challenge arises; the center has a much older history than most neighborhoods. The street pattern has been the same for almost 500 years! It would be a shame to change it. You would not change the canals in Amsterdam either, would you? Many of the buildings in our center are over 100 years old. The eldest (at the Rechtestraat and Stratumseind) are even over 400 years old! Also, buildings from the first half of the twentieth century are increasingly considered to be historical. They are our landmarks and make up the familiar streetscape of our city. Another characteristic of our historical center is the ratio between the different parcel sizes and the height of the different buildings. If a street-side would be replaced by high-rise, it would not only destroy a bit of heritage, but it will also destroy a familiar streetscape. New development will result in alienation. Be careful with high-rise in the historic city center.

Inhabitant centric densification

Finally, high-rise is a confusing term. The inhabitants of Nuenen consider anything over three stories to be high-rise. Even though that sentiment is likely not shared in Eindhoven, what is high-rise? It is not a synonym for flats, and flats are no synonym for 'dense urban development'. The center of Paris is void of flats, but still no one will claim Paris has the characteristics of a village. Paris is made to be a city where inhabitants can find their day-to-day needs within a 15-minute radius. Not the height of the buildings are what count, but the perspective of its inhabitants.

Eindhoven lacks vision on public space, on the commons, on what fits with its inhabitants, and on what is important for the actual owners of the city. Building more, especially in our city center, requires a human scale, a scale that fits with the small-scale nature of Eindhoven and its villages, and a scale that fits with the dynamic economics of our city. Due to Covid-19, the wishes of the small-scale Eindhoven and the economically dynamic Eindhoven have grown closer. Green and services in close proximity that connects the familiar, that is inviting, and is sustainable. A dense urban center like Paris could fit those needs, but extreme high-rise without accountability for heritage not. High-rise drives up the real-estate prizes and leads to gentrification. Developers are starting to see that, all that is left are our policymakers. ◀

References:

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An opensource housing alternative

WikiHouse

By: Vincent Muller, Wim de Groot, Arthur van Lier, and Pieter van Loon
Co-founder WikiHouseNL, engineer at SHR, engineer at Lüning, editor KOersief

A roof over your head, it should be a human right. A house that fits your needs, custom designed, something to live in, rather than a pile of bricks as investment. WikiHouse is an affordable, bespoke solution for real DIY housing. It is an innovative open-source construction package that is accessible to all.

The concept is simple: you can download a design from the database, mill all the components, and assemble it yourself! Alright, it is not quite that simple yet, but the community is growing quickly and globally. Create your own design or tweak one of the current designs, but make sure to upload your work so that future DIY'ers can use it for their projects.

Wikipedia explains open source as the following: "Open source is source code that is made freely available for possible modification and redistribution. Products include permission to use the source code, design documents, or content of the product." The goal of WikiHouse is to build a database with source documents that enable anyone to design, manufacture, and assemble their own home, as illustrated in *Figure 1*.

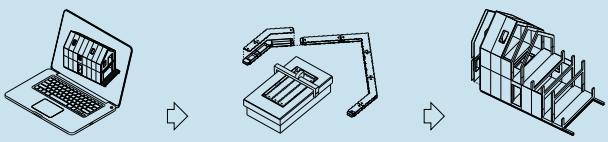

Figure 1: The WikiHouse concept: from design to manufacturing and assembly

The WikiHouse concept, founded by Alastair Parvin in the UK, now contains multiple systems. Each system with its own technical boundaries, its own parameters, and own set of design rules. The common denominator in all this is that all of them consist of 2D timber plates (2440x1220x18 mm^3), which CNC machines can mill to create building blocks of the structure. These building blocks can be manually assembled to form the main structural elements (like portal frames), which in their turn can be combined with the facade plates to become the 3D structure of the design. All this is done with just a few elemental timber connections like the box joints and dowel connections.

One of the implementations of this concept can be found in Almere, where the 'Woningbouwatelier' initiated the first neighborhood consisting of WikiHouses globally. The 'Woningbouwatelier' is an initiative in Almere that promotes innovative and sustainable residential projects. To realize the project the Wren system had been adapted by WikiHouseNL (cofounded by Vincent Muller) to facilitate larger spans. The improved system that can span up to 4.8 meters - 1.2 meters more than its predecessor - has been named Swift. To comply with Dutch codes, the design of Swift has been carefully collaborated with SHR, which provided the structural calculations and tests among others. Finally, a prototype of the system was realized on the BouwExpo in 2017 as a tiny house of 38 m^2. A picture of the finished house can be seen in *Figure 2*.

Technical challenges

When Vincent Muller approached SHR to ask for help developing the Swift system, a lot was still left open. The main parameters were that the system had to be constructed from flat sheet-panels (2440x1220x18mm^3), it should be able to span 4.8 meters, it should provide stability, and from an energy performance perspective, an insulation layer of 300

Figure 2: Tiny house prototype of the Swift

millimeters should be placed around the perimeter of the house. Furthermore, all connections should ideally be based on carpentry joints, or if necessary, screws. But no glue was to be used to keep the system demountable.

For Wim de Groot at SHR, this quickly led to the following basic principle; the structure would be made up of box girders with sufficient height to house the insulation. In this way, a decent amount of moment resistance can be made out of very thin sheeting material. Furthermore, by offsetting the seams in the flanges and webs, an element of 4.8 meters could be made out of sheets of 2.4 meters. *Figure 3* shows the test setup of a 4-point bending test performed at SHR to determine the capacity of the concept. As the red lines indicate, the seams of the web are at 1/3 and 2/3 of the span, whereas the seams of the flanges are near the supports and in the middle of the span. In this way, the box girder as a whole, is never discontinuous, so it can always transfer its bending forces from one sheet to the other. Furthermore, the flange plates were connected by dovetails rather than box joints, so the tensile forces can be transferred over the seam.

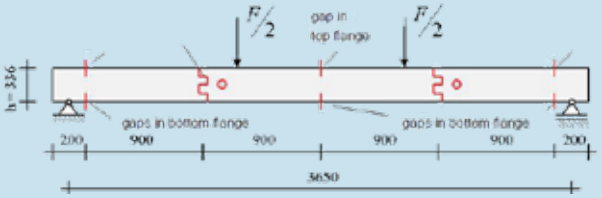

Figure 3: Test setup 4-point bending test

In order to make a stable house, the box girder concept was changed into a box frame (in the shape of the house) with stiff corners. The web plates were made continuous over the corners to ensure moments could be transferred around the corners of the frame, as can be seen in *Figure 4*. In the longitudinal direction of the house, stability is provided by panels that interconnect the portals.

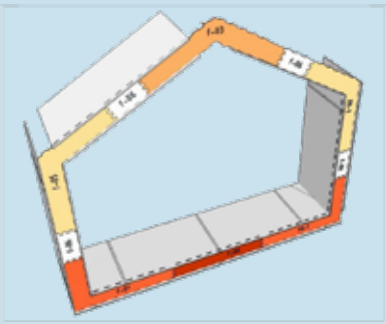

Figure 4: Continuous web-plates for moment-resisting corners

In the end, the tiny house consists out of seven floor boxes with eight portals. *Figure 5* shows a step from the assembly document of the tiny house. The figure clearly shows how the portals are interconnected to provide longitudinal stability. With a width of 1.2 meters, the modules leave plenty of room for window and door openings. With door openings, however, the module wall is considered non-loadbearing since a door opening takes up roughly the entire panel width.

The next stage: two stories

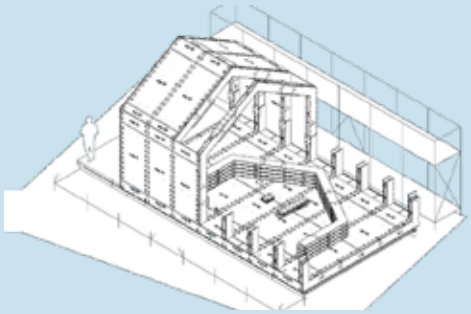

Figure 5: A step from the assembly document of the tiny house

Meanwhile, the next stage of the Wiki-neighborhood has started in Almere. Phase one of this stage, consisting of nine residences, is almost complete. Phase two, an additional 18 dwellings, is being built at the time of writing. These new houses range from 50 m^2 to 100 m^2 and most of them have two floors. A part of the new houses are built as row-houses, but the structural elements are being kept separate to keep all the houses modular and demountable.

Since the *Swift* concept was developed as a single-layer structure, the structure's performance had to be recalculated when an extra story was added. This resulted in a design that was off with a unity check of 2.8 in the SLS design as shown in *Figure 6*. The main challenge here was the wind load in the lateral direction, for which the moment-resisting box-frame is ensuring stability. The dwellings are designed as stand-alone villa's and therefore, each house should be able to withstand lateral wind forces on its own. For a single-story WikiHouse, the box-frame has sufficient capacity. However, when an extra story is added, wind forces on the structure increase significantly. This means that the box stiffness had to be almost tripled to suffice. Strength properties should also be increased but to a lesser extent.

Possible design considerations that were pursued within the

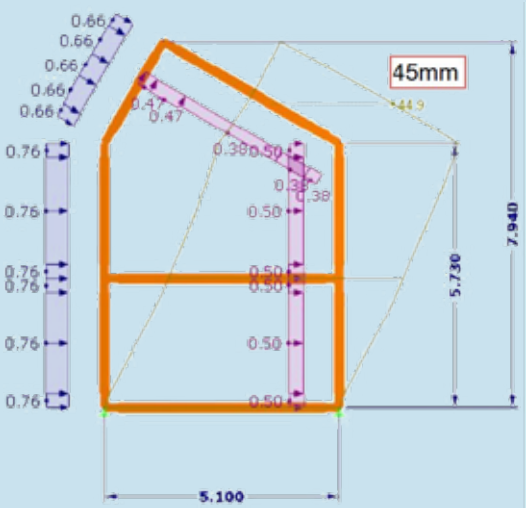

Figure 6: DLUBAL RSTAB calculation of deflection under lateral wind load. Maximum deflection = 8000 / 500 = ~16millimeters; U.C. = 45 / 16 = 2.8

WikiHouse concept were:
Adding extra plywood webs to the box frame.

1. Changing material to birch plywood, which has
2. superior material properties to standard conifer plywood. Optimization of the joint design.
3. Increase of the total box depth.
4. Adding stability wall panels that would be 'clicked
5. in' to the WikiHouse casco.

In finding a solution within the WikiHouse system it was difficult to deviate from the standard box lay-up from the SHR tests, since this would mean that the test result would not be valid for the system and new tests should be carried out. For some of these improvements, the section properties of the box could easily be derived. The SHR test was, for instance, carried out on a 600 millimeters wide box, and therefore, adding two extra webs in the center of the span would mean that on a 1.2 meter grid, two boxes would be effectively created and the stiffness and strength would therefore be doubled, see *Figure 7*. Other changes, like increasing the total box thickness and optimizing the joints, have effects that are not easily extrapolated due to the uncertainty in the slip

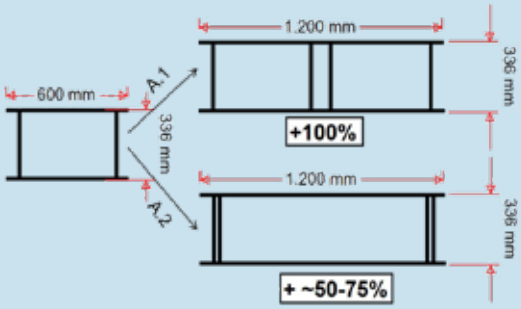

Figure 7: Consideration to increase box properties

factors of the (jig-saw) notches inside and between webs and flanges. New lab tests would therefore be necessary to find a solution that would decrease the U.C. of 2.8 to a respectable value. Unfortunately, these improvements were unrealistic to be carried out in the short time span of the project. Other factors, like ease of construction and weight of separate elements also played a role here.

The solution was therefore found in creating a Glued

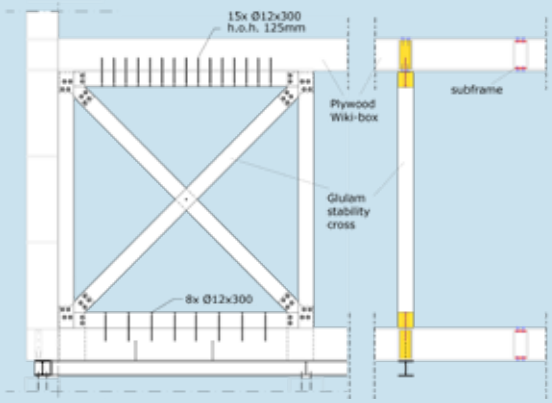

Figure 8: GLT stability frame with connector beam

Laminated Timber (GLT) cross on the bottom floor that is used as a stability frame (*Figure 8*). This cross is directly connected to the steel foundation frame. The first floor is designed as a stiff plate supported by the longitudinal plywood walls and the stability frame. The difficulty here was to implement a more traditional timber construction method into the innovative Wikihouse concept. Because the timber cross would behave much stiffer than the Wikihouse casco, all the stability forces would be directed towards the wall. Furthermore, the floor plate, consisting of 1.2 meter wide modules, had to be properly screwed and tied to let it behave as such. The shear forces in the floor are transferred using a screwed connection between the plywood plates and the subframe (*Figure 8*). The force is transferred towards the GLT cross via a GL beam inside the plywood box. The bending moment in the floor is taken by a steel strip for tension on one side, and through compression on the other side. From the first floor up to the top of the roof, the house would still behave like the 1.0 single layer version.

In the end, a toolbox has been developed for the design process of the Swift, as can be seen in *Figure 9*. The toolbox consists of modules, which can be assembled according to specific design rules to create a design. Installations, as well as interior and exterior finishes, can be chosen freely, as long as it complies to the building codes and local rules. With this, the core concept is achieved; democratization and digitalization of the design and construction process of a house! An easy to use toolbox, for proper DIY house design and building. ◀

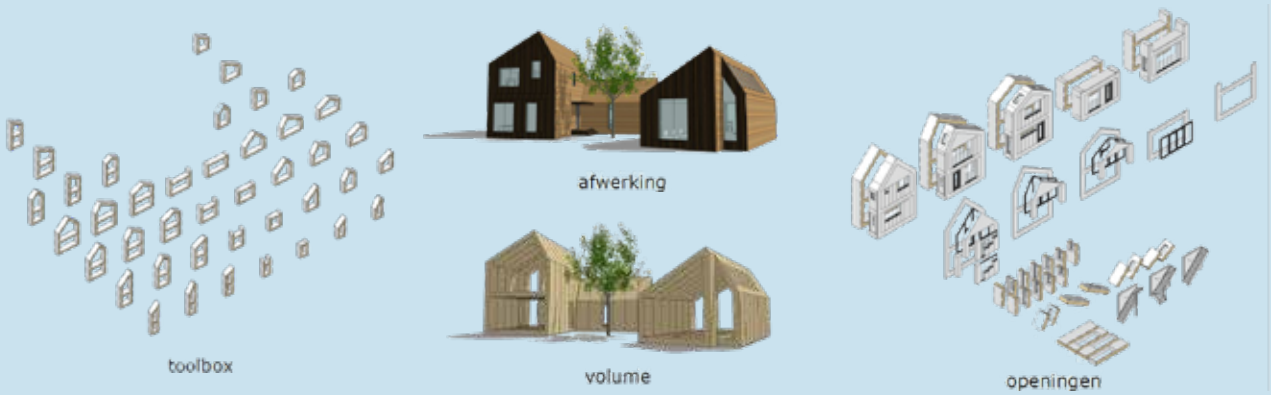

Figure 9: Toolbox of the Swift (a), possible design (b) and openings within the system (c)

heijmans

WIL JIJ BIJDRAGEN AAN DE GEBOUWDE OMGEVING VAN NEDERLAND?

Kom dan werken bij Heijmans en bouw mee aan toffe projecten, zoals woonwijken, kantoorpanden, universiteiten en ziekenhuizen. Dit doe je op gave locaties door heel Nederland. Benieuwd wat voor aandeel jij kan leveren aan de ruimtelijke contouren van morgen? Check dan snel **www.heijmans.nl** en volg onze social media-kanalen.

Fenixloodsen,Rotterdam

Fast, flexible and complete living in one

Heijmans ONE

By: Heijmans

The affordable and sustainable Heijmans ONE is a temporary dwelling of 39 m² with a clear layout that ensures that every resident will quickly feel at home. Already at the entrance, the living room with loft and view beckons. The kitchen, bathroom, and bedroom offer security. There is enough space for guests, and you're not on each other's lips. The use of materials completes the homeliness. The house meets the temporary building code, which guarantees quality.

The exterior radiates freedom and individuality with its quirky roofline. Freedom is also found in the ability to move the house easily. The robust design of home makes the house perfectly suitable for reuse. Two trucks, and a day later, the house is at a different location. It is also ideal for temporary use of space and the smart use of empty sites in towns and villages. By placing a series of Heijmans ONEs in such a place, the area is put on the map in a positive way, and life goes on.

Origin

The Netherlands is facing an enormous housing shortage. Waiting lists are growing, and construction costs are rising. But there is a lot of undeveloped land waiting for (permanent) structure. Space that can be used for temporary (rental) housing. Sounds simple, but in practice, it is still quite difficult. The Heijmans ONE can help to speed things up and relieve the pressure on waiting lists, with an eye for a healthy and attractive living environment. The foundation of the tiny house project lies on the pillars of freedom, quality and independence. The house appeals to these important values that apply to one- and two-person households. Their definition of these values are translated into a warm, homely design that is highly appreciated.

It is a proven concept and has amply demonstrated its value in more than 15 locations in the Netherlands. In cities, village centers, but also in peripheral areas. In all cases, the neighborhood got socially and visually enriched.

Figure 1: Section of the tiny house

Technical structure

The supporting structure of the Heijmans ONE consists of a laminated solid wood structure on the longitudinal side of the facade and the roof. Two steel portals are present around the front and rear facade, complemented by a steel frame around the first floor. The structure is supported by four stelcon plates, which are positioned at four corner points under the house at the level of the end walls. The floors consist of spruce beams with wainscoting.

The longitudinal walls and sloping roofs are realized on the outside with sandwich panels with trapezoidal profiles, including the necessary fittings and profiles. The end walls are finished with thermally modified wooden panels. The insulation values of the first floor, facades, and roof sections comply with the building regulations for temporary buildings (approx. 5.0 m²K/W).

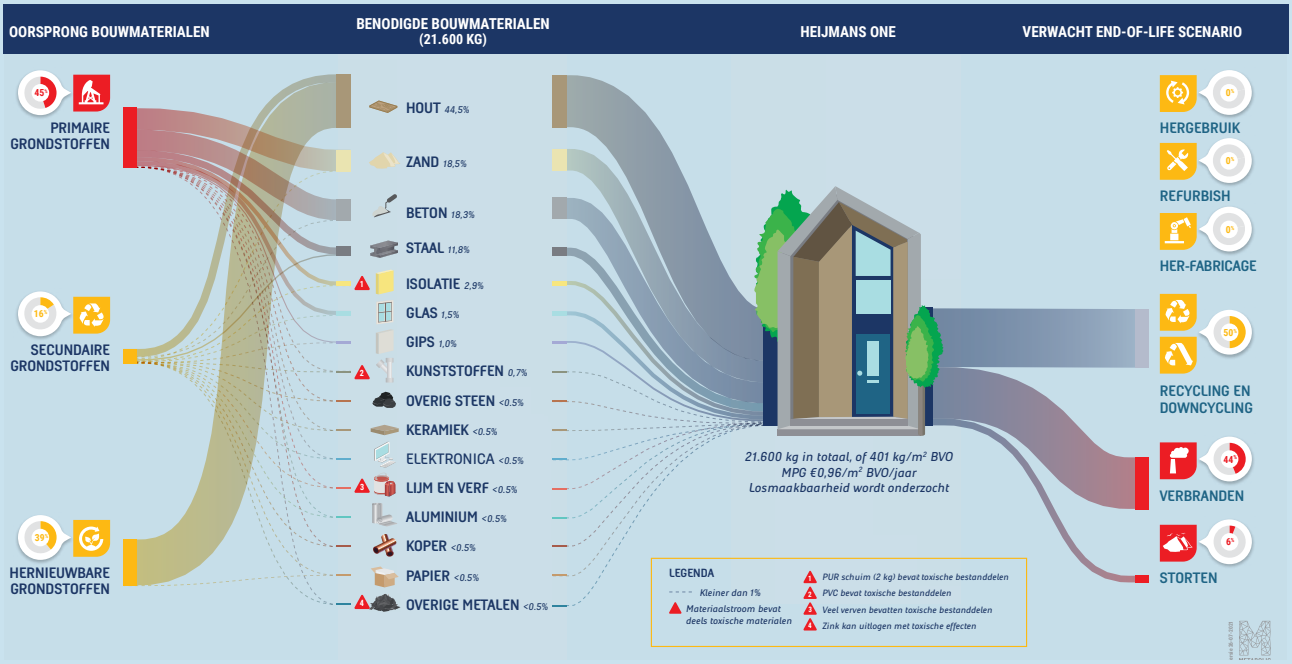

Figure 5: Building materials used for the building

In the house, there are interior walls around the kitchen, meter cupboard, bathroom, and technical room with a wooden frame with cladding. In figure 2, a section of the building can be seen, which shows these interior aspects.

A mechanical WTW ventilation system provides the air conditioning of the tiny house. It mechanically conducts fresh air from outside in and polluted air from inside out. The dwelling is comfortably heated by infrared heating. This represents the perfect way to heat homes with such a large void. Infrared heating directly heats objects such as walls, floor and ceiling. There is no gas connection in this type of tiny house; this house is all-electric.

Construction process

The Heijmans ONE is built using a standardized prefabricated production process. Transport and installation are easy to organize because of the smart design realized in 2 two-modules and the light structure. Figure 3 shows the sizes of the modules, where figure 4 shows the placement of the building components. The connection to water, electricity and sewage can be realized within one day.

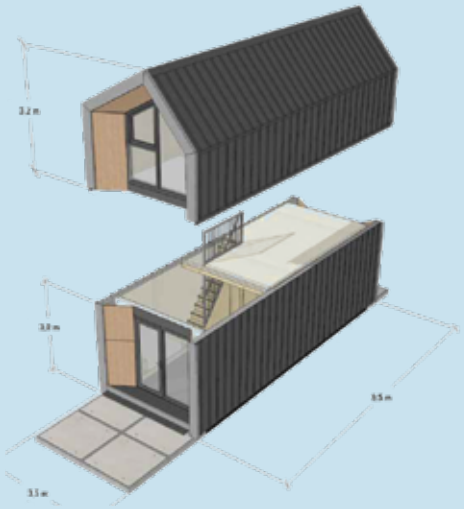

Figure 2: Dimensions of the structure

Because this type of house has a temporary structure, it may stand in the same place for a maximum of 15 years. It is possible to deviate from the zoning plan if a location does not have residential zoning. Thus, the dwelling can be temporarily placed on private land or on land made available by the municipality. The lifespan of the structure is 30-40 years so that after the first use, the structure can be reused at another (temporary) location.

Sustainability

The dwelling is well insulated and consumes little energy due to its small floor area. The house is well suited for the application of PV panels so that almost 60% of the required energy is supplied by the house itself.

In addition, the tiny house is made of sustainable materials that require little maintenance. Heijmans aims to use 100% sustainable wood. Sustainably produced PEFC wood is used for parts of the cottage for which no FSC-certified wood is available. By using wood, only less than half of the materials are obtained from non-renewable, primary raw materials, see figure 5. The dwelling has a Detachability Index of 0.63 and is thus above the Excellent level of 'the New Normal' of Circle City. This means that not only the house is reusable, but also the building products used in the Heijmans ONE. ◄

Figure 3: Placing of the modules

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Passion for a brighter world

Royal HaskoningDHV is a worldwide independent engineering and project management consultancy company. While our head office is in The Netherlands, we have a strong presence in the United Kingdom, South Africa and Indonesia. Approximately 6000 colleagues are working from around 100 permanent offices in over 30 countries.

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Michiel Visscher, Structural Design Engineer

royalhaskoningdhv.com

By: Cement
Knowledge platform about concrete structures

Building pit with freeze frame
At the Amsterdam Central Station, a new stairway was built under the forecourt (Noord/Zuid lijn) for a connection between train and metro. This connection is located directly above the existing zinc tunnel element of the metro. Therefore, the space was very limited. In addition, the sand package on top of the tunnel was not to be removed too much to prevent it from floating up. For these reasons, it was decided to create a construction pit using freezing.

The freezing was done by means of freeze lances installed from the floor of the Cuypers Hall to just above the roof of the zinc tunnel element. After excavation within the 4 m thick freeze walls, see *Figure 1*, the subfloor and the walls of the staircase were made. A major risk of the freezing body was the influence on the existing concrete structures. Due to the one-sided cooling of both the roof and the wall, a shortening occurred on one side of the cross section. As a result, not only did a certain degree of curvature occur, but also tensile stresses in the cooled section due to a possibly non-gradual gradient of the temperature in the cross section. However, due to the limited area of cooling, the curvature was prevented. The resulting stresses were considered per structural section, seeking the most optimal configuration of the freeze lances, with that, a balance between the influence on the existing concrete structure and watertightness was held. Part of the operation was also to make a passage through a diaphragm wall and a prefab wall. The load-bearing function of the wall was taken care of by a lintel, a double HEM 900 profile.

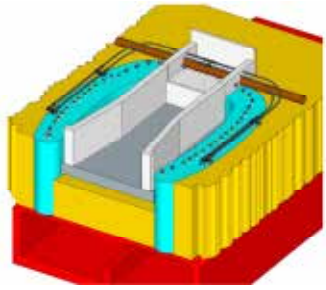


Figure 1: Overview freeze body Cuypers staircase

More about the Cuypers staircase can be found in the Cement article 'Construction pit with freezing body'. This article can be read at www.cementonline.nl/bouwput-met-vrieslichaam (only in Dutch)

Building against, under and on top of an existing Zuidas icon
The latest addition to the World Trade Center in Amsterdams Zuidas district is the 80-meter-high Tower Ten, a renovation and expansion involving construction against, under, and on top of one of the four original office towers. Part of the project is a 10-story addition. To make room for the new building, one of the existing towers was stripped down to the main concrete structure and several components were demolished, including the roof floor and two 12-story high bays, see *Figure 2*. After several variant and feasibility studies, it was decided to add one new central core in addition to the existing core and stability wall. This stands on a two meter thick pile that is poured between the lower two basement floors on the existing beam grid.

Because of the superimposition, the load on the existing concrete skeleton is considerably heavier. Therefore, a part of the piles have been replaced and another part has been reinforced by increasing the dimensions.

Because of the classification in consequence class CC3, a risk analysis was performed and a second bearing path was provided in the design. The choice of cast-in-place concrete structures and continuous steel beams suspended over several fields from prestressed wide slab floors, incorporating tension bands, makes it a robust main supporting structure with good structural cohesion.

More about the expansion of the World Trade Center with Tower Ten can be found in the Cement article 'Building against, under and on top of an existing Zuidas icon', available at https://www.cementonline.nl/bouwen-tegen-onder-en-op-een-bestaand-zuidas-icoon (only in Dutch) ◄

Figure 2: Stripped main supporting structure World Trade center

TimberCore Modules – solving the housing crisis

By: Han Krijgsman
Structural Engineer at ABT

The TimberCore Modules construction method (in Dutch: HoutKern Modules) is a unique construction method consisting of modular timber 'building blocks' built quickly, in a sustainable way, and with low emissions.

The Netherlands is facing a significant challenge in the construction sector. The housing shortage is high. Until 2030, there will be a demand for approximately 800,000 – 1,000,000 good and affordable homes. At the same time, building requirements are becoming increasingly strict. CO_2 and nitrogen emissions in combination with stricter legislation and environmental regulations result in great complexity in project development. The international construction sector is one of the largest CO_2 emitters (responsible for 38 percent of global CO_2 emissions). It will have to play an essential role in making society more sustainable in the coming years.

The TimberCore module has been developed as a solution for the Dutch construction situation. The construction concept combines two sustainability concepts: the use of biobased material and a modular construction technique.

What is unique about the TimberCore construction method is the way the modules are connected. The modules consist of a wooden floor of CLT and load-bearing laminated timber columns. The walls of the modules are not necessary for the stability of the structure, which creates considerable flexibility in design options. Modules can be easily linked to larger spaces.

Figure 1: TimberCore modules in HEKO factory

The modular construction of units with a width of 3 to 3,5 meters and a length of 7 to 13 meters makes it possible to realize a wide variety of housing plans and housing types. The possibility of application ranges from small studios for students to two-, three- and four-room apartments to larger public spaces such as school buildings, hotels, and offices.

Another option is to add an extra layer of TimberCore modules to existing (concrete) buildings. The TimberCore module is four times lighter than a concrete module. The low weight makes it easy to place the modules on top of existing buildings without requiring significant changes to the existing structure and foundation.

Figure 2: Floriade Pavilion

The TimberCore construction method is a circular concept: prefab construction ensures a reduction in emissions, a shorter construction time, and a lower cost price. This makes it a particularly sustainable and flexible way of building. The TimberCore modules can be disassembled so that the TimberCore modules are suitable for a temporary structure, and the modules, the components, or the material can be reused (circularity).

Figure 3: Energy hotel

The HoutKern modules are built prefabricated. Scaling up production lowers costs, as do standardization, predictability, and efficiency. Controlled conditions in the factory ensure increased quality and a decrease in the percentage of failure costs. Building services, bathrooms, etc. are built-in and are plug-and-play ready after installation of the module. The fast and cost-efficient construction method has a favorable effect on both the investment costs and the operating costs of the homes.

Together with the Noordereng Group, ABT, as part of Oosterhoff, has developed the concept of the TimberCore module. The concept is in the final stage of development; the first project is the Floriade pavilion, see *Figure 2*, to be finished end of 2021. The pavilion is followed by the Energy hotel in Ede, see *Figure 3*, which will start in 2022. ◄

Remountable dwellings in Hillekensacker, Nijmegen

Affordable Circular Construction

By: Croes Bouwtechnisch Ingenieursbureau

The current housing situation in the Netherlands presents us with many challenges. A growing shortage of (affordable) housing urges us to respond quickly by speeding up new developments. If we do not take action, many people will be limited in their opportunities and, for example, be forced to live with their parents for longer.

The current housing situation in the Netherlands presents us with many challenges. A growing shortage of (affordable) housing urges us to respond quickly by speeding up new developments. If we do not take action, many people will be limited in their opportunities and, for example, be forced to live with their parents for longer.

Perhaps an even bigger challenge is the fact that we need to preserve our planet and its resources. There is a growing awareness among people to think about their way of living and how to minimize their environmental footprint.

We are facing two major challenges which, at first, seem to conflict: major new housing developments versus reducing the depletion/exhaustion of natural resources. However, the traditional way of building needs to change to meet both challenges.

Catching up with the current housing shortage will remain a challenge for a long time, and the materials used in construction are often reduced to waste at the end of a building's life cycle. It is, therefore, important that new building methods realize a reduction in both development time and CO_2 emissions. Many suppliers and traditional builders need to adapt to be part of this transition.

We are already familiar with the use of prefabricated components. However, compared to other industries, many things at the building site are still very labor-intensive. LEAN manufacturing might not be the first thing one thinks of in construction. To achieve this, the building process should increasingly take place in off-site industrial environments. The activities at the building site will consequently be more related to assembly and less to traditional masonry or concrete pouring. This change is a small step but achieves great results: producing components in a way that they can be easily dismantled and reused. Permanent in-situ connections should therefore be avoided.

In Hillekensacker (Nijmegen), several progressive parties have met the challenges with the project 'Three Remountable Dwellings'. The main supporting structure is essential to the concept of off-site industrial production. The structure consists of prefabricated concrete partition walls and hollow-core slab floors. These days, floors have numerous functionalities (e.g., vertical load transfer, horizontal stability, electrical wiring, plumbing, heating, and aesthetics). These functionalities will not be embedded in concrete but will remain detachable. Therefore, the pipes will not be cast in, anchors will be used for structural connections, and the screed will be a separate application so that it can be easily removed at the end of the building's lifespan.

Figure 1: Hillekensacker Nijmegen Visualisation

The off-site industrial (workplace) approach shortens the construction time. The system of quick assembly will be applied to all components, including the walls and roof. Completely finished components will be placed with only the joints needing to be assembled on-site. Scaffolding is unnecessary. The anchoring is designed to be accessible from the inside for disassembly. The use of adhesives, sealants, or polyurethane foam (PUR) is excluded to keep the different materials 'clean'. This approach essentially changes the structural details. As a result, the engineering should be more precise to achieve a sufficient seal for the acoustic and thermal requirements. In the end, this results in a reduction of failure and construction costs, which is beneficial for solving the housing problem. It is a necessary evolution from a traditional building process towards an industrialized system. ◄

croes
Bouwtechnisch
Ingenieursbureau

How structural engineers can impart quality

Living Green 70 meters Up

By: ir. Lars Croes
Structural Engineer at Adviesbureau Tielemans

The goal of one million houses built within ten years in the Netherlands equals an increase of roughly 15.000 houses in Eindhoven alone. An increase in the density of our city is a big focus. We see that previous hubs of industrial productivity, like Strijp-S and the Campinaterrein (now "De Caai") are now becoming gentrified. The developments in Strijp-S have resulted in a unique area where there is a large concentration of culture and living space intertwined.

Housing corporation Trudo has played a large role in the dynamic development of this area. Housing is being created in two ways. Firstly, the characteristic Philips buildings are renovated, like the well-known Anton&Gerard, Philips Bedrijfsschool, and het Veemgebouw. By retaining the iconic aesthetic and using the flexibility of these industrial buildings to create unique living spaces, the housing problem is solved in the most durable way. Secondly, new buildings are constructed that increase the urban density of this area. Buildings like Haasje-Over, Space-s, Blok 59, sixty5, Lux-tower, NEXT, and most recently, the Trudo Tower transform the Eindhoven skyline.

Figure 1: New highrise buildings on Strijp-S

In the past few years, a lot of (semi) highrise buildings have been developed or constructed in Eindhoven as a push to create much-needed housing. In the design process of these types of buildings, being inventive as a structural engineer is of utmost importance. Their specific size results in a high degree of importance of a smart structural concept.

With an increase in urban density comes the risk of transforming this cultural hub into a concrete jungle. Trudo Tower, designed by Stefano Boeri Architetti, counteracts this by creating a literal "vertical forest" with 125 trees and 5,200 smaller plants. In the words of Stefano Boeri Architetti's partner Francesca Cesa Bianchi: "The Eindhoven social housing tower establishes the possibility of combating both climate change and resolving the problem of housing through interpreting the idea of urban forestry."

Figure 2: Facade of the Trudo Tower

As the lead structural engineer in all of the aforementioned projects, Adviesbureau Tielemans strives to create quality with inventiveness. For the Trudo Tower, a flexible facade is designed by means of high-strength concrete columns with high-strength concrete beams looping around the tower. This way, the planters of the tower can be coupled in one of three different ways, resulting in a flexible and organic vertical garden where every housing unit has its own green balcony. This approach to the facade reduces heat stress whilst creating a biodiverse environment that is a worthy green space for the residents. Design aspects like a central core combined with an open facade and a loft-like floor height of 4 meters were chosen to benefit the comfort and quality of life of the end-user as well as future reusability.

As a structural engineer, your participation and inventiveness in design processes will unlock the creativity within the design team. You are not just an engineer but also a designer. By thinking not just of the current building use, but also of long-term housing needs and future demands, sustainability becomes an integral part of solving the housing crisis. As a conscientious structural engineer, you can ensure quality in a project. ◄

High-quality temporary housing

Not for Eternity

By: ir. Mic Barendsz
Project manager at Bouwen met Staal

Temporary housing can be realized quickly and is an excellent short-term solution for the current housing shortage. Until now, temporary houses are still rarely built. That is about to change.To alleviate the current housing shortage in the Netherlands, approximately one million houses need to be built. With an average of 75,000, the shortage will cease at the earliest in 2035. Qualitative temporary houses are an excellent short-term solution. Prefabrication offers increased construction speed, fast delivery, and quick access by inhabitants.

No alternative

"What else can we do?", Yasin Torunoglu of alderman Housing in Eindhoven, is quoted in the magazine of Eigen huis, an association representing 700,000 homeowners in the Netherlands. The municipality needs an additional 5000 houses in five years. A single residential project takes seven years from planning to final delivery. "We cannot tell residence seekers to come back in seven years."

Therefore, 700 temporary houses will be realized north of Eindhoven in the hamlet Te Veld in the upcoming two years. Other municipalities also take refuge in temporary housing to relieve the short-term needs of the housing shortage.

Figure 1: Domoticube

Temporary, yet of good quality

Throughout the project, no cutbacks on investments costs were made to ensure good comfort for the inhabitants and low maintenance costs for the homeowners and housing associations. A combination of industrial and biobased building products fit for their application guarantees good quality and comfort of living. Smart design and lean and mean production with lightweight materials achieve low environmental impact. The result is fast, good, sustainable, economic, and comfortable housing for millions.

Figure 2: Inside view of the Domoticube

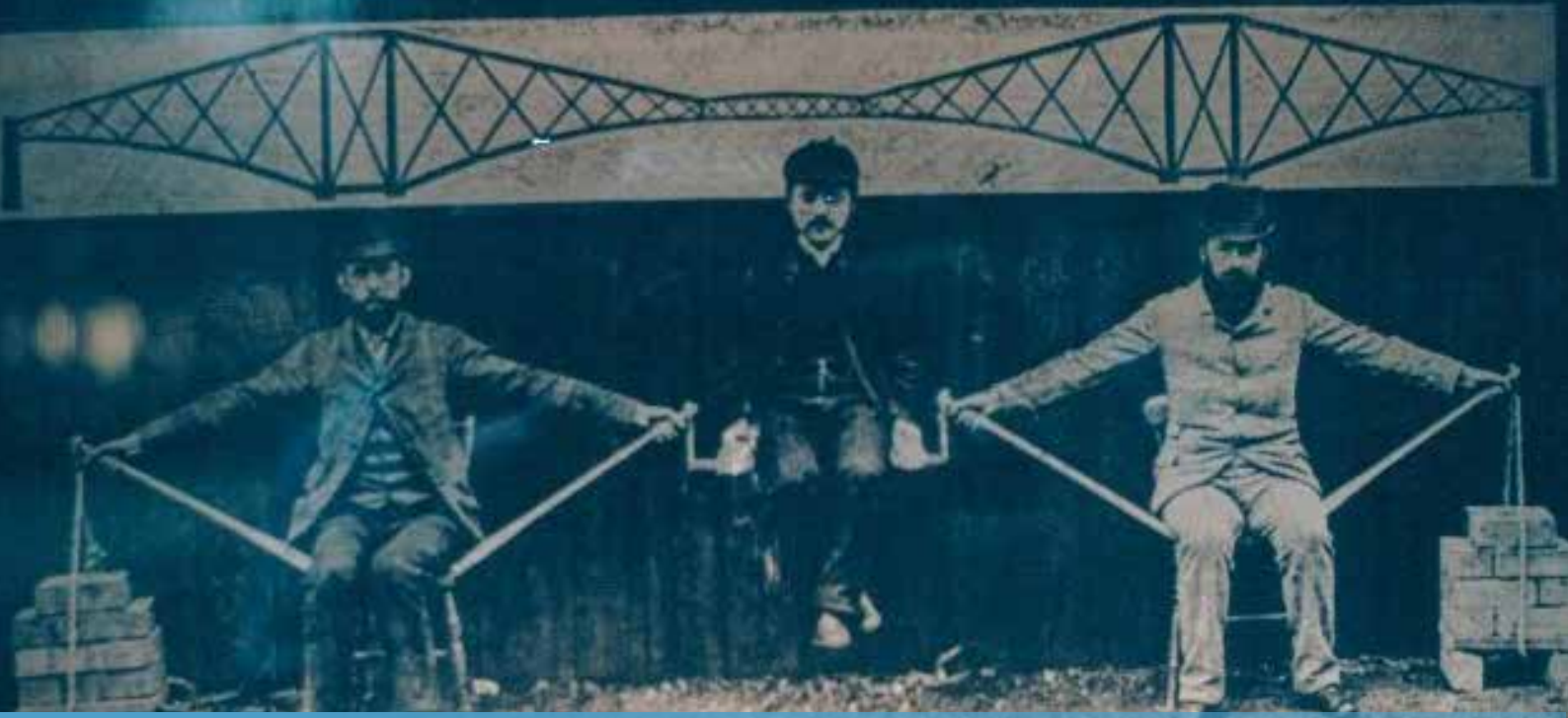
Where does steel fit in?

Steel is a prefabricated, low-cost, slender, lightweight, load efficient, and indoors maintenance-free construction material. Furthermore, it enables a structure that is easy to assemble and disassemble. Concepts for temporary housing make use of steel for the structure, floors, and connections, and occasionally also for cladding, roofing, and window frames.

Domoticube

A relatively new Dutch supplier of high-quality temporary housing is Domoticube, see *Figure 1*. Domoticube makes use of standard modules of 6mx6m or 7.2mx7.2m, expendable with 1.2 meter. The structure of light gauge steel framing offers a very low dead weight and high strength. Walls are assembled in the workshop with thermal insulation, gypsum, and timber board enabling good (mass-spring-damper-system) sound insulation, fire resistance, and diaphragm action. Moreover, the modules are delivered on-site entirely with glazed window frames, plug and play installations, and wall sockets. The walls are placed on a hot rolled steel ring beam directly connected to the concrete screw foundation piles. The interior can be seen in *Figure 2*. Strong points of Domoticube are:

- Lightweight, yet high comfort (sound, fire-resistance, and floor stiffness).
- Modular, allowing design flexibility in all directions.
- Economic and fixed price offering affordable housing.
- Industrial and prefabricated, guaranteeing faster construction and higher quality.
- Limited use of materials resulting in low environmental impact.
- Dry connections allowing easy assembly, disassembly, and, if necessary, reassembly. ◄



How does time change structural engineering?

Previously on the KOersief

By: ir. Michiel Visscher
Structural Engineer at Royal Haskoning DHV

In 'Previously on the KOersief', companies that have published articles in previous editions are asked to write about changes in their company over the years. One of the companies that has written articles in previous KOersief editions is Royal Haskoning DHV. They wrote, for example, an article about a bicycle bridge in Katwijk and the Noord/Zuidlijn in Amsterdam.

Structural engineering remains structural engineering: it is about putting materials together to withstand forces of gravity, wind, and water. Futhermore it should provide sufficient stability, strength, and safety. It is about finding ways to create spaces and structures that our clients need for their purpose. That is what engineers do and what our predecessors and successors will have in common. How engineers do this work, is always subject to change depending on time, context, and culture. It is also defined by the tools we use, the knowledge we have, how we communicate, and position ourselves in the market or society.

Twenty years ago, Royal Haskoning DHV (RHDHV) did not exist, although we just celebrated our 140th anniversary! Our structural engineers were working at different companies (among others Royal Haskoning, DHV, D3BN, Corsmit, AIB, and others…), and due to takeovers and merges, the current company grew. Twenty years ago, I was graduating at the University of Technology Eindhoven, experimenting with a sustainable design of high-rise buildings. I had dreams of improving the world; I was eager to learn engineering in a broader context. My wide interest even caused a struggle to define myself as an engineer or architect.

Today RHDHV has various groups of structural engineers active in different markets (buildings, infra, maritime) embedded in multiple multidisciplinary teams. The structural engineers originating from many companies have grown into a dynamic, interconnected group of many nationalities, various skills, and different backgrounds. They find each other at the basis of shared interest, experience, and inspiration. As for myself, today, I still have my dreams to improve the world, and I am still learning every day to be a better engineer than I was yesterday. The culture at RHDHV and the holistic, integrated design attitude I developed at TU/e allowed me to find my place and find my strength.
The Feijenoord project (see *Figure 1*) shows how we apply parametric design in a complex, large-scale project: the perfect bowl for the perfect stadium experience. The Karel Doorman (see *Figure 2*) was twenty years ago ahead of its time and is a showcase of sustainable (re)use of materials

Figure 1: Feijenoord stadium: parametric design for the perfect bowl

Figure 3: Non-linear analysis to simulate seismic behavior of masonry

Figure 2: Karel Doorman: 16 new storeys on top of existing building

in both reuses of existing buildings and new buildings/ extensions. In Groningen, we apply advanced non-linear analysis to the dynamic behavior of masonry dwellings under seismic load to predict the actual strength and safety of people's homes as accurately as possible, as can be seen in *Figure 3*. With a forensic engineering approach, we investigate the root cause of structural failures, such as the roof of AZ stadium and tribune of NEC stadium (see *Figure 4*).

Figure 4: AFAS: forensic engineering identifies root cause of collapse

In doing projects like these, we put ourselves in the foreground of the profession. Ever-changing technology and societal context offer the means to get to the results our clients desire. But, it is always the people who make the real difference, people who wish to create, excel, innovate, and be an engineer. We challenge ourselves and each other every day to investigate the task from various angles, discuss, and reflect with the team and the partners involved.

So what is the main difference in 20 years…?
Sustainability: from a topic for softies to a very urgent global issue reflecting the built environment in an energy transition and different ways to (re)use materials.

Technology: internet, cloud solutions, data-driven design, parametric design, AI, and 3D/4D modeling enable both the design itself and the collaboration in design processes. We can even still do our jobs working from home in a pandemic.

Information: the amount of information in projects has exploded; software allows us to process this properly. But, the more you know, the more you discover how little you know. So, never forget the human scale, stay open and curious and prevent information paralysis.

I am proud to be a TU/e and KOers alumnus, and I hold dear memories of my time as a student. Since life-long learning has become vital in the ever-changing world, you never really stop being a student. What changes is that you gain experience, so the job gets more manageable in some aspects. When you master things, your influence will grow, and you will also support others. But, your learning never stops, and it comes with fall and rise. For the past twenty years, my path has been a bumpy road, and frankly, I expect nothing different for the next twenty years. What will be your path? ◀

Marc Nijenhuis

The Experience of ...

By: Marc Nijenhuis
Structural Engineer at Adviesbureau Van de Laar

In January 2021, I graduated from the Eindhoven University of Technology as a structural engineer and with that, my search for the next challenge started. Having already finished MBO and HBO in building engineering, I knew that I wanted to work at an engineering firm where I could apply the theoretical and practical knowledge gained during these different studies and internships. As I have always been interested in construction engineering and detailing, I preferred a job where I could apply both of these interests. With this as a starting point, the search for a job began.

During my board year at KOers, I came in touch with different structural engineering companies. This helped me to get to know possible employers and to orientate on the job market. I had the privilege that there was a high demand for employees, at the time of applying for a job. This allowed me to apply for job interviews at companies that I thought suited me best and where I would find the most fun in my future work. For the companies I had an interview with, I contacted some former students of Structural Engineering and Design who were working there. They told me about their working days and their activities and tasks. After some very nice job interviews and conversations with familiar employees, I knew I wanted to work at engineering firm Van de Laar in Eindhoven. Their wide variety of projects and engagement with the realization and construction phase of the projects were very appealing to me.

Van de Laar is involved in all kinds of projects, from small new houses to large utility buildings, and from small renovation projects in homes to renovations of theatres and big hotels. Their role in these different projects varies a lot. Apart from being mainly a structural engineering company, Van de Laar also often acts as the coordinating structural engineer during the execution phase. As the main structural engineer, we are involved in the project from the start and actively participate in the design team. As the coordinating structural engineer, we are working

Figure 1: The extension of the Catharina Hospital

for a contractor and ensure that the designed structure is also feasible in the building phase. This also includes finalizing the design of the structural details. For example, we design joints of the structure and, if necessary, design and calculate structures for temporary supports during the execution phase.

For the past half year, I have worked on a variety of projects. I started with some smaller projects, for example checking existing buildings for the possibility of placing solar panels. In such projects, we start with collecting the necessary information about the existing building and study the structure of the building. Based on the existing structure of a building, the working strategy for the examination is determined: in the case of concrete floor slabs, it is often possible to make adjustments to the original characteristic

Figure 2: The connecting hallway between the new and existing buildings

load combinations. However, for buildings with timber or steel sheet roofs, completely new calculations are usually required. This makes the work for every project unique, and project-specific solutions are often necessary.

One of the first bigger projects I got involved in is a new school in Arnhem, see *Header image*. In this project, we are the main structural engineer and have been actively involved since the start of the design process. Just after the first preliminary design was finalized, I got involved as the structural engineer in the construction team. The team is also composed of the project manager, architect, installation technical advisor, and building physics engineer. What I like in a design team is the workflow and communication, which allows us to give our input from the start of the project and ensures that the project will fit all requirements. Every two weeks, we have a construction team meeting. This allows me to learn about all aspects involved and to follow the progress of the project.

Another project I got involved with is an extension of the Catharina hospital, see *Figure 1*, which is one of the many projects by Van de Laar around Eindhoven. The new building mainly consists of a structure of concrete floor slabs and columns. Stability is guaranteed by concrete walls and one steel bracing. In addition to the construction of the new building, this project presents many challenges in the transition between the new building and the existing hospital. The biggest challenges are designing the foundations and ensuring that all buildings are structurally independent: the new building and connecting hallway need to be stable by themselves and must have their own foundation. Also, the connections between the buildings need to be water- and airtight. In the connecting hallway between the new building and the existing building, see *Figure 2*, a steel structure with fixed joints and concrete slabs is opted to guarantee stability and avoid wind bracings in the open glass areas.

Figure 3: Renovation of the former glass lab of Philips

Furthermore, I am regularly involved in renovation projects. One of these projects is the renovation of the former Philips Glass Lab on Strijp-T, now referred to as building TY, see *Figure 3*. I find it very satisfying to see that an old building, which has already been used intensively, is given a new lease of life, see *Figure 4* and *Figure 5*. This project involves more than just designing a new structure. In this renovation, we are dealing with monumental parts and materials within the building. To preserve all components, you sometimes have to think out of the box to find an efficient solution. For example, steel girders are added to support the future concrete floor and glass facade that replace the old roof plates in the ridge of the building. These steel girders are placed on top of the existing steel trusses to retain these trusses and keep the details visible from below. The same procedure is followed for a new roof construction that covers the existing monumental "Bimsbeton" roof plates. This solution separates the added structure from the existing roof plates and prevents possible damage to the roof plates when solar panels are added. Currently, the building has been completely stripped down and a new shell is being built around the building. To coordinate all aspects of the design in an integral way, we have a lot of contact with the contractor and various suppliers of building components.

Figure 4: Existing structure of building TY

Figure 5: Impression of the renovation plans

What I like the most about my job is the variety of projects and the different roles I have within the various projects. I come in contact with the clients, architects, or the construction company, and together, we work toward a fitting and thoughtful solution. Within Van de Laar, we have a diverse team of over 30 people, from starters to seniors and from structural designers and engineers to modelers. We work in different teams on every project and ensure all facets and disciplines are incorporated into our team to bring every project to the desired result. ◄

Adviesbureau Tielemans

Internship

By: Iris Cornelissen
Student structural engineering and design

In the period from September 2020 till April 2021, I did an internship at Adviesbureau Tielemans in Eindhoven. The entire internship was done from home due to COVID-19 restrictions. Via Teams, I got in contact with my colleagues daily. I would have liked to feel and experience the ambiance at the office, since this was also one of the reasons I wanted to do an internship. Even though I could not experience the ambiance at the office physically, I experienced it online. All colleagues were open to meeting with me and teaching me things.

The internship started with getting to know and learning to work with Technosoft, the program which is used a lot at Tielemans. When Technosoft was mastered, I got my first project. I did a lot of internal renovation and extension projects for residential houses. Every project was different and had its own difficulties. Furthermore, together with a colleague, I wrote a report concerning cracks that were observed during construction. For this project, cracks were measured on the construction site, and an analysis was made about the cause of these cracks and whether or not these had an influence on the structural safety.

I learned a lot about combining theory with practice by doing these projects. By asking a lot of questions to my colleagues and seeing more and more projects, I got a better understanding of the practical aspects in the field of structural engineering.

I also got the opportunity to have contact with the clients of some of the projects I did. Communicating with the client is an essential aspect of being a structural engineer. I was happy that I got the responsibility from my supervisor to do this myself for my projects.

Furthermore, one of the goals of the internship was to go to the construction site. In the internship period, I went with different colleagues to different construction sites. It was educational to see how the designs and calculations done at the office became a reality. The chosen profiles and dimensions of the structural elements were seen in real life, which was also informative. It came to my attention that a woman on the construction site was rare, especially as a structural engineer. I got a lot of comments on the fact that I am becoming a structural engineer. Still, the people were interested and enthusiastic about the fact that more and more women are interested in the field of structural engineering.

At the end of the internship period, it came to my attention that meetings are also a big part of the job. I joined one meeting for a project from my supervisor. This was an interesting meeting since all parties involved were at this meeting (sound, light, air, architecture, structural engineers, installations). The other meeting that I accompanied was especially a meeting where the topic was structural design. The main discussion in this meeting was the use of prefab or in situ concrete for the building. Together with the contractor, structural designers, and the client, conclusions were drawn.

The internship was a very educational period, where I learned a lot about all aspects of being a structural engineer in the company of Tielemans. I still work one day a week at Tielemans as a junior-structural engineer. ◄

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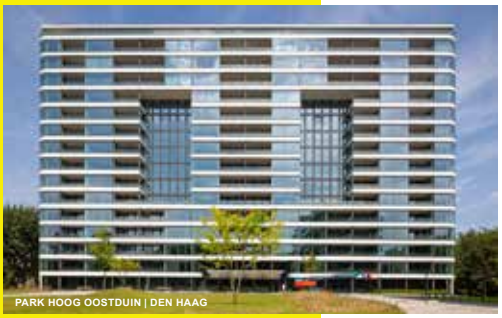
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GROTIUS | DEN HAAG

KOers Abroad

Studying in Austria

By: Jordy van Gorkum
KOers member

My name is Jordy van Gorkum; as an Architecture student, I have always been interested in traveling. That is why I thought it would be great to live abroad for a while, and an Erasmus experience is the perfect opportunity for this. So, since September, I have been studying Architecture at the Graz University of Technology in Austria.

Graz is the second-largest city of Austria and is slightly larger than Eindhoven, with almost 300,000 inhabitants. Of these inhabitants, roughly 45,000 are students, so it really is a student city. Graz is best known for having the largest medieval city center in Central Europe. Because of this, you can find beautiful historical architecture throughout the historical center. My dorm is only a five-minute walk away from there, next to the Stadtpark.

One of the reasons I chose to go to Austria is the Alps: Graz is located at the foot of the Alps. Even in the city center, there is the Slossberg on which a castle and a clock tower are built. The nearest higher mountain is Schöckl, which is located about half an hour from the city. On the weekends, I often go hiking. The beautiful views at the top always reward the challenging climb up (see *Figure 1*). Besides hiking, I spend my free time with people I meet through the Erasmus Student Network. Every Wednesday, they organize a drink for international students studying in Graz. This is an ideal place to meet new people from all over the world. With these people, I go to parties, bars and sometimes we also cook and sport together.

Figure 1: Schöckl

At Graz University of Technology, I am taking some interesting courses, such as the "History of the City" and "Architecture Photography." In addition, I am also doing a Masterproject in a group of two. The location of the project is in Munich, in the suburb of Aubing. The assignment is to transform a vacant industrial site into a residential area where culture and sports meet each other. At the beginning of the project, we had a trip to Munich with the project group, where we visited various inspiring locations and the project site. The week was very intensive, with a presentation at the end entirely made with analog means such as a scale model and sketches. The project is very open in its execution, although there is a requirement that all existing materials on the site must also be used. The site consists of an existing ground floor of a warehouse and asphalt pavement. Because of this, we have to develop new ideas on how to reuse or recycle materials.

Our idea for the project is to create a composition that is based on the relationship with the surroundings. The volumes are sometimes raised, allowing various sports and cultural activities to take place underneath the buildings. Think, for example, of a partially covered skate park, wall climbing, or a movie theatre. Besides this, the idea is to design an organic landscape of hills, which can also be used for different sport and cultural activities, such as a tribune or picnic area.

So far, I am really enjoying my time here. I have learned a lot and met many people. With only two months to go, I am already looking forward to the Christmas markets, hiking in the snow, or maybe even learning to ski. I really would recommend everyone to do an experience abroad as well; the experience is definitely worth it! ◄

Master's Thesis

Parameter Study to Improve Sustainability of Concrete High-rise Structures

By: Tom Diks
Supervisor: Prof. ir. S.N.M. (Simon) Wijte, R. (Rijk) Blok, S.C.H (Sander) Vernooij

One of the most significant challenges of our time is the major building task of offering a home to all people in the Netherlands. Living in the city continues to be increasingly popular, and this is not expected to slow down. However, most cities have limited space and therefore focus on densification nowadays. A result of this is that more and more towers show up in cities and get higher. Besides the build-more-houses challenge, there is much to be done on the environmental impact of these buildings. Unfortunately, these concrete giants belong to one of the biggest environmental polluters. Enough reason to do some research into making concrete high-rise buildings more sustainable. This research was conducted together with the chair of sustainment of structures and BAM Advies & Engineering.

Parameter study

A parameter study was chosen for this research. This means that research has been carried out per high-rise building parameter to determine how significantly this influences the environmental impact. An overview of the investigated parameters with the corresponding research domain can be seen in *Table 1*. This is done for several different bracing systems done at different heights. A default design has been drawn up for each of these combinations in which all parameters are constant. Then each parameter is individually varied over a certain domain. Each generated variant is checked for maximum compressive strength in the ultimate limit state (ULS) and for maximum deformation at the top in the serviceability limit state (SLS). Each variant is varied in concrete class and reinforcement ratio. The variant that meets the ULS & SLS with the lowest environmental impact is selected. In this way, a trend line can be drawn up per parameter on the influence of sustainability.

Parameter	Minimum value	Maximum value	Deafult value
Core width [m]	10.0	16.0	13.0
Average core thickness [m]	0.25	0.50	0.40
Ceiling height core [m]	2.50	3.50	2.65
Cross-section rate core [%]	0	50	25
Fragmentation core [-]	2	10	3
Facade width[m]	18.0	35.0	28.0
Width window facade [m]	1.0	2.5	1.6
Height window facade [m]	1.0	2.5	1.6

Table 1: Parameters with research domain and default value for core and facade

Research boundaries

Terms such as sustainability and high-rise buildings are broad areas of research. Therefore, choices had to be made on what to focus on. Regarding sustainability, the research looked purely at the environmental impact of the embodied carbon released during the production process [phase A1-A3] of the materials concrete and reinforcement of the bracing system. In terms of high-rise buildings, only concrete high-rise buildings between 100 and 200 meters were considered. The foundation is not taken into account, and the tower is modeled in a fixed connection. To compensate for this, a more stringent deflection requirement of 1/750 has been applied. Finally, three different bracing systems are investigated: the core, extended core and facade tube.

Method

Thousands of high-rise designs were calculated for the study. That is why a lot of effort has gone into a fully automated parametric structural analysis. Rhino+Grasshopper was used

for this. From Grasshopper a geometry of the bracing structure is created. Also supports, a mesh and (wind)loads are conform Eurocode and national annex. An important part is determining the bending stiffness (see next paragraph). When all necessary structural information has been determined, a finite element analysis is performed. Karamba 3D was used for this (see *Figure 1*). All variants were calculated using a first-order linear-elastic theory.

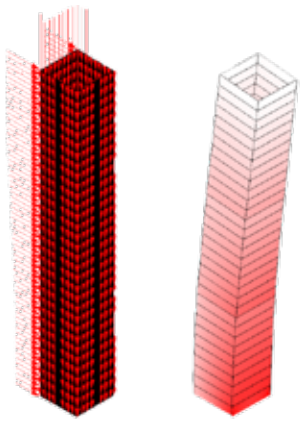

Figure 1: Default design core model view (left) and stress pattern (right)

Bending stiffness

The core and extended core are assumed to behave as one rigid cross-section. This means that plane sections remain plane. This means that an M-N-κ diagram is allowed to be used. For reinforced concrete this means that the four characteristic points (cracking, yielding, end of elastic concrete, and ultimate) are determined. Based on the characteristic moment in the cross-section, a global bending stiffness EI can be determined as follow:

$$EI = \frac{M}{\kappa}$$

Because each floor can have a different normal force and cross-section, each floor's bending stiffness is determined. To automate this process, a python script has been written that determines the bending stiffness in a few milliseconds using the M-N-κ principle. The four characteristic points are iteratively determined by finding equilibrium in the vertical direction. An example of an M-N-κ diagram of a story is shown in *Figure 2*.

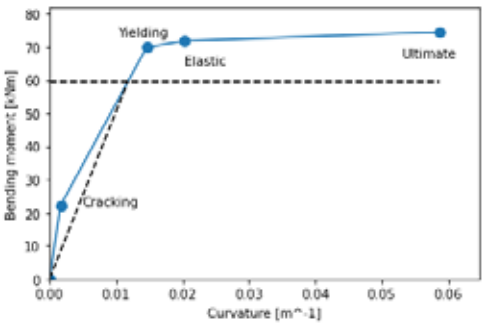

Figure 2: Quasi-linear determination of bending stiffness

Quantification of sustainability

Once the bracing system meets the structural checks, it is known how much concrete of which concrete class is needed and how much reinforcement is needed. The environmental impact of these required materials is determined for each variant. This is done based on embodied carbon expressed in CO_2-equivalent. This was chosen because CO_2 has the greatest impact of all environmental impact indicators (EN 15804). In addition, CO_2 is relatively easy to quantify and compare.

Concrete

Concrete comes in many different mixtures. As standard, most mixtures are coarse and fine aggregates, water and binding agents, and admixtures. For the quantification of the embodied carbon, each component was investigated. Additional attention was paid to the binding material, because this has the most significant influence and can differ greatly. By far, the most commonly used binder is cement, particularly Portland cement. For this study, a representative CEM-III/B has always been used.

Reinforcement

Since reinforcement is a homogeneous material, there is much less variation here. For the study, only B500 was used for the analysis. This is the most common material. This reinforcement has a relatively large environmental impact. Because a maximum of 4 percent longitudinal reinforcement is allowed in a concrete cross-section, the total reinforcement volume is limited. However, due to the high emissions, reinforcement is responsible for a large part of the total impact. An overview of all embodied carbon per material is shown in *Table 2*.

Material	Embodied Carbon [kg CO_2/m^3]
C12/15	95
C16/20	95
C20/25	95
C25/30	95
C30/37	102
C35/45	116
C40/50	125
C45/55	133
C50/60	142
B500	22365

Table 2: Embodied carbon per material

Durability

The longer something lasts, the more sustainable it is. It is, therefore, important that a structure can be used for a long time. If you look at the reason for the end-of-life of buildings, it is often not the technical lifespan but another aspect that causes early end-of-life. High-rise bracing structures have little to no flexibility once built. It is therefore crucial that the design choices take into account a future-proof design. Several practical aspects are, for example, the maximum vertical transport capacity that fits in the core. In addition, a small opening percentage with a facade tube and a low ceiling height is often less flexible and therefore not really future-proof.

What's next?

Since the research is still going on, it is too soon to publish definitive results. However, by the time the KOersief 114 is published, I will most likely have finished the research, so do not hesitate to contact me if you would like to know more about the research! ◄

Figures:
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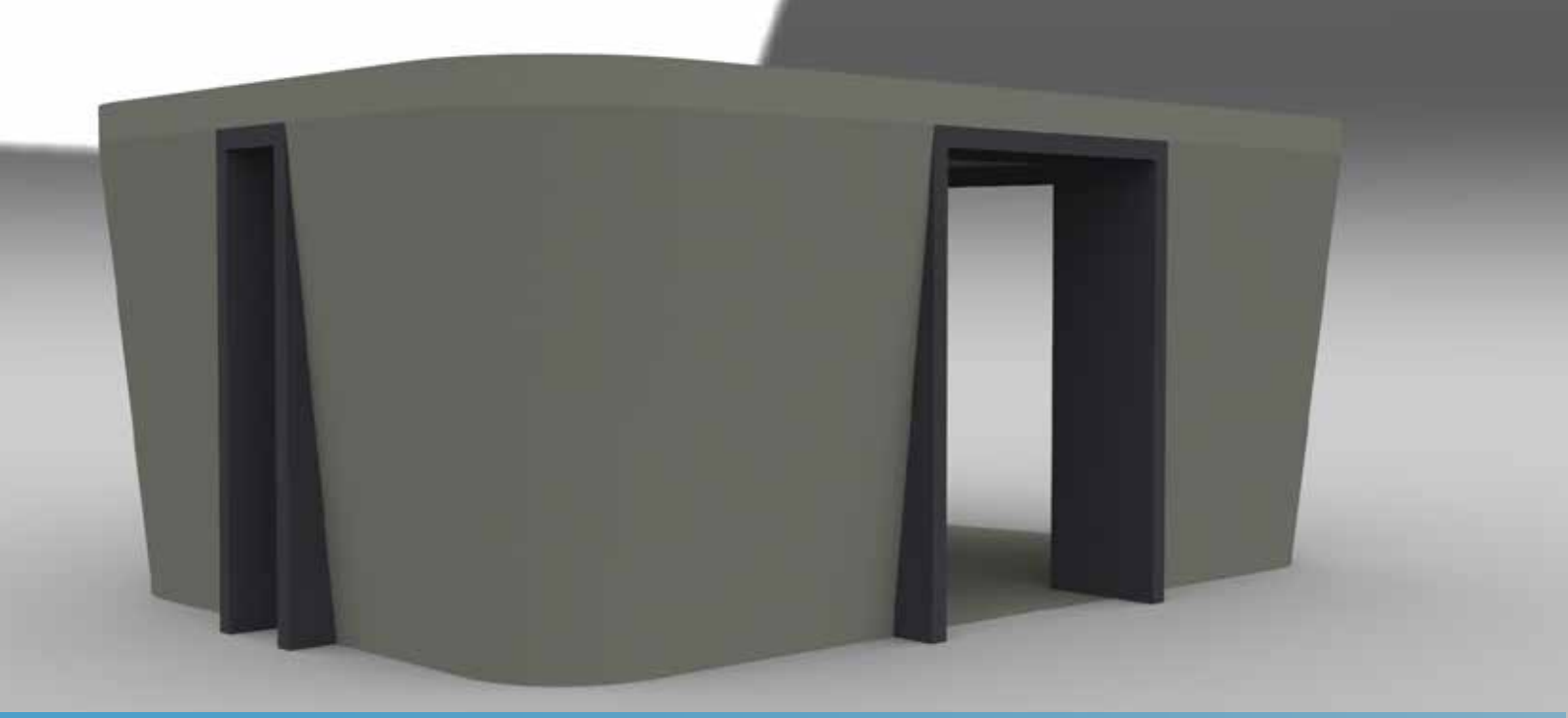

Master's Thesis

Buckling Analysis of Double Leaved 3D-Printed Concrete Walls

By: Olaf Vens
Supervisor: Prof. dr. ir. T.A.M. (Theo) Salet, dr. ir. R.J.M. (Rob) Wolfs, and ir. A.H. (Arjen) Deetman

Concrete is one of the most used materials in the world. It is a very versatile material that allows for structurally simple structures, like a classic beams and columns building. On the other hand, it also allows for architectural pieces, for example the Portuguese National pavilion by Siza or the shell structures from Isler. However, all these structures have the downside that formwork is needed for it to be cast.

Especially architectural structures need formworks that are not reusable, with unique and multi curved shapes. This results in a large amount of waste materials. Constructing buildings with a concrete 3D printer allows for a large degree of form freedom without the need for wasteful and labor-intensive formworks. Besides a lack of formwork needed, a 3D printer also allows for structurally efficient printing. It is possible to place the printed materials there where they are needed. At the moment, one type of optimization is largely used and researched: efficient design through geometry. Efficiently curving planes result in strong elements, as a curved section is more stable and can withstand larger forces before buckling out of plane. Using this optimization as a starting place, there are still large steps that can be taken to optimize concrete printing. Mostly by locally using other types of concrete or by using other sections.

What to analyze

In this study different wall compositions will be analyzed and compared to see what holds of the initials preconceptions about 3D printed concrete. Because it can pretend to be durable, but if you need too much material to make it sustainable, can you still call it as such. To study this, different wall compositions are being analyzed. These types can be seen in *Figure 1*. The first option is a wall printed as is done now. This is to set a benchmark and see whether this might be the best option after all. The second option is printing one leaf with the required thickness to be a load-carrying wall. The idea is that this would require more concrete to obtain the same load-carrying capacity as using both leaves as load-bearing. In order for both leaves to be load-bearing, they need to be connected by foam, bracing, or warm concrete, because it does not have any buckling supports. However, the advantage of this composition is that you

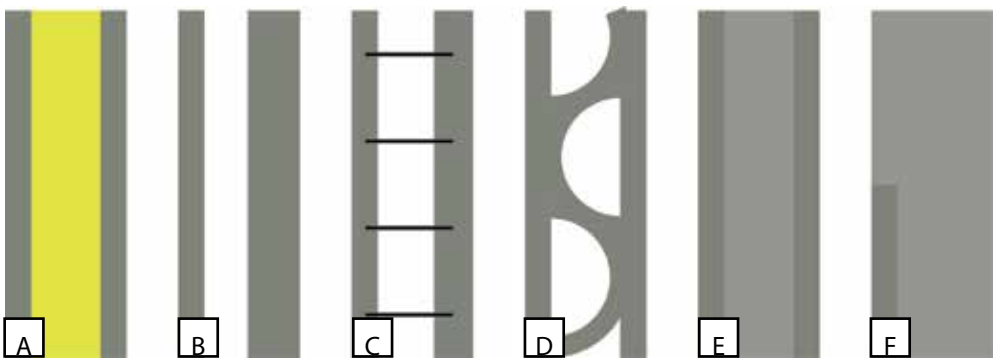

Figure 1 A/F: f.l.t.r.t.b wall as printed now, single load-carrying wall, braced wall with pins, braced wall with printed snake, insulated wall with warm concrete, effective printed strong concrete

only have one type of concrete which can be completely reused or recycled. The third and fourth options both contain bracing. The braces of the third option are pins made from a different material, resulting in smaller thermal bridges. However, this does introduce another material that would have to be separated in a potential end-of-life situation. In the fourth option the brace is a concrete printed snake. Both compositions have the advantage that they support the load-carrying wall for buckling, potentially improving the load-carrying capacity. The last two wall types again are very similar. Both are largely composed of warm concrete, a material not particularly good for load-carrying. However, since all the material is still concrete, the material kan be fully recycled in an end-of-life situation. In all other situations the material largely behave the same as the original wall type.

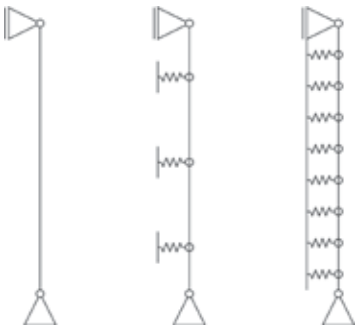

Figure 2 a/c: Structural simplification of wall compositions

How to analyze the different wall types

The main analysis performed on the wall is a buckling check. The way this is calculated differs per composition, but in all cases the results stem from the Euler buckling formula.

$$\frac{\pi^2 EI}{l_e^2} \qquad \textit{(Equation 1)}$$

Using Potential Energy, we can derive the base formula for the standard buckling situation and when it is supported by a finite amount of springs as seen in *Figure 2 a and b*. The formula for an infinite amount of springs, as in *Figure 2 c* is derived by Friedrich Engesser and results in a formula not dependent on the buckling length.

$$F_{cr} = 2\sqrt{kEI} \qquad \textit{(Equation 2)}$$

Continuing with the derivation of the first two simplifications. We start with the normal expression of Potential Energy , with w being the deflection and P the applied load and N_0 = -P.

$$\Delta V = \frac{1}{2}\int_0^l E\,I\,w''^2\,dx - \frac{1}{2}\int_0^l \frac{P}{2}\,w'^2\,dx \qquad \textit{(Equation 3)}$$

This needs to be extended to include the influence of the springs in the total potential energy. This is done by adding an additional term to the formula which is a sum of all spring stiffnesses multiplied by the deflection at the location of the spring cubed.

$$\frac{k}{2}\sum_{i=1}^{s} w\left(\frac{i}{s}\right)^2 \qquad \textit{(Equation 4)}$$

In this extension k stands for the spring stiffness, s for the number of springs, and i is the index of the summation. The next step is to determine the shape function. As in its essence, it still is a system pin supported on both ends a sine function is most probable to be a correct approximation of the shape. This assumption is also supported by Alfutov in the book Stability of Elastic Structures. Therefore, with an unspecified amount of terms, the shape function results in *Equation 5*.

$$w(x) = \sum C_i \sin\frac{i\pi x}{l} \qquad \textit{(Equation 5)}$$

C is a constant and i is the index for the number of terms used in the shape function. Using these formulas, it can be determined at what stiffness the springs can be considered as intermediate pin supports. For the first four situations, the derived functions can be seen in *Table 1*. For more springs, the by now visible pattern can be continued. For each row, there are also buckling forces beyond the point it reaches the classic Euler formula. However, it is chosen to only show the critical forces until this point for easier reading and it is assumed to be known for these cases. From this table, it can be read that for all amount of intermediate spring supports the Euler buckling formula also appears preceded by a factor depended on the spring stiffness.

Implementation of the analysis

The derived formulas then are implemented in a grasshopper model, with which can be checked whether the maximum buckling forces are exceeded. In the grasshopper model the maximum load on the structure is calculated using a plugin that allows the integration of SCIA Engineer to calculate the load on the load-carrying wall. In the grasshopper model the different wall types are all implemented and can thus be systematically checked for which setup the best load carrying capacity is given. With this information, different optimizations can be done. On the one hand it can be optimized just for load-carrying capacity and the least amount of concrete used. On the other hand, a possibility is to implement a small addition to the script and to optimize for something like the environmental impact of the complete lifecycle. In the end, the script can be used to generate a lot of different designs and quickly check whether they hold in terms of buckling and maximum stresses. ◀

0	$F_{cr} = \frac{\pi^2 * E * I}{l^2}$			
1	$F_{cr} = \frac{2 * k * l}{\pi^2} + \frac{\pi^2 * E * I}{l^2}$	$F_{cr,2} = \frac{4 * \pi^2 * E * I}{l^2}$		
2	$F_{cr} = \frac{3*k*l}{\pi^2} + \frac{\pi^2*E*I}{l^2}$	$F_{cr,2} = \frac{3*k*l}{4*\pi^2} + \frac{4*\pi^2*E*I}{l^2}$	$F_{cr,3} = \frac{9*\pi^2*E*I}{l^2}$	
3	$F_{cr} = \frac{4 * k * l}{\pi^2} + \frac{\pi^2 * E * I}{l^2}$	$F_{cr,2} = \frac{4*k*l}{4*\pi^2} + \frac{4*\pi^2*E*I}{l^2}$	$F_{cr,3} = \frac{4*k*l}{9*\pi^2} + \frac{9*\pi^2*E*I}{l^2}$	$F_{cr,4} = \frac{16 * \pi^2 * E * I}{l^2}$

Table 1: Buckling forces with different amount of springs

Thesis update

Design of a Midrise Modular Building System

By: Bart van der Born
Supervisors: Prof. Dr. -Ing. P. (Patrick) Teuffel & ir. A.P.H.W. (Arjan) Habraken

The housing shortage in the Netherlands is currently a hot topic. According to the ministry of Internal Affairs, the present shortage is around 279,000 units *[1]* , which results in high housing prices. In addition to this, the European Union strives to be the first continent that is circular and CO_2 neutral in 2050, making building codes stricter and pushing up the prices of newly built homes even more.

Figure 1: Section of the building system

To solve this issue, the residential building industry needs to increase efficiency. The aim of this graduation project is to increase efficiency by developing a building system with a high degree of prefabrication. To maximize the afterlife possibilities, a modular system is designed that supports a midrise building of 20 meters with a flexible footprint for either a residential, office, or educational function. After its functional lifespan, the separate building elements can be fully demounted and re-used for a different building project. The most important aspect for modular building and design for disassembly is dimensional stability. All elements need to fit exactly without any on-site customizations. This will be mainly achieved by using engineered timber products that are fully prefabricated. Engineered timber is CO_2 neutral, relatively lightweight, easy to process, and dimensionally stable. The mentioned properties make it a suitable material for dry prefabricated construction.

The project's focus will be on the strength and stability of the full structural system and the connections. Nevertheless some building physical aspects are also included. Due to the lightweight nature of timber structures, they are prone to vibrations and have a bad acoustic performance. This will be solved by increasing weight, adding acoustic decoupling and insulation, increasing stiffness, or a combination of these methods.

Another known risk of timber is fire resistance. Timber buildings can be as safe as regular concrete or steel buildings when designed correctly. Timber chars when exposed to fire, but the unaffected part of the section still has its original mechanical properties. So by adding sacrificial layers of timber and/or insulation, a fire resistance of 120 minutes can be achieved, which is required for buildings with a top floor above 13 meters. The required fire insulation of 60 minutes can be achieved by these same measures.
All requirements mentioned will be checked using relevant codes or regulations. The main challenge will be to combine all requirements into one coherent building system that meets all contradicting requirements. For instance, the floor needs to be decoupled from an acoustic point of view, but this is disadvantageous for the global stability of the building. Another example of such a contradiction is a porous ceiling that is beneficial for sound insulation but not for fire insulation since the fire barrier is not closed. Combining all the properties of the building system in combination with a 3D drawing environment (*Figure 2*) secures a precise fit and prevents inconsistencies.

The final product of the graduation project will be a designed structural system that meets all structural requirements in combination with fire safety and acoustical demands, including detailing and checks on an element and global level.◀

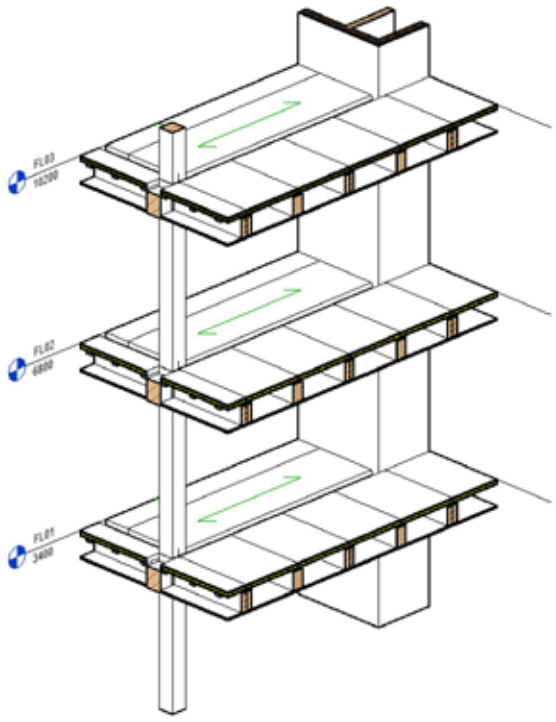

Figure 2: 3D drawing of the building system

References:

[1] *Ministry of Interior and Kingdom Relations (n.d.) Het statisch woningtekort verder uitgelegd. https://www.woningmarktbeleid.nl/onderwerpen/berekening-woningbouwopgave*

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Analyzing accuracy of crack calculation methods using data analysis

Analysis of Crack Calculation Methods

By: I.A. (Anton) van der Esch
PhD Candidate

Thank you, KOers, for the opportunity to present something related to my PhD research! Before I dive into details, first, let me shortly introduce myself. I am Anton van der Esch and started in February 2021 as a PhD candidate for the unit Structural Engineering and Design. My PhD research is related to how one can accurately determine the crack width and spacing in reinforced and prestressed concrete structures. If you have further questions, feel free to contact me at i.a.v.d.esch@tue.nl or walk to my desk on the 9th floor of Vertigo. I am always happy to help you and answer your questions!

Background

Concrete cracks already at relatively low principal tensile stresses. Cracking can occur roughly due to two types of forces: external forces and forces caused by the restraint of imposed deformations. The latter occurs when deformations in structures are restrained by the structure itself or its surroundings. For example, when a fresh concrete wall is poured on a hardened floor slab, the wall will shrink. However, this is (partially) restrained by the floor, leading to tensile stresses in the wall and thus possibly to cracking, see *Figure 1*. Cracking is a complex phenomenon, especially in the case of restraint-imposed deformations.

Figure 1: Cracking in a new concrete wall, poured on a hardened concrete floor [1]

During the last century, more than 100 crack calculation methods (CCMs), such as the one described in Eurocode 2, have been developed. These methods try to describe the crack pattern as accurately as possible, but often fail to predict the crack pattern accurately. This is because cracking in concrete is a complex phenomenon: concrete exhibits stochastic behavior, has time-dependent properties, and the material behavior is nonlinear. There is a lack of insight into which CCMs are more suitable and accurate for a given application than others.

From a maintenance perspective, it is important for Rijkswaterstaat (RWS) to predict the remaining service life of structures or the design life of structures as accurately as possible. Therefore, this PhD research will focus on and be used to find answers to the question of which CCMs are more accurate by using Data Analysis Techniques (DATs). It is also of interest how this result can be used to improve predictions in practice, e.g., for engineers.

Little background

Most CCMs predict the crack width as a single characteristic value, which is often related to the 95 percent prediction interval. However, the CCMs do not give a full probabilistic crack distribution. Therefore, this research will use Bayesian inference to predict a full crack distribution as an output. This has the advantage that it will lead to better insight into the statistical output of the crack behavior and considers the stochastic behavior of concrete. Moreover, Bayesian techniques can better handle missing data and provide interpretable predictions.

Methodology

To be able to use a probabilistic approach, a database will be constructed that contains the most important parameters for different performed crack width experiments, together with the results. This will be a large database with over 5,000 samples. Then, an overview will be created of currently frequently used CCMs with their application areas. These CCM are then categorized, see *Figure 2*.

Next, it will be investigated which DATs are the most appropriate for this research. These techniques will be used in a later stage to predict the crack widths, based on the collected info in crack experiments and described in the literature. The predictions can be compared with the output of existing crack calculation methods. At the moment of writing, the most promising techniques are the application of Bayesian Neural Networks (BNNs) and Relevance Vector Machines (RVMs). These methods can perform nonlinear regression combined with Bayesian Inference, leading to a prediction of the crack width and crack spacing in a probabilistic framework.

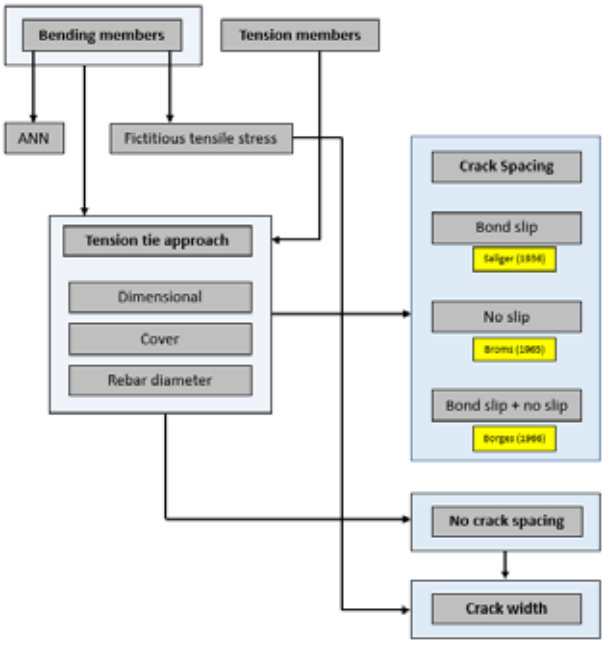

Figure 2: Proposed categories for existing CCMs

BNNs are a type of Neural Networks (NNs), see *Figure 3*. In essence, NNs are tools that work with different activation functions with certain input weights. By optimizing the input weights, a solution is searched for with the lowest error. The method is called Bayesian because the inputs are not weights but probabilistic functions, hence BNN (*Figure 4*).
RVMs are a type of Support Vector Machines (SVMs). In regression problems, these algorithms search for the largest margin between a possible regression line and the data. The advantage of this method is that a maximum certain error can be given a priori and SVM or RVM will find an appropriate fit.

The last step is to train the DATs and compare the predicted crack widths of these DATs with the crack widths that are described in the experiments. How does this work? Almost all DATs are trained by minimizing a cost function. Training will be done based on the collected data from the literature. The cost function can be defined as the squared difference between the observed value (training data) and the predicted value. With sophisticated solvers, such as stochastic gradient descent (SGD), an optimal set of values is obtained, which is found at a local minimum of the cost function.

At this point, the DATs are trained and ready to make predictions. The next step is then to compare the predictions of the DATs with the outcomes of the existing CCMs to select the most accurate CCMs. Accurate CCMs then have a small difference compared with the DATs and can describe a large part of the variance.

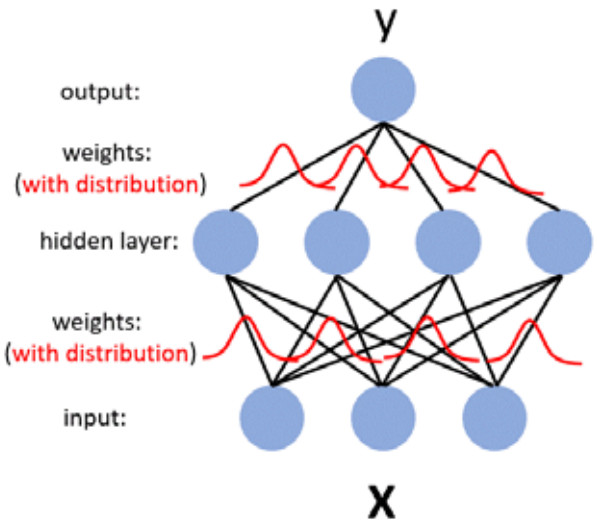

Figure 4: Structure of a BNN [3]

The DATs are scientific and sophisticated tools and not user-friendly for engineering purposes. In the last phase of the research, it will be investigated how these scientific tools can be used to derive an engineering tool.

Results

With this PhD research, insight into the performance of different CCMs will be obtained and a probabilistic tool will be developed, which takes better into account the complex phenomenon of cracking. ◀

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[1] *Dijk, M. (2021). Nieuwe methode scheurwijdteberekening. Cement, 68-72.*

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[3] *Ling, X., Zhen, H.-L., Li, Z., Zhang, Q., & Kwong, S. (2018). A batched scalable multi-objective bayesian optimization algorithm.*

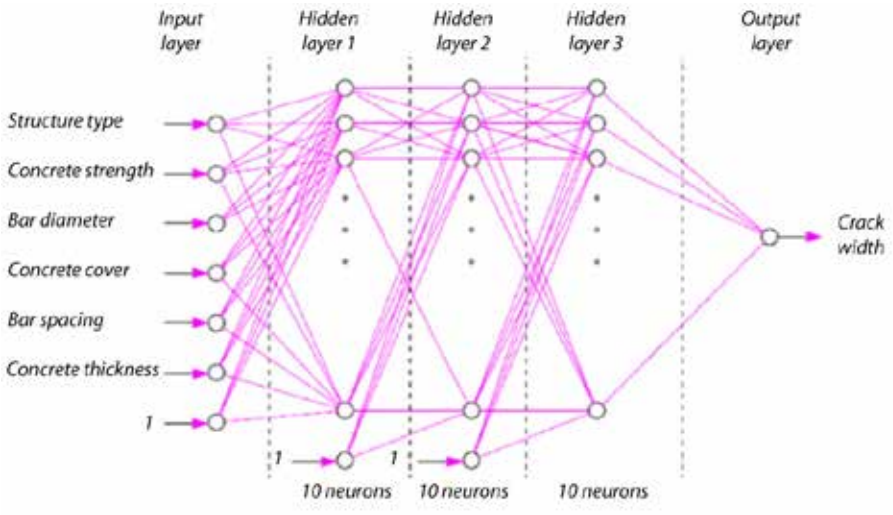

Figure 3: Example of a NN, used to predict crack widths in concrete [2]

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A Workflow for the Design and Manufacturing of 3D Printed Bridges in a Circular Economy

By: Matthew Ferguson and Rong Yu
PDEng Candidates

The construction industry has considerable responsibility for its impact on the environment. A big part of this is how we use concrete – we need to rethink how we are using this material. There are two ways of which the first is by using as little as possible, in other words, optimization, and the second way is designing for reusability or adaptability. Doing so means the structure does not have to be destroyed after its first use ends. The project described here has been commissioned by Rijkswaterstaat to explore how 3D printing concrete could offer a solution to help address these problems.

The project builds upon research conducted during the realization of two 3D concrete printed bridges previously created with input from the TU/e: the Gemert and Nijmegen bridges and is supported by Rob Wolfs and Theo Salet who worked on them. This project looks at how material optimization, circular design strategies, and sensor technology can improve productivity and sustainability.

With this project, we are creating an integrated workflow for the design, structural analysis, and fabrication of post-tensioned 3D concrete printed bridges up to 30 meters in span. The ambition is to create a parametric design tool with embedded structural feedback and manufacturing constraints to ensure material efficiency and manufacturability.

Key aspects in the project are sustainability, and more specifically, circularity. Likewise, productivity and digitization are crucial focal points. For these reasons, we do not create a single bridge design or a one-off structure but rather a workflow that moves from design, structural calculations, to fabrication, use, and reuse. The benefit of creating a workflow is that it establishes a process that can be repeated and adjusted through both digital design and digital manufacturing to suit different scenarios: a parametric approach that can be altered for the requirements.

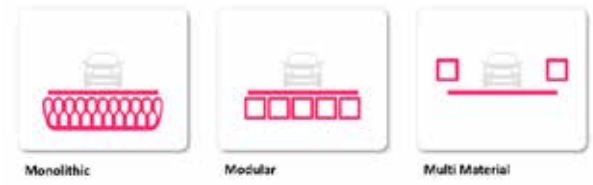


Figure 1: Bridge Concepts

Figure 1 above shows different bridge concepts. The left-hand image shows a continuous print path. The 'Modular' illustration looks to separate these elements to aid the widening or narrowing of the bridge as required. Then, the 'Multi Material' moves the beams to the side and suggests that other materials could be used for the deck.

As mentioned earlier, we are using a workflow to generate bridge designs. The simplified steps of the workflow are as follows:

1. Alignment curve: The user selects a line to go from point A to point B;
2. Cross-section shapes can be chosen from a library and are applied to the alignment curve;
3. A 3D Form is generated from these cross-sections. At this point, a structural algorithm is running and it gives the user feedback as to whether the load requirements are met;
4. These beams are split into sections, with each segment being printed as a separate piece;
5. Code Generation: the code to control the printer can be generated.

At present, we have a simple version of the workflow working from design to production, and are currently verifying the structural calculations with a series of load tests on small-scale 1.5-meter beams as seen in *Figure 2* below.

Figure 2: Four-point-bending test on bridge segment

One way in which we are trying to build on the previous two bridges is by incorporating design for disassembly strategies. Ideally, the bridges will be able to be dismantled, adjusted, or moved if necessary. A key for this is the connections between the printed concrete elements. We are exploring ways where 'dry' connections can be incorporated.

Current infrastructure requires on-site visual inspections. Therefore, another aspect we are exploring is Structural Health Monitoring (SHM). We are in the process of investigating how we can add sensors during production to assist with the understanding of the behavior and if preventative maintenance is required. Once the bridge is installed, a 'digital shadow' of the as-build structure would exist to aid SHM.

Currently, the project is at its one-year point, with another year remaining. Besides a large-scale prototype, the project will result in a working design tool with an efficient structural algorithm to allow users to intuitively and easily generate different options. This would enable stakeholders involved in future projects to work in more collaborative ways, with engagement from the client, structural engineer, and manufacturer from the outset. The collaboration can develop design options that are materially efficient, manufacturable, and demountable. Additionally, the tool would offer guidance when design decisions are being made to suggest how much material is used and how long it will take to produce. Ultimately, this could result in a more streamlined process to aid the Netherlands' ambition to move towards a circular economy in 2050. ◄

KOers committees

KOersief Committee

By: Laura Dings
Editor-in-chief KOersief

The editorial board of the KOersief is the committee that is responsible for publishing the magazine the KOersief. Twice each year, the committee works hard to deliver a new edition, full of interesting structural engineering stories. Each KOersief consists of thematic articles, sponsored articles and advertisements, and KOers related articles, such as graduation theses, internships, and work experiences.

At the start of a year, there are two brainstorming meetings: one to decide a new theme and one to find interesting stories related to this theme. Recent themes include: The digital era, Below the surface, Concrete giants and timber towers, and Special collabs. The choice of a new theme depends on the current relevance, the amount of related articles available, whether a similar topic has been discussed in the past five years, and whether we find a theme interesting and want to know more about it.

Once a theme is chose, the editors then contact different companies to ask them if they are willingly to supply new articles. These articles will need to be checked and sometimes translated, also a job for the editors. Once the articles are ready, the layout team will put the articles in the InDesign layout. Afterwards, the articles are checked by an external team of spelling and layout checkers. That team consists of KOers members, that are still part of the KOersief, but do not join the weekly meetings. When all articles are double checked, there is one big check where the committee will look at the magazine as a whole to spot any mistakes. At that point, the articles will also be sent back to the company once more so they can view the result. Now, the new KOersief is ready to be sent to the press.

In addition to the physical KOersief, there are online articles on the website of KOers. The KOersief is also responsible for posting these articles. Furthermore, there is a KOersief Instagram channel, where quizzes and updates are posted about the KOersief. Usually, there are two to three KOersief members who are responsible for maintaining the online KOersief.

One of the great advantages of the KOersief committee is the contact with different companies. This enhances your network and helps you in finding a job after graduation. There is no obligation to write articles yourselves, but it is a possibility if you want to improve your writing skills. If you are interested in graphical design and want to become better at working with InDesign, you can be part of the layout team. The KOersief committee takes relative little time compared to other committees. There is a weekly one-hour meeting and approaching companies, checking, and writing articles takes an additional hour per week. Finally, it is a very fun committee with relaxed meetings (including snacks) and occasional committee activities, such as having dinner together, going bouldering, and trampoline jumping.

Figure 1: Celebrating KOersief 111

We are always looking for new members, please contact us if you want to join as editor, layouter, spelling checker, or online responsible! ◄

KOers committees

Podcast Committee

By: Pieter van Loon
Co-host of the KOers podcast

As the co-host of the KOers podcast 'Kunnen wij het maken?', I have the best job of any committee member. Once every two weeks, I get to have an interesting conversation with an inspiring professional from the built environment. The aim of our podcast is to have engaging, low-key discussions about anything and everything building related.

In the past year, we have touched a wide range of topics in our episodes. Some episodes are related to materials like timber or glass, other episodes focus on a specialization like seismic design or aerodynamics. Sometimes, we stray a bit further from our roots and we discuss topics like sustainability and Life Cycle Assessment (LCA) and yet in other episodes we talk to students who are involved in cool projects like the BeerCratesBridge or team VIRTUe. So, how do these episode come to be?

Figure 1: Podcast with Derk Bos

First of all, there is an entire committee behind the podcast. Every week we come together to discuss what might be an interesting topic or guest for our next episode. Furthermore, we discuss topics like how the recording went, what promotional material we can make, and how the podcast can be improved. Besides that, there are several roles within the committee, some are flexible, but there are a few things that need to be done for each podcast. We have a PR person, who contacts the guests, a writer who makes the scripts for the episode, an audio technician who is in charge of recording, an editor who cuts out all the mistakes, and the two hosts who talk with the guest.

Figure 2: Podcast with VIRTUe

Unfortunately, most of us are getting old, hoping to graduate soon. So, we are looking for new people! Are you interested in meeting inspiring people? Broadening your horizon? And/or audio technical recording and editing?

Come by at the KOershoek or send us an email Podcast@koerstue.nl.
Lets keep the conversation flowing!◄

Kunnen we het maken? - The KOers Podcast

"Kunnen we het maken" is primarily a Dutch podcast created and run by KOers members. The goal is to bring interesting conversations to everyone interested in the Built Environment and Structural Design. The final episode of the first season is released in the summer, after which the second season started in September! Scan the Spotify code or search for "kunnen we het maken?"on Spotify, Apple podcast, or Soundcloud.

Online recorded

S1E16A: Britt Cordewener & Tim Schellekens – Na de studie deel A
We ended the first season with a special in which we spoke with two former students that graduated less than two years ago. We learn where students can end up and how they experience their new job. We spoke with Britt Cordewener who does a Ph.D. and Tim Schellekens who inspects existing structures at Nebest.

Online recorded

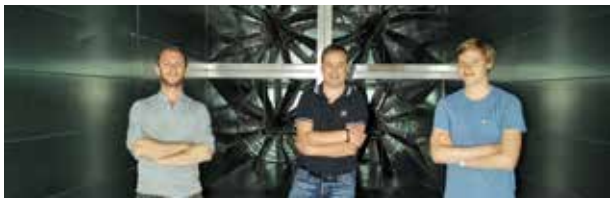
S1E16B: Lieneke van der Molen & Thijs de Goede – Na de studie deel B
This episode is a follow up on part A. In this episode, we spoke with Lieneke van der Molen and Thijs de Goede. Lieneke works as a building costs expert at Van Wanrooij and Thijs works as an adviser in the field of circularity at Alba Concepts.

Online recorded

S1E16C: Monique Morren & Thomas Dam – Na de studie deel C
In the third part, we spoke with Monique Morren and Thomas Dam. Monique follows a traineeship at TBI, while Thomas works as a structural engineer at Royal HaskoningDHV.

S2E1: Harm Leenders – Ontwerpen met brand
Safety comes first, also with buildings, but how do you ensure that a building is fireproof? We asked this and other burning questions to Harm Leenders, who deals with fire safety in structural engineering every day.

S2E2: Dirk Rinze Visser – Ontwerpen over de grens
Structural engineering does not only happen in the Netherlands. Together with Dirk Rinze Visser from Buro Happold, we spoke about all the issues regarding our profession abroad. What is the building culture like in Spain, England, Dubai, and Haiti? We asked this and many other questions to Dirk Rinze Visser.



S2E3: Bert Blocken – Wind in de gebouwde omgeving
Buildings can sometimes create strong winds on the street, but how do you prevent streets from becoming uncomfortable due to wind? Professor Bert Blocken is an absolute authority in the field of wind engineering. We traveled to a wind tunnel for this episode and spoke with Bert about wind behavior in the built environment.

S2E4: Pablo van der Lugt – Biobased bouwen
In a sustainable world, renewable raw materials will become increasingly important. When the people in the Dutch concrete country think of timber or bamboo, they think of treehouses and rocking chairs. However, these biobased materials have much more to offer. In this episode, we discussed the opportunities of biobased materials in the built environment with Pablo van der Lugt.

Online recorded

S2E5: Frank Maatje - Bouwen met Staal
Concrete and timber are commonly discussed materials in this podcast, but steel can be just as interesting! That is why we spoke with the director of Bouwen met Staal, Frank Maatje. We spoke with Frank about current trends in the field of steel and we extensively discussed the environmental impact of steel and how it can be reduced.

S2E6: Bowie Steutel en Pim van Rijsbergen – Team VIRTUe

Everyone knows the student challenge of solar cars, but did you know these challenges also exist for houses? Student team VIRTUe designed and built their interpretation of a sustainable home for the Solar Decathlon Challenge. In addition to the conversation we had with Bowie and Pim at the table, we received a tour!

S2E7: Emanuela Bosco – How to apply mechanics?

Which profession can deal with sewer pipes and art paintings, such as the Night Watch? Structural engineers! Together with Assistant Professor in Applied Mechanics Emanuela Bosco, we spoke about the mathematical world of forces and equilibrium.

S2E8: Jelle Versteege en Laura Vrenken – Bierkrattenbrug

In addition to buildings, bridges are also designed at the TU/e including beer crate bridges. For years, there has been competition between the universities of Delft, Twente, and Eindhoven. In 2022, Eindhoven will try to break its own record of 26.69 meters. In this episode, we spoke with Jelle Versteege and Laura Vrenken about this potential new world record.

Online recorded

S2E9: Axel Koper – Leren van instortingen (AZ/AFAS stadion)

Everybody knows Air Crash Investigation. These researches are essential since they can teach us how to prevent similar crashes in the future. This type of research also exists within the built environment called forensic engineering. We discussed this topic with Axel Koper of Royal HaskoningDHV by explaining the collapse of the roof AZ stadium.

Online recorded

S2E10: Joey Janssen – Gridshells

They are beloved among architects: large glass roofs and domes. An often used term for these structures is gridshells. But how do you design a gridshell? What are the structural challenges? Are there innovations in the world of gridshells? In short, enough reasons to invite a gridshell expert. We spoke with Joey Janssen of Octatube.

Online recorded

S2E11: Rick Titulaer – Parametrisch ontwerpen

One of the most significant developments within our profession is parametric design. This new skill is already implemented in many courses at the TU/e. But what defines an excellent parametric design? Together with Rick Titulaer of Arup, we try to find an answer to this question.

Online recorded

S2E12: Rudi Roijakkers – Klassiek ambacht en digitale tools

The original craft of a structural engineer consists mainly of manual calculations. Today, the computer has a prominent place in the life of a structural engineer. In many cases, the computer is superior to a manual calculation, but how does a structural engineer keep an overview? Together with Rudi Roijakkers of ABT, we discuss this balance.

Online recorded

S2E13: Sebastiaan Bakker en Rutger Rauws - EHVXL

The construction industry in the Netherlands has never been busier due to the large housing shortage, especially in big cities. Also in Eindhoven, many new high-rise buildings are constructed. The platform EHVXL was founded to follow these urban developments and see the public opinion. Two board members of EHVXL were willing to join us and talk about the current developments in Eindhoven.

KOers Puzzle

By: Derk Bos
Creative KOers member

BeerCrateBridge without scaffolding?

Berend has been following the news on recent attempts at building the longest BeerCrateBridge. He is, however, not that impressed and thinks he can make a longer span without using scaffolding. After testing the crates of his local brewer he found a maximum compressive resistance of 4 kN and a self-weight of 2 kg. He has come up with the design principle as shown in *Figure 1*. Can you calculate if he can break the current world record span (26,69 m) with this technique?

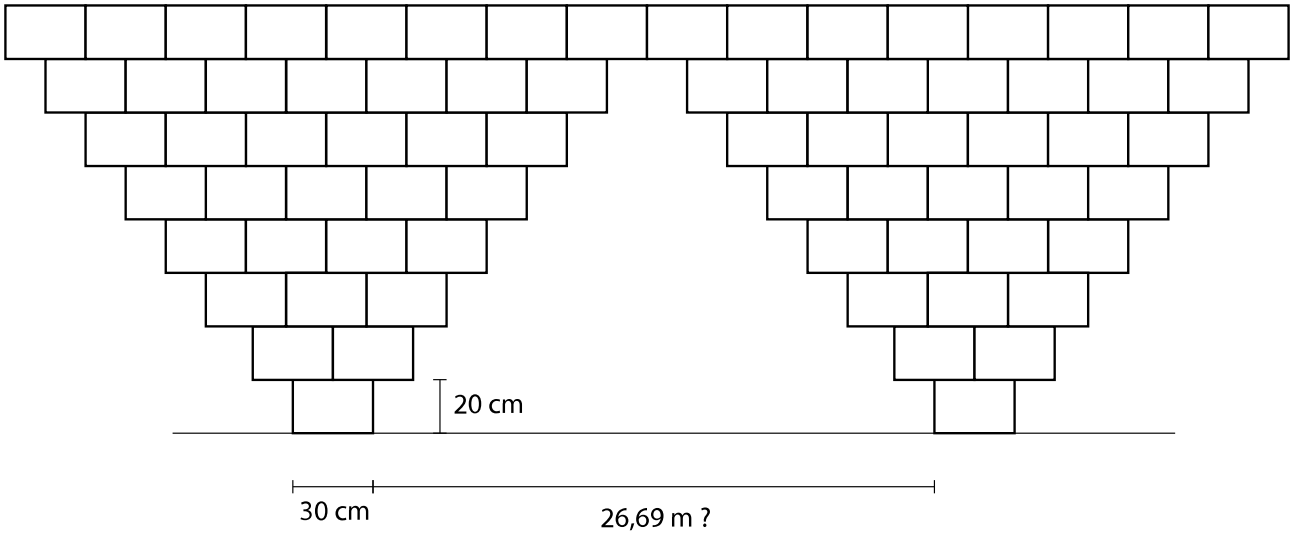
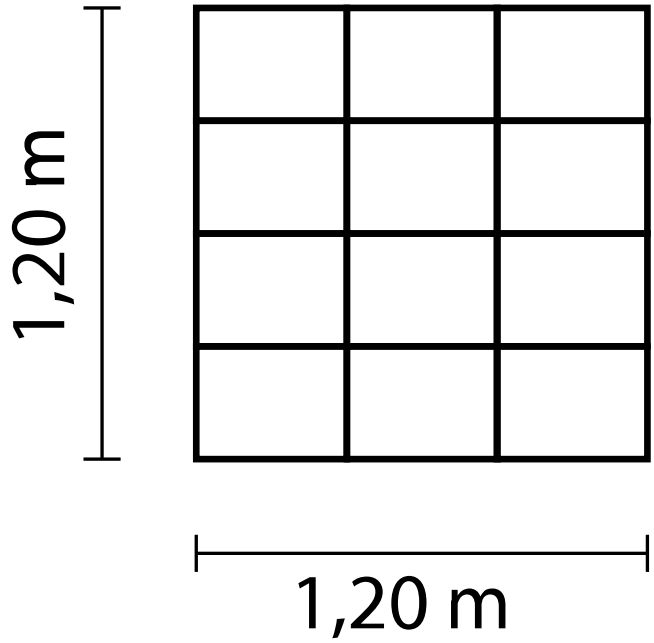


Figure 1: BeerCrateBridge

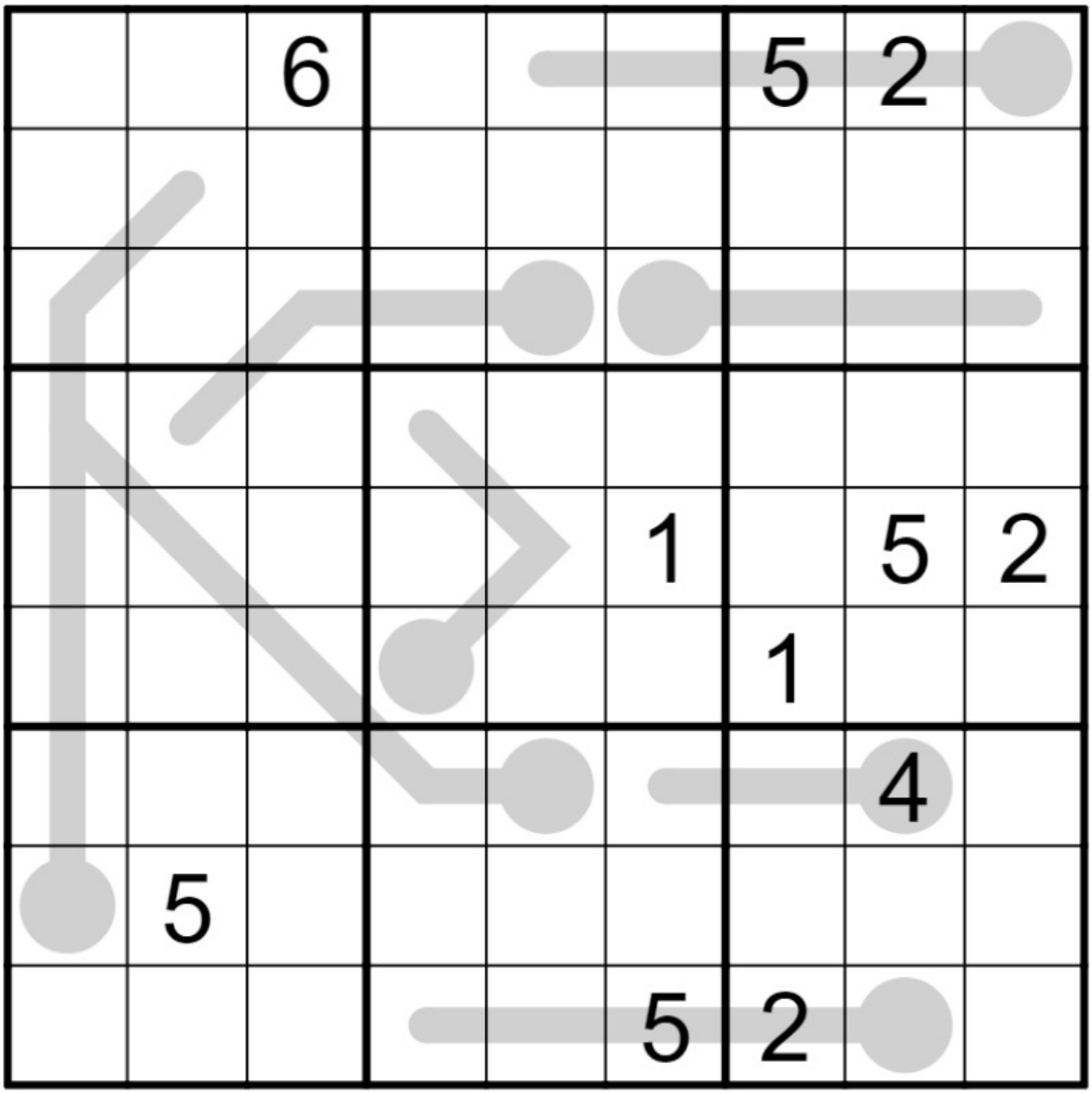
Not completely satisfied with the results, Berend decides to start a new world record challenge: the highest BeerCrateTower with a bounding area of 1,20 x1,20 m. He assumes the crates are homogeneous blocks (30 x 40 x 20 cm, depth x width x height) and fully connected. Furthermore, the crates have an effective stiffness of 100 MPa when assumed as a homogeneous block. Can you calculate the maximum height he can reach before the structure fails in compression or self-buckling?



By: Robin van Steen
Editor KOersief

Thermo sudoku

In honor of the 52nd board of KOers and the 114th edition of the KOersief, this puzzle has been made. The rules for this puzzle are as follows: Normal sudoku rules apply (each box, column and row should contain the numbers 1 to 9 once), furthermore the thermometers in the sudoku should increase from the bulb's end towards the tip. A number can not repeat on a thermometer.



Every edition a new puzzle, can you find the correct answers? Try, and send them to secretaris@koerstue.nl, this is possible until 1st of July 2022. Good luck!

Column

House for sale, you can read it on the sign.

Hans Lamers

Photo: Vincent van den Hoogen

One of the necessities in life is a roof above one's head, having a safe shelter, a practical house to live in, a cozy home. In our small and crowded civilized country, this is not so evident anymore. The demand for houses is higher than the supply. True, but this assertion is too simple. The Dutch situation is complicated. Many rented homes are in the bigger cities. Generally, they are in a poor state of maintenance with inadequate insulation and high energy consumption, so little value for money. The hiring of private real estate is exorbitantly costly. The remaining and popular option is to buy a house. With the current low mortgage interest of around one percent, you can say money is cheap. The return on savings or equity is nearly zero, the risks on the stock exchange market are high, cryptocurrencies have no intrinsic value, and therefore this hype is dangerous. In the end, all money will probably evaporate. Putting your money into property is the safest long-term investment since World War II. I bought a house in 1996 for €140.000, and recently the same house of my ex-neighbors was on the market for €450.000. So in 26 years, the value tripled.

I must admit that the situation is over the top in the 'high-tech Brainport region' around Eindhoven. Even after a two-year Covid pandemic, the economy is flourishing, and despite all expectations, the house prices continue to go up (2020 increase of 7,8 percent, 2021 increase of 5,5 percent). Critical factors such as positive consumer confidence, solid household income, easy accessibility of credit, the typical Dutch mortgage tax-relief, and the 'only-interest mortgages' boost house prices higher compared to other countries. The Dutch government cannot act. Contrary, the construction of new houses is slowed down by legislation regarding the emission of nitrates. Maybe it is time that local authorities take provocative initiatives and start with the transformation of empty office blocks hosting residence for communities. For example, the former Philips factory buildings on 'Strijp S.' And the building of subsidized temporary homes, flex-houses, tiny houses for young starters on the overheated housing market. Time for more action.

Colophon
KOersief is a student magazine published Twice a year by KOers, study association Structural Design within study association CHEOPS and the unit Structural Engneering and Design of the department of the Built Environment at the Eindhoven University of Technology.

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