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CONSTRUCTIEF ONTWERPEN

Oersief

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Structural Renovations

VAN ROSSUM
RAADGEVENDE INGENIEURS

www.vanrossumbv.nl

Editorial

Dear reader,

We hope that we have drawn your attention with the impressive image of a part of the Rijksmuseum on the cover of the 107th edition of the KOersief. It took more than ten years to renovate the Dutch national museum, which is situated in Amsterdam. The renewed museum fits in the 21st century, both regarding the needs of the visitors and the requirements of the structure itself.

Renovation is applied to structures in order to restore and adapt them to the demands of the present time. One of the biggest issues of today is the shortage of dwellings, while a large part of the office buildings are unoccupied. Restoring these office buildings and transform them into apartments is a good example of the purpose of renovation. Another good example is maintaining the use of monumental buildings, just like the Rijksmuseum. In addition to that, and thinking about sustainability, it is important to not fully demolish structures of which its lifetime has passed, and reuse elements when possible.

Next to buildings, also civil projects, like the train stations, are being renovated. Eindhoven Central Station, as in the editorial board picture above, has also transformed. In the beginning of this year, it has officially reopened after a renovation of almost five years.

We can conclude that renovation is everywhere, even in the editorial board of the KOersief! You can also read about the graduation project of our former editorial board member, Eline, and some new puzzles are waiting for you to be solved!

On behalf of the editorial board,

Caroline Koks
Editor-in-chief KOersief 107

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Chairman's note

Dear KOers members and relations,

First of all, I would like to welcome all our readers to our association on behalf of the 49th board of KOers. I hope you all had a great year so far and enjoyed our previous editions of the KOersief. Also, I hope you will stay with us for the upcoming releases as well.

This is my first note as chairman, although it has been a few months since we started as the new board of 2018-2019. I think we had a great start this year, looking back on all the activities we already have organized. Probably every board will experience the first few weeks the same: very busy and hectic. However, when your first activities are a success, such as the KOers Introduction Day, it brings satisfaction and raises new energy for organizing new activities. With a large group of students, we discovered the business industry at the Nationale Staalbouwdag and the Betondag. We also visited Enschede for their attempt to the longest Beer Crate Bridge. However, the record is still with us in Eindhoven!

This year is once again a special year for KOers since we are celebrating our 8th lustrum. The lustrum starts on the 3rd of December and ends on the evening of the 20th of December. During this evening at midnight, we can raise our glasses to the 40th dies natalis of KOers.

With a view to the future, we will do our utmost to match the quality of the activities and the KOersief with previous years or to make them even better.

Last but not least, I would like to thank the editorial board for this new edition of the KOersief. I hope you will all enjoy reading this edition about renovations and I wish you all happy holidays and a happy new year!

Yours sincerely,
On behalf of the 49th board of KOers,

Willem Bouwsema
Chairman of the 49th board of KOers

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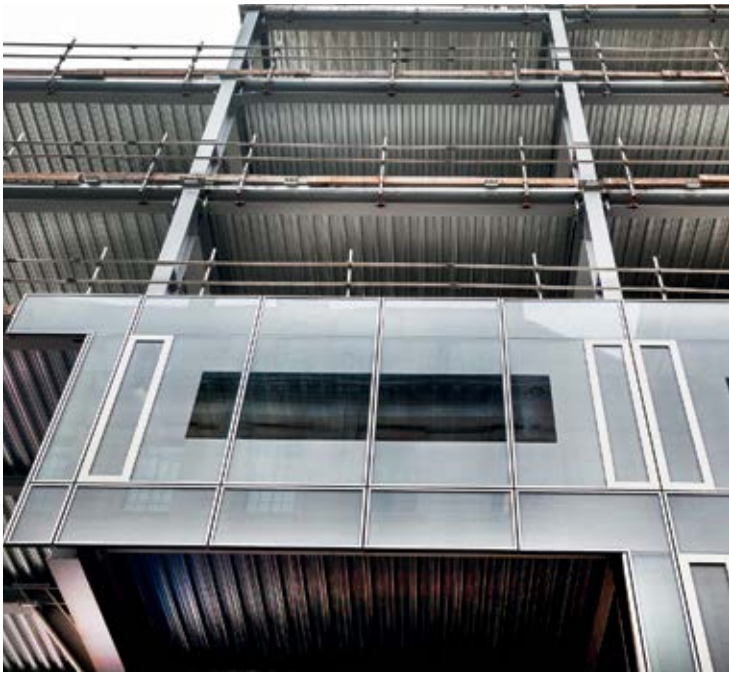

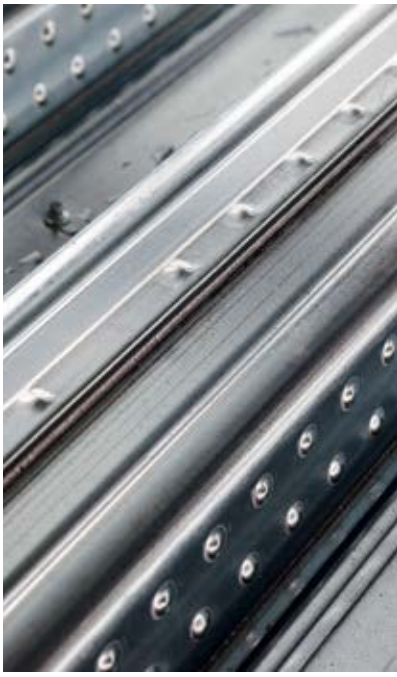

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Agenda

Constitution drink *September 12th*

KOers Introduction Day *September 20th*

Lunch lecture Reijneveld *September 27th*

Nationale staalbouwdag *October 3rd*

8th lustrum KOers

December 3th-20th Eindhoven

This December, KOers will become 40 years old and will thereby organize its 8th lustrum. To celebrate this, numerous activities are organized:

- KOers Gala (December 14th)
- Pub quiz (December 20th)
- Design challenge (December 7th)
- and much more!

Keep an eye out on the KOers website, 8th Lustrum KOers Facebook, or @koers_lustagram Instagram, and stay up-dated!

New years drink

January 2019 SkyBar!/Floor 2

The lustrum is followed by the Christmas holidays, which means there is some time to rest. After the holidays, KOers is planning to continue where we left of, namely with a drink! Depending on the number of people, the drink will be held in the SkyBar! or just on floor 2. So make sure you subscribe in time on our website!

Grasshopper course

February 2019 TU/e campus

The Grasshopper course of last year was a great success, and therefore KOers is going to organize this event again. Do you want to learn a thing or two about parametric design? Do you want to implement it in your design project of the third quartile? If yes, you should definitely come to this course. Subscribe on our website!

SCIA and Abaqus courses

February/March TU/e campus

More upcoming courses in Q3! In the third quartile, both the Abaqus and the SCIA courses will be given. Abaqus is a program to perform finite element analysis, so if you are following the FEM course or if you are a bachelor student that is already interested in these subjects, keep an eye on our website. The SCIA course is meant for students that, for example, are taking the large span or high rise project, and will try to give them a kick start on their project. Also for the SCIA course, keep an eye on our website!

KOKO floor 9 *October 4rd*

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49th board of KOers

Introducing the new board of KOers

While most of the readers enjoyed their holidays, the candidate board members where busy forming a new board. The board can be seen in the picture above, with from left to right: Tim Schellekens, Lars Hogenboom, Willem Bouwsema, and Dominique van der Weijden. In order to introduce the board members to everyone, who has not had the opportunity to formerly meet, some question where asked.

Willem Bouwsema
Chairman

Where are you from?
I come from a small village called Holwierde in the north of Groningen. About a 1,000 people live in Holwierde, which why most of the inhabitants know each other. This is why I find it worth it to go back home nearly every week. For the past two and a half years I have lived here in Eindhoven, but before that I have only been here twice.

Why did you join the KOers board?
Since I did not know anyone here in Eindhoven when I started here, I tried to get to know more people from my study. One of the best ways was to just join the KOers KOffietijd in one of my first weeks. This is how I got introduced to KOers. After that, I became more active and joined a few committees and got even contacted to join the 48th board, but at that point I had not even finished my premaster. Therefore, I told them I would wait at least another year before I would join the board. After that, it was pretty certain for the 48th board that at least I would join the 49th board.

Which structural engineer inspires you the most?
It might not be a specific engineer, but I would say the Romans. The amazing structures they built already 2,000 years ago and still counting. The things they accomplished is not something I would think will ever happen again.

What material has a special place in your heart?
For me, it would be timber. I have done several projects during my studies in which I tried to use timber as much as possible. It is a great renewable construction material which in many cases results in a great finish without hiding the raw structure.

"Nothing goes above Groningen."

A peoples person or an Einzelganger?
Most of the time I am around a lot of people, which I absolutely do not mind. From time to time, it is also

completely fine by me to get home in the evening and just enjoy the peace. After all, I prefer to be around other people.

Where are you standing in 30 years?
In 30 years, I will probably be working somewhere in Groningen, at least that is what I think now. But, lets first focus on finishing my master and then I will look further.

Where is KOers standing in 30 years?
I definitely hope KOers will still be around and hopefully thriving at that time. With the way KOers is functioning right now, it is definitely possible to stay around for the upcoming years.

What is your biggest dream?
Well, besides going to Japan, what we already did with KOers past summer, I think I will go for designing and engineering, and maybe even building my own home somewhere in Groningen. It might take a few more decades, but it is definitely something I would like to do in the future.

Tim Schellekens
Commissioner Public Relations and Secretary

Where are you from?
I am from a beautiful small village called Liempde. A village with about 5,000 inhabitants located between Eindhoven and Den Bosch. Every Sunday, I play football here with the local football team DVG. With the 6th team we perform, especially in the 3rd half, at our best. Since I am a fan of the best football club of the Netherlands, PSV Eindhoven, I have been regularly found in Eindhoven since I was a little boy.

Why did you join the KOers board?
It took a long time before I was really sure I wanted to join the board. Last year, I became more involved with KOers, especially because of the Concrete Canoe Race committee. I discovered that there were more fun activities and that KOers consist out of a nice and committed group of people. After many doubts, I finally took up the challenge and this great opportunity. I think it will be a busy but also a very fun and interesting experience.

Which structural engineer inspires you the most?
I think it is hard to choose a specific structural engineer. If I must choose a well-known engineer, I think it will be Santiago Calatrava. Especially through the combination of impressive architecture in collaboration with the structural elements. I think that the cooperation of both the architecture and the structural elements are a key factor for making the most beautiful structures.

What material has a special place in your heart?
A few years ago I would have said concrete. However, this was probably the case because it is simply used a lot. At the moment, I think I should say aluminum as a kind of obligation, since I am now working on my graduation project at the aluminum chair. Off course I made the choice for aluminum for a reason. During my master, I discovered that there were more interesting building materials with much more freedom than concrete. Especially the fact you can optimize and design aluminum sections to every little piece attracted me.

A peoples person or an Einzelganger?
I prefer to be among people. However, being alone every now and then is not bad, just to escape from the hustle and bustle. I also think I can work well individually.

Where are you standing in 30 years?
I hope to work at a big structural engineering office with some outstanding projects. Then to work as chief engineer or project manager seems wonderful to me. I think the most important thing is to still learn every day and keep the joy in this field.

"My town is called Liempde, but you pronounce it like Liempt."

Where is KOers standing in 30 years?
I still hope as active as now. Given the strong position now and the number of new structural engineering students every year, I think that should not be a problem.

What is your biggest dream?
This will be a very cheesy answer, but I think to remain happy and healthy for many years to come. It would be also nice to work on an outstanding building or bridge which will be a landmark. Showing it later on to my children would be the best thing I can imagine.

Dominique van der Weijden
Treasurer and Secretary

Where are you from?
I still live in IJsselstein, a town somewhere below Utrecht. This is also where I go to the scouting every Saturday and work as a structural engineer. Every day, I go to the south of the Netherlands where they talk with this soft g, but after some years I got used to this and will miss it when my studies are finished.

Why did you join the KOers board?
I think we can conclude by now that I am a bit impulsive at making decisions, full of crazy ideas, and besides that also love food. Being part of the board of KOers is the perfect place to express this. There are a lot of nice members that can come with us on our adventures, but who also like a piece of pie so once in a while.

Which structural engineer inspires you the most?
I have absolutely no idea, I have to admit that I barely know any famous structural engineers by name. But you should always be inspired by the things you do yourselves. So I

hope that in a couple of years I can answer with my own name when someone asks this question again.

What material has a special place in your heart?
WOOD!!! Definitely wood, who does not love the warm shades of brown together with all the various patterns, creating a piece of art in itself. Also, the smell of fresh sawn timber is lovely and gives great memories to all the Sundays that were spend in the shed creating almost everything from small puzzles for the KOers Introduction Day to 4.5 x 5.5 meters canopies.

A peoples person or an Einzelganger?
This is a bit depending on the situation. Most of the time, I like to be around people. However, sometimes it is very relaxing to be alone and be able work very efficiently. In the end you will need others or everything will get very boring.

"I live in Utrecht, come on, it is only a 45 minutes bike ride from IJsselstein!"

Where are you standing in 30 years?
Hopefully somewhere in the mountains, filling my days with all sorts of mountain activities like paragliding, rafting, climbing, and hiking. Besides that, also doing some engineering work or working at a construction site.

Where is KOers standing in 30 years?
In literal sense, KOers will probably be in the same spot it is now, only with some new furniture and people, unless the TU/e has another plan of course. But I hope KOers will still be around and will organize a lot of nice activities and the fourteenth lustrum for the members.

What is your biggest dream?
I think this is a shared dream of every built environment student around the world; building your own house and in my case building it in Austria. It sounds like a wonderful idea to do the whole process from the beginning until the end by yourselves; the design, the calculations, the planning, and being at the construction side putting your own house together.

Lars Hogenboom
Commissioner of Education and Vice-President

Where are you from?
I am from a small town called Beuningen, near Nijmegen. This town is famous for numerous celebrities like Piet Velthuizen, goalkeeper for Vitesse Arnhem, and Rob Trip, newsreader for the NOS. As a child, it was a lovely town with a lot of places to play football, hockey, ice skating, and play other games. As an adolescent, Nijmegen's nightlife was more suitable. I would suggest that every person who is taking him or herself seriously, moves to Nijmegen.

Why did you join the KOers board?
As a student, I try to stay active in committees and other activities that have an added value besides studying alone. The intrinsic motivation is that doing additional things create a bond with students who are in the same boat. Extrinsically, my parents always motivated me to try to give something back to society. This started with volunteering on events for the hockey club and is now resulting in giving something back to students following the master track structural design. Hopefully they will all come to our next lunch lecture!

Which structural engineer inspires you the most?
My great inspiration and motivation to keep on going might not be a structural designer, nonetheless is this phenomenal individual's great influence widely visible in our field. Isaac Newton's third law, action is reaction, is not only applicable in our engineering practice, it is also applicable in the way we should communicate with people. Always keep in mind how someone would react on for example criticism. This guidance is key in our society.

What material has a special place in your heart?
As a child, I fell in love with timber. During my skiing trips in Austria, this material was somehow associated with the family gathering, drinking a beer, or a warm chocolate milk. Nowadays, I am not sure if I have a preferable material. Let us keep it on timber.

A peoples person or an Einzelganger?
I think a peoples person, but I do not think people should actually judge themselves regarding these classifications. Let us see how my board year will go and then we could classify me!

Where are you standing in 30 years?
In 30 years, I am already heading towards retirement, haha! No, based on our current demographic development this is just a joke of course. This is actually, looking at the big changes concerning new technologies, improving software packages et cetera, hard to tell. My first answer would state that I would be looking forward to giving advice to a new generation. But I think that, at that time already, I can learn a lot from the new generation structural designers graduating from our universities.

"I am always right. Even if I am not. Wait.. what?"

Where is KOers standing in 30 years?
If KOers still exists in 30 years, it will be the exact same as now. We would still own the BierKrattenBrug world record, we will still win the sjoelbokaal on a yearly basis and we will remain champion during the bierpong battles. However, it is hard to tell if the number of student associations in the built environment at the TU/e will remain constant over such a large time span.

What is your biggest dream?
My greatest dream is to inspire youth. ◄

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Execution of the concrete repair of the deteriorated immersed Maastunnel

Underground challenges

By: Dr.ir. C.B.M. Blom, ir. W.A. Gellweiler, and ir. E. Taffijn
Civil engineers at the municipality of Rotterdam

The Maastunnel (1937 - 1942) is a concrete immersed tunnel situated below the river Maas in Rotterdam, the Netherlands. The 1,373 meters long Maastunnel is one of the three main traffic connections with the city center and is a national monument. It consist of two traffic tubes, one cyclist tube, and a pedestrian tube (*Figure 1*). Each traffic tube has a concrete deck, on which the vehicle lanes are located. Below the concrete deck, there are three ventilation tubes with pipes at a regular distance connected to the traffic tube.

During visual inspection of the ventilation tubes, heavily corroded reinforcement has been observed at the floor and the ceiling (bottom side of the traffic deck). From measurements, it was detected that a high chloride concentration was present around the reinforcement. The chlorides arise from de-icing salts and due to the ventilation regime in the tunnel.

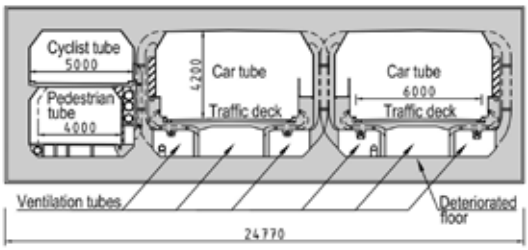

Figure 1: Cross section of the tunnel with traffic and ventilation tubes

Extensive structural analyses have been carried out to prove that structural safety still fulfills current requirements. However, corrosion was still progressing. Therefore, due to the observed damage and the fact that the Maastunnel is already 75 years old, it has been decided to perform a renovation. The desired life time extension is 50 years. The concrete deck will be demolished and a new concrete deck will be placed on the floor of the ventilation tubes.

Consideration of the repair principle

Chloride induced depassivation of protective layer around the steel bar and heavy corrosion mainly occurred in the tunnel bottom floor. It has been decided that the concrete cover has to be restored and that corrosion should be stopped to preserve the remaining structural strength of the tunnel.

Two main repair principles have been investigated and their feasibility has been proven: (i) concrete removal and application of the concrete overlay (conventional patch repair) and (ii) cathodic protection. After consideration of these two principles, it turned out that the first principal including removing the concrete was more beneficial to the project of the Maastunnel.

Structural safety during execution

A very important issue was the structural safety of the tunnel. At the time the heavy deterioration was noticed, the first concern was whether the safety is still sufficient. Extensive analyses have been carried out to prove that the structure still fulfils all safety requirements [2]. It has been concluded that linear elastic calculations failed to prove this. Therefore, nonlinear and probabilistic analyses were applied and the structural safety was proven to suffice.

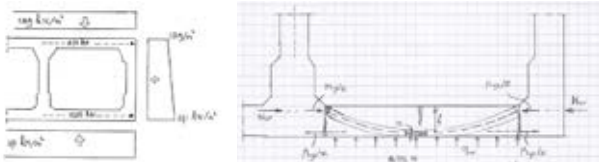

Figure 2: a) Maximum loading situation and b) Hand calculations by considering arch action in the floor when no reinforcement is considered

The designed repair method of removing the contaminated concrete up to 3.0 centimeters behind the rebars, makes it very important to investigate whether the structural safety remains adequate during the repair. Namely, during repair works the concrete around the rebars is temporarily removed but all the loads still act on the structure (i.e. over 25 meters water pressure) (*Figure 2a*). Because of that, the top reinforcement of the concrete bottom floor cannot contribute to the structural safety. Hand calculations (*Figure 2b*) and analysis with FEM models (Atena and Diana) showed that Ultimate Limit State could be fulfilled. The probability of the occurrence of a single concrete crack (*Figure 3*) has been reduced by adapting a concrete removal length of 6.0 meters in the longitudinal direction of the tunnel.

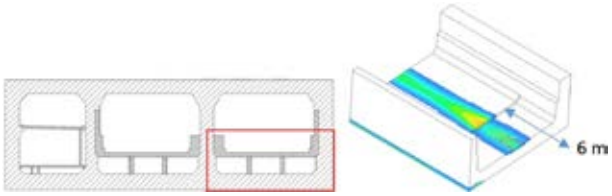

Figure 3: Crack width analysis 6 meters concrete removal, TNO Diana FEM

Concrete mix, design, and tests

Fresh concrete has to be applied to embed the reinforcement, re-establish the alkaline environment around it, and to provide a concrete cover.

Based on the current state-of-the-art for concrete repair, a basic mix without or with low fiber content can be applied. Fibers are implemented considering the recommendation that, due of imposed deformations and susceptibility for cracking, repair materials should contain fibers [3]. Current trends in research also suggest that the application of strain hardening mixtures (SHCC) is very promising for concrete repair [4]. In order to choose the optimal mix for this project, a wide range of tests has been performed on five mixtures whereby the surface of the substrate was prepared by hydro-jetting. After consideration the final mixture, a 1-2-3 mixture with a small amount (1.35 kilograms/m^3) of fibers was chosen.

Figure 4: Result concrete bottom floor after hydro-jetting

Execution

In July 2017, the repair of the western tube started. Within three weeks, the demolition of the traffic deck was realized. Serious attention was paid to the asbestos present. The hydro-jetting of the upper 15 centimeters of the concrete bottom floor (three centimeters behind the rebars), in alternating parts of 6.0 meters each started in September 2017 (*Figure 4*). After some start-up problems the result was sufficient, i.e. an acceptable average demolition depth, and cleanness of the rebars. During those activities monitoring of the ground cover on the tunnel, the bending of the hydro-jetted part as well as the vertical position of the tunnel as a whole took place.

Figure 5: a) and b) Execution of the new traffic deck

From December 2017 to March 2018, the new traffic deck was realized consisting of a connection with the existing walls by bonded rebars (*Figure 5a* and *Figure 5b*).

Both the new top layer of the concrete bottom floor and the traffic deck showed as expected only limited cracking due to shrinkage. Also, the bonding to the substrate was sufficient.

Figure 6: Final result of the western tube

In July 2018, the renovated western traffic tube was reopened for traffic (*Figure 6*). At this moment, the renovation of the eastern traffic tube is ongoing. Some optimizations have been implemented. For logistic benefits, the contractor has adopted hydro-jetted patches of half of the tube width. For the traffic deck, there is more attention and preparation needed for the monolithic connection, i.e. optimalization of the connection, which directly results in an increasing quality of the outer and middle wall. The opening of the tunnel is foreseen for July 2019. ◄

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Figures:

Header *Frank de Roo*
1- 6 *Municipality of Rotterdam*

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Wij voeren wereldwijd, vanuit 100 kantoren in 35 landen, projecten uit die de leefomgeving raken. Onze 7000 professionals voelen zich hierbij gesteund door de kennis en ervaring van hun collega's. Door de combinatie van wereldwijd opgedane kennis en kennis van de lokale situatie leveren we toegevoegde waarde voor onze klanten in hun projecten.

Wij zien een belangrijke rol voor onszelf in innovatie en duurzame ontwikkeling. Daarom willen we bijdragen aan oplossingen om onze maatschappij duurzamer te maken, samen met onze klanten en anderen die eenzelfde visie hebben.

Stage lopen of een afstudeeronderzoek doen bij Royal HaskoningDHV is een goed begin van een succesvolle carrière. Vaak ben je lid van een projectteam en werk je mee aan onderdelen van een project. Nieuwe inzichten en kennis zijn zeer welkom bij het zoeken naar de meest ideale oplossing voor een klantvraag.

Op onze website staat meer informatie over wie we zijn, waar we ons in de praktijk mee bezig houden en ons actuele aanbod afstudeeronderzoeken, stages en vacatures.

"Duurzaam bouwen draagt bij aan een positieve invloed van gebouwen op mens en milieu, nu en in de toekomst. Dat vergt een innovatieve aanpak met het oog op de hele levenscyclus van een gebouw."

Michiel Visscher, Constructief Ontwerper

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Renovation from 2018 till 2020

De Nieuwe Afsluitdijk

By: Hidde van Wezel
Editorial board

The Afsluitdijk is a 32-kilometer-long flood defense that closes off the IJsselmeer from the Wadden Sea. At the same time, it is a dam that connects the provinces of Noord-Holland and Friesland. An important traffic route, A7, runs along the Afsluitdijk. The Afsluitdijk has been built after a large number of dikes along the Zuiderzee broke through due to a heavy storm in 1916. In 1927, the construction was started.

On May 28th, 1932, at 13:02 hours, the Vlieter (the last hole in the Afsluitdijk) was closed. Thanks to the dike, the sea is kept outside and the land borders and the Netherlands has become much safer. A breach of the Afsluitdijk can have serious consequences. In order to continue to protect the inland in the future, the dike will be given a refurbishment. From 2018 to 2022, the consortium Levvel (collaboration between BAM, Van Oord, and Rebel) works on the renewal of the Afsluitdijk commissioned by Rijkswaterstaat. The renovation consists of:

- Reinforcing the dike body, guards, and the sluices (flood risk management);
- Increasing the capacity to drain water (water management);
- Improving and maintaining the A7 motorway;
- Projects in the field of economics, nature, and sustainable energy (by the initiative of De Nieuwe Afsluitdijk).

Dike reinforcement

On the side of the Wadden Sea, the dike is raised and reinforced with a new covering. Levvel uses innovative and specially designed concrete elements for the Afsluitdijk, the so-called Levvel blocs. These blocks weigh approximately 6,500 kilograms each, are very strong, have a wave-inhibiting effect, and are easy to install. About 100 blocks a day are produced in Harlingen in a fully automated process and transported by ship to the dike, and approximately 75,000 Levvel blocs are placed in total from a crane pontoon. Because of the symmetry and continuous placement, the block gives a calm image that strengthens the tight, autonomous character of the sluices (*Figure 1*).

Water drainage

The sluices at Den Oever and Kornwerderzand transport excess water from the IJsselmeer to the Wadden Sea. If the water in the Wadden Sea is at low tide, the sluices open. The water from the IJsselmeer then flows to the Wadden Sea; under 'free fall', gravity does the work. The capacity to drain water by the sluices is no longer sufficient. Therefore, the water discharge capacity must be increased.

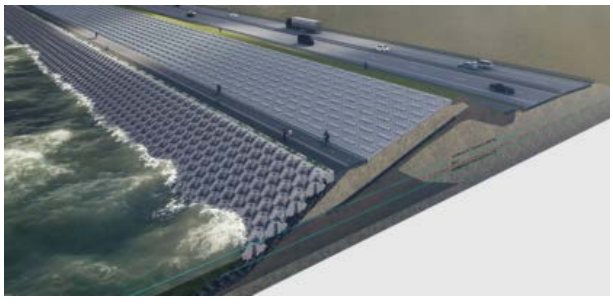

Figure 1: Section of the new Afsluitdijk

The lock complex at Den Oever will be extended by building new sluices at the intermediate islands (*Figure 2*). Draining is not possible when water is at a high level in the Wadden Sea. That is why Levvel builds two large pumping stations in Den Oever. The pumps have a very low energy consumption and are fish-friendly. The energy for the pumps is generated in

a sustainable manner by means of solar energy. With these measures, the Afsluitdijk is resistant to the power of the water up to at least 2050.

Flush when possible, pump if necessary

Flushing is, and remains after the renovation, the preferred method to drain large volumes relatively quickly. The pumps are only used when it is really necessary: flush when possible, pump if necessary. Especially in peak situations, this is important. However, it is crucial to be able to use an additional method that can be used at all times, even when flushing is temporarily not possible. Pumps can work against gravity; by pumping, water can be drained if the tide in the Wadden Sea is higher than in the IJsselmeer.

Fish migration

The Fish Migration River is an opening in the Afsluitdijk where migratory fish can swim through to reach the IJsselmeer from the Wadden Sea and vice versa. Migratory fish need both fresh and salt water for their life cycle. Due to dikes and dams, such as the Afsluitdijk, this is hardly possible. This is one of the important reasons why the numbers of migratory fish are lower than before the Afsluitdijk.

Figure 2: New design lock Kornwerderzand

A solution was devised for this: the Fish Migration River. With the Fish Migration River, it is aimed for that the obstacle to migratory fish is eliminated with De Nieuwe Afsluitdijk. Millions of fish are now lying in the Wadden Sea waiting for the sluices. They smell the fresh water and want to go inside. However, the current flow is usually too strong for these migratory fish to swim against. A permanent opening via the Fish Migration River trough the Afsluitdijk should make it possible for these migratory fish to swim freely from saltwater to freshwater. Rijkswaterstaat is also taking measures to stimulate fish migration between the Wadden Sea and the IJsselmeer. For example, a fish friendly lock management is being applied and a fish passage is being constructed at Den Oever. Together, these measures ensure that the number of migrating fish increases.

The Fish Migration River is about three kilometers long in the IJsselmeer. Due to its length, the river can be open for a long time during the changing of tides. The salt water with the fish (larvae) can flow freely into the river at high tide. Because of the length it takes a long time before the salt water reaches the end of the river. The length also ensures gradual change in the fresh-salt transition and thus mimics the natural situation best. The entrance of the Fish Migration River is connected to the drain basin, where the fresh IJsselmeer water is discharged. Fish 'smell' this and are attracted by it. By tidal action fresh water flows to the Wadden Sea when the tide is low. In this way, fish can find the entrance to the fish migration river. The sway character of the Fish Migration River creates a difference in flow rates, which is important for fish to be able to hide, forage and rest. A slow flow rate, designed in the river, also gives weak swimmers the chance to migrate. They also let themselves be drawn by the flood stream. The smart thing about the design of the Fish Migration River is that it is possible for fish to migrate, but keeps salt water from flowing into the IJsselmeer (*Figure 3*).

Unique project with global appeal.

The Fish Migration River is a system that stays close to nature and that operates optimal for fish and the ecosystem. Worldwide, there are several comparable situations where this would be a solution. Therefore, it is a unique project for the Dutch hydraulic engineering sector with an international appeal.

Figure 3: Top view on the Fish Migration River

Recreation

In order to facilitate visitors better, De Nieuwe Afsluitdijk includes a number of initiatives. For example, there will be an extra bicycle path on the Wadden Sea side, along the entire dike. The space around the Monument of Dudok will be improved and made more accessible to the public. The current pedestrian bridge will be relocated, strengthening the vertical character of the monument (unique on the dike). At Kornwerderzand, there will soon be a new walking route where pedestrians can walk to the Vismigration river.

A starting point for wider visit.

New for visitors to the Afsluitdijk is the Wadden Center. Here, you get a total experience of the Unesco World Heritage Wadden Sea, the Fish Migration River, the IJsselmeer area, and the Afsluitdijk itself. A visit to this interactive center gives a good picture of the surroundings, but also of the many hydraulic engineering and other innovative projects that will be realized in the coming years. ◄

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[1] *www.deafsluitdijk.nl*

Figures:

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Design and challenges

Renovation of The Rijksmuseum

By: Monique Morren
Editor KOersief

The Rijksmuseum in Amsterdam is one of the most important 19th century monuments of The Netherlands. The showpiece of the collection is the world famous 'Nachtwacht' by Rembrandt. A renovation of 10 years took place to make it meet the current requirements for international modern museums. The renovation has been carried out to a design by the Spanish architects Cruz and Ortiz. The structural design was provided by Arcadis with support on the field of geotechnics and groundwater management by respectively Crux and Wareco. The most striking part of the renovation was the creation of a large underground square of about 3,000 cubic meters. Advanced calculations and monitoring strategies have been used to assess the effects of the new construction elements on the existing building.

The central idea of the design of the architects Cruz and Ortiz was to move the main entrances of the two small towers on the Stadhouderskade to the passage of the museum. The buildings that were added over the years to the courtyards have been removed so that these could be restored in their original glory. The old basement structure under the passage has been demolished and replaced by a new more slim and open concrete structure. In this way, the desired connection between the courtyards is achieved and creates a large central square that functions as the new main entrance. Two new basements have been realized under the courtyards, of which the floor level is located on the level of the old basement under the passage (*Figure 1*).

The proposed design of the architects introduced a number of serious design challenges. These are mainly related to the implementation of the underground structural components, located at a short distance from the existing structure. This introduced geotechnical complications and restrictions with regard to the influence on the monumental building that is based on 8,000 wooden piles. Therefore, some practical design rules were set. Some important ones are: no additional load on the existing foundation, existing structural elements remain founded on the original piles, new structural elements are placed on new piles, and existing and new structures are separated by dilatation joints. The structural influences on the existing structure are closely monitored.

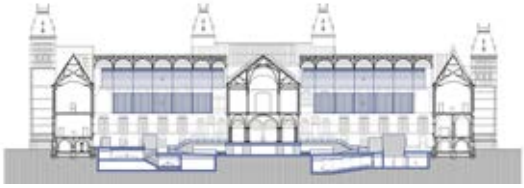

Figure 1: Section east-west of The New Rijksmuseum

In 2000, the first studies on the quality of the foundation had been started. This consisted of retrieving archival data on the various foundation types, execution of deformation measurements, and performing a facade inspection. It could be concluded that differences in displacements occurred over such large distances that small angular rotations were caused along the structure and that there was hardly any damage to the structure of the museum. Globally, it could be concluded that the entire museum has settled

approximately 0.2 meters in the past approximately 125 years. Based on these studies, it was concluded that for the situation in Amsterdam the performance of the foundation was reasonable. Also, the building was in good condition and the appearance of cracks was limited.

During the design phase, it was decided to start doing research on the actual bearing capacity and load-displacement behavior of the existing pile foundation. In the courtyards, load tests and foundation inspections were carried out at four characteristic locations. A characteristic load tests showed that the pile still does not encounter for a continuous settlement at a load of 300 kilonewton, and therefore has not yet reached its geotechnical load capacity. To conclude, also from these inspections a good foundation was found with little damage. Calculations with the computer program Plaxis predicted the expected soil deformations (*Figure 2*). Strength and stiffness parameters are derived from laboratory research and tested against the spectrum of values from experience with the Amsterdam soil layers.

The geotechnical predictions and analyses from the design stage have been translated into a monitoring plan, in which the surveillance of influences on the Rijksmuseum during the implementation is specified. The objective of monitoring during execution of the project was the availability of measurement data at various stages of execution on the development of possible deformations, vibrations, and changes in the groundwater levels. The measured values were compared during the execution phase with the alarm and limit values set in the monitoring plan.

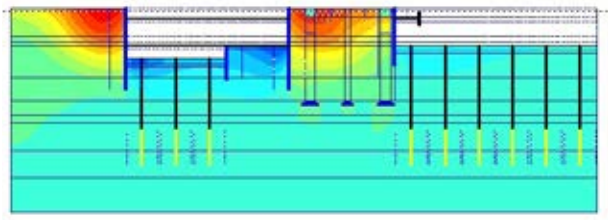

Figure 2: Plaxis model

The Rijksmuseum lifted

The design of the architects Cruz and Ortiz introduced a number of serious constructive challenges, such as the complex replacement of the basement structure of the passage. In the following paragraphs, a more detailed overview is given on the construction phases of this part of the renovation.

In order to demolish the existing basement, the load from the above structure has been diverted by means of steel frames and jacking techniques to a temporary foundation. To achieve this, the groundwater level was lowered to the bottom of the existing basement floor. This made it possible to drill holes in the basement floor for the purpose of the new (temporary) foundation piles. In order to absorb the increased splitting forces in the temporary situation, the foot of the existing masonry columns and walls have been strengthened and a stability frame of steel has been applied. After removal of the passage floor, hydraulic jacks were placed on the support structure, which consist of a temporary pile foundation and steel beams. By bringing the hydraulic jacks to tension, the top load was transferred to the new temporary foundation.

Figure 3: Demolition of the existing basement structure

The existing basement structure could then be removed and was fully carried by the temporary structure (*Figure 3*). After local reduction of groundwater level and excavations, the new concrete foundation piles were made. The new basement structure needed curing time after which the permanent flat jacks have been installed between the new basement structure and steel beams. By tensioning, the loads are again completely transferred to the original foundation. It was possible to remove the temporary structure and shorten the transit steel beams to include them in de new concrete structure. Finally, the last part of the new basement structure, including the passage floor, were poured. After curing, the stability frame above the passage floor and the stiffening measures for the existing masonry columns and walls were removed.

In order to minimize the chance of damage to the museum during jacking, the following preconditions had been set: the maximum permissible vertical displacement of the columns is set at 3 millimeters, and the existing masonry columns may only be demolished as soon as it is certain that all loads from the column have been taken over by the temporary foundation. An extensive jacking protocol has been drawn up for the work within the above preconditions.

During the entire execution, the measured loads corresponded well to the values determined in the weight calculation and the measured deformations remained within the maximum permissible limits. Thanks to careful design, execution, and monitoring, no damage has occurred at all in the above sensitive structure of the passage. Finally, after years of hard work to make the renovation of the Rijksmuseum a success, the museum has opened its doors again in 2013 to the public. ◄

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Strengthening and energy efficient renovation of terraced houses

Seismicity

By: Ing. M.P. Kleefman, ir. G.J. Slager, and ir. M.M. Scheen
BORG (Consortium of: ABT, abtWassenaar, BAM Bouw en Techniek regio Noord, BAM Advies & Engineering, and BBN Adviseurs)

Since the 2012 earthquake of Huizinge, in the Groningen province, a lot of developments are made in terms of strengthening measures. Engineering companies are working in teams to find the best solution for seismic strengthening of the buildings. One of the teams is called BORG, a company specialized in seismic analysis on buildings in the province of Groningen. Employees of BORG, all with different backgrounds and expertise, work closely together to create durable solutions for the seismic strengthening of buildings. In addition to seismic strengthening and renovation, there is an opportunity to make these buildings more sustainable at the same time.

Eight housing corporations from the earthquake area in the Province of Groningen are working with Centrum Veilig Wonen (CVW) to combine the seismic strengthening (according to the NPR9998) with the renovation of rental housing. At the same time, the energy efficiency of the houses is upgraded to Net-Zero-Energy Building (NZEB) standard, which means that they can be occupied in an energy-neutral manner.

Figure 1: Semi-detached house, before the renovation

Centrum Veilig Wonen has asked BORG to make the seismic strengthening advice of several projects. In early 2017, BORG started the seismic strengthening advice for the renovation of 375 houses in the province of Groningen. The project comprised of 38 sub-projects, located in eight different villages spread around the province (*Figure 1)*.

At first sight, the existing buildings look quite similar. However, there are a lot of differences between the sub-projects: There are several types of dwellings (semi-detached houses, terraced houses) from different construction periods (construction years dating from 1948 to 1974), carried out with various construction methods and with several foundation methods (piles, strip footings, or masonry foundations).

Moreover, a short lead time of the various sub-projects is necessary. The assignment is that BORG makes the strengthening advice. After that, seven contractors with their own structural engineers take care of the further constructive design and development of the sub-projects, based on the seismic design.

Seismic design
One of the methods to assess the seismic capacity of buildings is the nonlinear pushover (NLPO) analysis. The NLPO analysis is widely used at BORG. With a NLPO, the structure of the house is subjected to an imposed displacement, which leads to a global force-deformation relation, also called the pushover curve of a building.

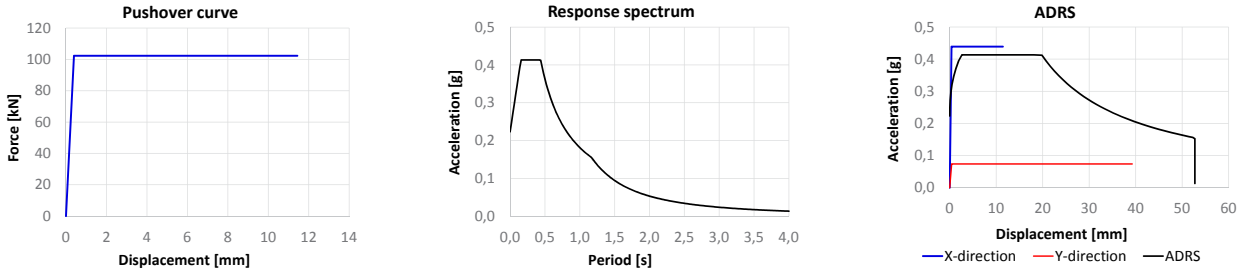

Figure 2: (a) Bi-linearized pushover curve, (b) response spectrum, and (c) Acceleration Displacement Response Spectrum

The structure of terraced houses consists mainly of unreinforced masonry walls and timber or concrete floors. From this structure, an analytical 3D model (3Muri or ETABS) can be created to compose the pushover curve, or a calculation by hand can be made for each main direction of the building. *Figure 2a* gives an example of a pushover curve of a house in the strong direction. When the horizontal force (this is the building's force capacity) – of this curve is divided by the building's mass, the pushover curve becomes an acceleration-displacement relation (*Figure 2c*). *Figure 2b* gives a response spectrum for a given earthquake.

From the response spectrum, an acceleration displacement response spectrum (ADRS) can be composed (*Figure 2c*). The pushover curve can then be plotted with the seismic ADRS. The global stability of the building is not affected by the earthquake when the pushover curve satisfies the seismic demand (the acceleration or displacement capacity is larger than the seismic event). In this case, the x-direction is not affected by the earthquake (acceleration capacity is larger than the seismic acceleration), while the y-direction does not satisfy the seismic demand. Therefore, this direction needs strengthening.

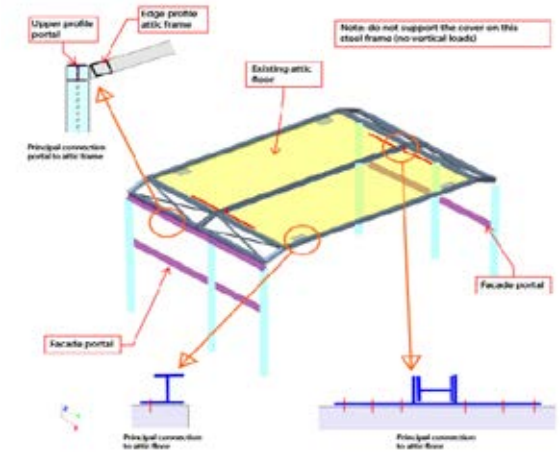

Figure 3: Seismic design sketch

Terraced houses have a clear weak direction due to the typically large openings in the front and back facade. Generally, the seismic demand is not met in the weak direction, which means strengthening is necessary. Sometimes strengthening of the strong direction (direction of the building walls) is also necessary (*Figure 3*).

A widely applied strengthening measure, for the in-plane behavior of masonry walls, is using steel moment frames. These frames are designed by also using the NLPO analysis. By using this analysis for steel frames, it is allowed to give these steel frames a large horizontal displacement, in the order of 50-100 millimeters, whereby the steel frames have a ductile behavior. Due to this, energy is dissipated and forces in the steel frames are relatively low compared to moment frames that are designed linear elastic. By keeping the forces low, less or no strengthening of the foundation is needed.

After the global behavior of the house is checked, individual parts are analyzed. For masonry walls, the out-of-plane behavior should be checked and, if necessary, strengthened. Out-of-plane failing of a wall means losing the in-plane capacity, which influences the global stability behavior of the building. Therefore, out-of-plane behavior of stability walls is an important mechanism to analyze.

Figure 4: Final result

Other individual parts of a building are analyzed, such as the roof structure, floors, connections between these elements, and the foundation, to complete the seismic strengthening advice. When this advice, including strengthening drawings, is finalized, the contractor and their advisors can complete the structural design with detail engineering and integrate this in the renovation plan. This plan also contains the energy efficient upgrades of the building.

Energy efficient renovation

After the seismic strengthening structure is added to the existing building frame, the masonry outer leaf is replaced with a high-quality insulated and earthquake-resistant facade, with triple-glazed windows. Also, the houses are fitted with a new, insulated roof, including PV panels. The installations for heating and ventilation are completely replaced by new, energy-efficient equipment, such as a balanced ventilation system with heat recovery unit and a heat pump. This means that the net zero energy building-concept can be met. With these measures, these houses are completely earthquake-resistant and energy-efficient renovated (*Figure 4*). ◄

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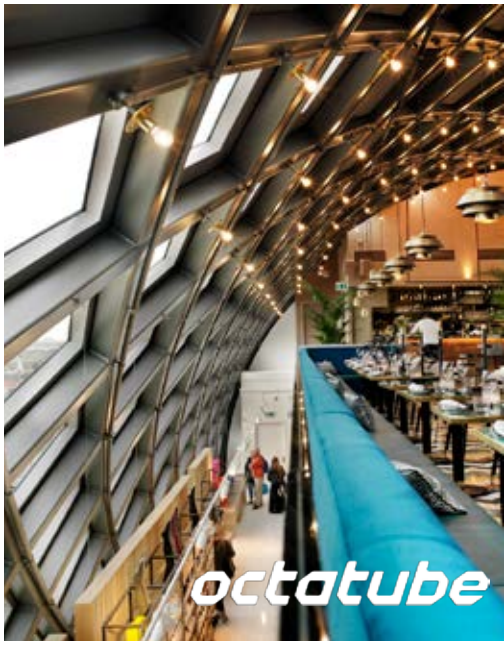

Elaboration of NEN 8700

Renovation for a structural engineer

By: Lars Hogenboom
Editor KOersief

Circular construction is, more than ever, a relevant theme. Reuse of materials, reuse of structures, or even reuse of entire buildings are hot items in today's society. An important extrinsic motivation might be the depletion of certain building materials. It should not come as a surprise that the resources needed for instance, for concrete, are prone to this depletion. Reuse of materials, entire structures, or even entire buildings need a lot of measuring and calculation. To quote the Cement [1]: "Luckily, and justly, structural engineers are becoming more and more involved in the early process of redevelopment of a building."

Designing a structure, which is to be constructed, is done according to design codes. The structure is based on different parameters, most of them already known in an early stage. Larger renovation projects have more question marks during the design stage. Do the structural drawings match reality? Is the current structure in a good state? Is it even feasible to reuse the structure?

The structure as it is needs to be evaluated. Lots of structures differ from the drawings, for example by alterations during construction. Therefore, the structural engineer needs to visually check the structure, as is recommended for the engineers from other fields of the built environment. Together, the stakeholders can conclude whether it is feasible to proceed to a more thoroughly assessment. Original calculations and drawings can help gain insight in the remaining capacity of the structure, thus self-evidently archives need to be visited. However, archiving of these documents has not been consequently done over years. As stated by the Cement [2]: "Soil quality reports, cone penetration tests, and structural reports are often absent in the archives."

After gathering this information, the engineer is capable of making a first quick scan. Afterwards, it can be concluded if a structure needs adjustments and whether these adjustments are again feasible. When the gathered information is insufficient, (non-)destructive testing could be inevitable. A more broad analysis needs to be conducted to assure the structural safety of a building. NEN 8700 introduces the renovation level, and insufficiency level. By this introduction, three levels to evaluate a structure are made: the sufficiency, the renovation level, and the insufficient level (*Figure 1*). This code is ought to be a guide for an assessment on every existing structure older then fifteen years. Some essential differences between the codes for renovation and new buildings are:

1. Assuring the safety level is relatively expensive for renovation projects in comparison to new buildings. This is why lower safety factors are acceptable in some specific cases.
2. The lifespan of the structure is often different in comparison to newly built structures, since in specific cases the estimated lifespan is already exceeded. The remaining lifespan of a building is often assessed. The level of insufficiency is given to buildings having a remaining lifetime of less than a year. The renovation level states that a structure has a remaining lifetime between 1 and 15 years. Authorities could reject a structural design with a detailed motivation.
3. As stated earlier, the possibility to evaluate the structure is incorporated in NEN 8700. This is an addition to the code for newly built structures.

Figure 1: Illustration of the sufficiency level, renovation level, and insufficiency level

For the transition of a building, the existing structure should of course withstand the loads for its new purpose. If this is the case, and a building has a remaining lifespan of more than 15 years, no adjustments are necessary. One could investigate the possibilities for the resistance of the structure to withstand higher loads than strictly necessary, if this is for example desired by a municipality.

If certain elements do not meet the requirement of a remaining lifespan of more than one year with a reference period of at least 15 years, adjustments need to be made which meet at least the renovation level. Without these changes, the level of structural safety is named insufficient. The extra capacities are the main reason for NEN 8700 to contain normative guidelines and recommendations. The main points for this insufficiency level are the following:

1. It differs from the basic norm, NEN-EN 1990. The norm is regarding the loading history, regardless the type of material, and the probabilistic behavior of the building type itself.
2. The lifespan that is regarded for the capacity of the structure is one year. The lifespan for loading conditions depends on the consequence classes. CC1A takes a lifetime of exactly 1 year into account. CC1B, CC2, and CC3 are keeping a lifetime of 15 years into account. This differs from NEN-EN 1990 that could incorporate a lifetime which needs to be assessed of 50 or 100 years.
3. The division of consequence classes is different for NEN 8700, in which CC1 is divided in CC1A and CC1B. Buildings with CC1A have a safety class 1 according to NEN 8700 and have a reference lifespan of one year according to the Bouwbesluit 2012, which was published before NEN 8700. Buildings with CC1B have a safety class 1 and a reference lifespan of 15 years.
4. According to public law, a structure is insufficient when the level of safety could not be met regarding a minimum remaining life time of at least one year.

If the structural safety of a building is above the minimum level of insufficiency, but beneath the renovation level, the owner of the building decides whether and what measures are taken. By partly changing, renewal, or enlarging a structure, one could calculate with the remaining lifespan of the renovated building part. This renovation level is mainly introduced due to feasibility. Renovation is often not feasible if codes for newly constructed buildings are considered. To visualize how NEN 8700 is working with the new construction level, the renovation level, and the existing structure level, *Figure 2* illustrates NEN 8700 regarding the reliability of a building against the time. ◄

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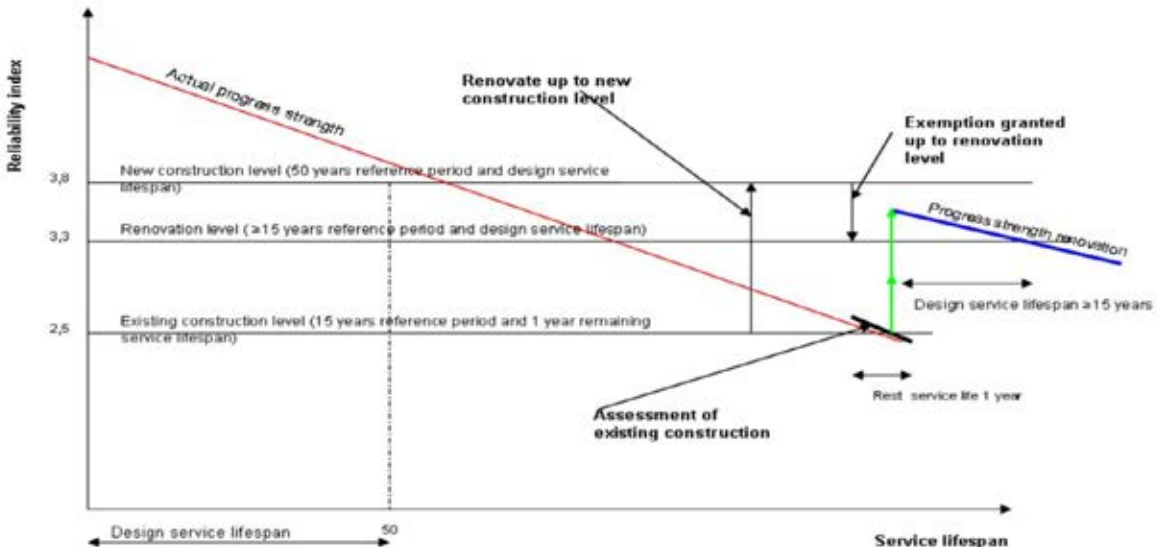

Figure 2: Illustration of regulations regarding structural safety in terms of reliability over time

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News

By: Cement
Knowledge platform about concrete structures

Confusion over the definition of the concrete strength class
The compressive strength is one of the most important properties of concrete. You can express this strength in various ways. In practice, there is sometimes confusion about which value to use in calculation.

Cubic versus cylindrical
The difference between cubic pressure strength and cylindrical pressure strength lies in the test pieces for which the strength is determined. The same concrete will give a higher strength in a test on cubes than in a test on cylinders *(Figure 1)*. In the Netherlands, the strength class is usually determined according the cubic strength. A characteristic cubic pressure strength is thus determined (the second number in the indication of the strength class). However, the structural engineer does not calculate with the cubic pressure strength but with the cylindrical pressure strength (the first number in the indication of the strength class).

Figure 1: Compressed cylinder (left) versus compressed cube (right)

Weighted maturity
The strength class does not say anything about the strength development. In order to be able to say something about this strength in an early stage, it has to be determined, e.g. to determine the moment of demolding. For this, different methods are available. The most reliable and most applied method is the weighted maturity method. However, it is not (yet) possible to define the strength with this method

Calculating with the demolding strength
The required demolding strength must be translated to a characteristic compressive strength. The structural engineer must be aware that in order to achieve a characteristic strength, the average value on site must be much higher. Also, a contractor is thinking more easily in an average strength Therefore, it is important that the structural engineer, contractor, and manufacturer communicate clearly about the type of strength they are using.

Concert hall floats seven meters above ground floor
The Elisabeth Center Antwerp is situated at the Koningin Astridplein, right next to the central station and ZOO Antwerp, in the heart of Antwerp. The new Queen Elisabeth hall is a structural eye-catcher (*Figure 2*).

Figure 2: The concrete wall, supported by a concrete portal

For the structural design, the maximal interaction between the entrance area and the existing historic buildings is important. As a result, the hall as a whole was lifted 7 meters. In order to achieve this, a hybrid structure of concrete and steel has been designed. The hall itself is a kind of concrete box with 20 meters high walls on each side. The floor of this box is supported by a number of beams in the transverse direction which are connected on top of concrete columns. The roof is supported by steel trusses. The hall gets its stability from the concrete walls. On three sides these walls extend partially into the basement. For the concrete wall on the entrance side this was not possible. Therefore, this wall is supported by an architecturally designed, rigid concrete portal (*Figure 2*).

The 20 meters high longitudinal walls are supported in the out-of-plane direction by buckling stiffeners via the cantilevered balconies. The stiffeners can transfer the forces to the walls in transverse direction by means of in-plane force distribution. ◄

More about these topics can be found on www.cementonline.nl/...
[1] .../sterkte-welke-sterkte
[2] .../concertzaal-zweeft-7-m-boven-begane-grond

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A project of BAM

Renovation of Tilburg Central Station

By: ir. Pierre Hendrikx
Structural engineer at BAM Advies & Engineering

In the city of Tilburg, BAM has recently started the renovation of Tilburg city hall. The project is a UAV-regulated work that was tendered in two parts: demolishing/stripping of the existing building and renovation of the building with existing building structure. The demolition was executed by demolishing company Gubbels.

In 1969, the city hall was constructed. Now, about 50 years later, the building is ready for a makeover, because of the changing demand in the city of Tilburg. In addition to the previous functions of offices and the city council, space is made available for shops and meeting facilities for the citizens of Tilburg. The building consists of three parts and a parking garage, ranging in height from 7 to 45 meters (one to ten stories). Next to the building there is a palace connected to the city hall by a bridge. The palace originates from 1847 and was constructed under supervision of King Willem II of the Netherlands. Nowadays, the palace and two adjoining sycamore trees (platanen) are registered as a monument, which means they may not be damaged at any cost. Since they are connected to the existing building, this poses a challenge for the execution of this project. *Figure 1* shows an overview of the plan.

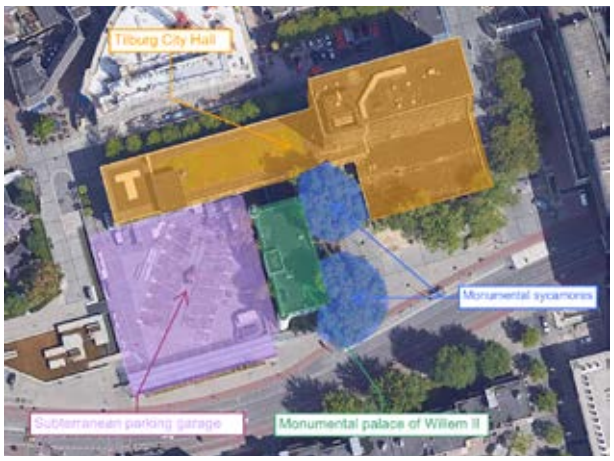

Figure 1: Overview of the plan

The major part of the structure is maintained, which makes it a renovation project. For the execution of the project, maintaining the existing concrete structure is a fairly 'hard' boundary condition. On the one hand, you are bound to the condition of the concrete structure, which is 50 years old, and on the other hand, you are bound to the choices made during the original building phase. In the 1960's, the buildings were resurrected bottom-up and completely cast in place. Floors, lintels, and parapets are one monolithic structure, which can be seen in the cross-section in *Figure 2*. As a result, access of the floors for materials and equipment is limited to the height of the original window openings.

In addition, due to the close urban environment of the project and the parking garage near the building, transportation of large goods to and across the building site is challenging. An idea to optimize the transportation,

Figure 2: Cross-section of the tower with highlighted floors and lintels

is to locate the a crane on top of the tower (at 45 meters above street level) with a span of 60 meters for improved accessibility. As a young engineer, these calculations on itself are not everyday practice, even without taking into account the effects of aged concrete. Nowadays, one of the advantages that makes the challenge easier is the use of laserscanning. After the stripping phase, the building is measured through laser scanning with sophisticated equipment. Engineers are able to combine this data with a 3D BIM model to recreate the building within the margins of millimeters. This method allows the engineer to do a great part of his work before the start of the renovation on site, which reduces the risk of errors during the execution phase.

Project information

Architect	DEDRIE Architecten
Structural design	IMd Raadgevende Ingenieurs
Contractor	BAM

For more information on the progress of the project and other projects of BAM works on, visit http://www.bam.com or https://www.bambouwentechniek.nl/specialismen/bam-advies-engineering.

Near the start of November, the reconstruction started and the plan is to finish the building near the end of 2019 (building time ± one year). ◄

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Internship experiences of a KOers member

By: Britt Cordewener
Master student Structural Design

A year ago, I decided that, as an addition to my study program at the TU/e, I wanted to gain some insight in the practical field of structural engineering. So, during the Bouwkunde Bedrijvendagen, my search for an interesting company to follow an internship. During one of the workshops, I got to know Pieters Bouwtechniek, a progressive engineering firm with several offices in the Netherlands, specialized in the design and engineering of a broad range of structures. Pieters Bouwtechniek is involved during all stages of the construction process, from the early design stages up until the final construction phase. With an interest in construction technology as well, this was exactly the reason I was very glad to be able to do my internship at their company.

My internship started with a meeting in December with Ycha van Diermen, one of the Partners at Pieters Bouwtechniek in which we discussed my field of interest and the general set-up of my internship.

In February, I started working four days a week under the guidance of Walther Plönes (a TU/e alumnus). I got the chance to work on a broad range of projects, varying from the preliminary structural design and rough cost indications of a spaceframe roof of 200 x 200 meters, to the structural calculations and reports of a festival stand for TREK. In this article, I will tell you something more about some projects I worked on and what I learned from my internship.

My first project concerned a cost indication of a large space-frame roof. For a roof of 200 x 200 meters, any improvement in the profile size and thickness of the profiles can save a significant amount of money. With the help of SCIA Engineer the stresses in all steel members were analyzed and ranked in several categories in order to optimize the total weight (and costs) of the structure.

Furthermore, I have been working on a wide range of projects. Among others, I performed preliminary design calculations and made the structural design drawings for several housing types for residential park Hoevelaken.

With the architectural drawings as input, a structural design was made and the corresponding design calculations for slabs, columns, and walls were performed with the help of Technosoft calculation software. Some additional calculations were then performed for cantilevered slabs and foundations.

One of the fun small projects I worked on as well, was the structural design and calculations of a festival stand for the foodtruckfestival TREK. The stand was to be built quite soon. However, the structural design was still open for many possibilities.

In close collaboration with the builder, several building methods were elaborated to finally come to the most suitable and (easily) demountable construction method. The project was concluded with a report containing all structural calculations and in ultimate limit state (ULS) and serviceability limit state (SLS), and we even got to see the end result in Rotterdam (*Figure 1*).

Figure 1: TREK foodtruckfestival

One of the projects I was most involved in, was the structural design and calculations for a residential building in building application phase. In close collaboration with Orga Architects, we aimed for a structural design with low environmental impact, resulting in large Douglas trusses.

The extraordinary design resulted in complicated connections and details for which additional calculations, for (among others) the moment and shear capacity, were performed.

To conclude, it could say I really enjoyed my internship at Pieters Bouwtechniek Utrecht and I learned a lot of it. Above all, it helped me to gain insight in what working at a structural engineering firm would be like. I could recommend it to all students, since it is a good preparation for the future and it also prepares you to deal with aspects that we do not learn during our study. ◄

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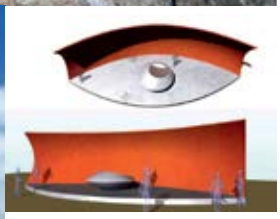

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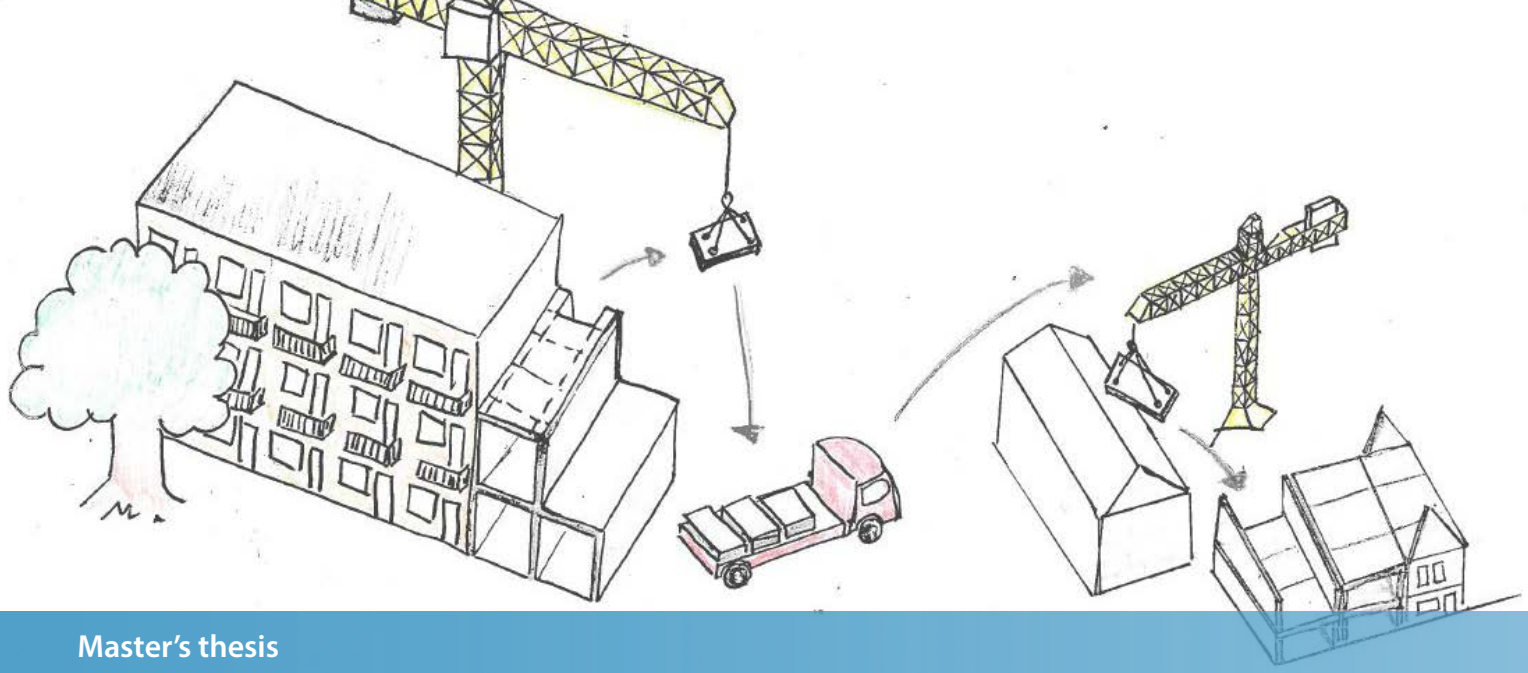

Master's thesis

Structural feasibility of reusing concrete floors

By: Eline Dolkemade

Supervisors: prof.ir. S.N.M. (Simon) Wijte, prof.dr.ir. T.A.M. (Theo) Salet, ir. R. (Ronald) Wenting

In 2016, the Dutch government published a program that aims for a circular economy before 2050. In a perfect circular economy, no waste is produced. Products will be maintained as long as possible, after which elements of the products are reused as complete as possible. To close the circle, raw materials are reused for the same or a better product. Although many materials are already being recycled in the Netherlands, the demand for raw materials is growing, just like the production of waste. In practice, waste will always be produced, but can be limited. For instance, by using waste products as alternative raw material in another production cycle, as shown in *Figure 1*. The governmental program mentions the construction industry as one of the five priorities that require a specific approach.

At the beginning of the research, little knowledge was available about the circular built environment. Several reference projects with a circular philosophy have shown that for a circular building demountability, reuse of elements, and a material passport are the most important changes compared to regular construction. Due to the large application and the attention to the environmental impact, the research focuses on concrete structures, in particular on monolithic concrete floors. Comparing a concrete structure in the current industry with the scheme of *Figure 1*, it is striking that each phase is already accounted for and new developments are still going on. The only phase where it is still quiet is the reuse of elements. Despite the fact that discarded concrete already gets a new life as road foundation or in small amounts in new concrete, the lifespan of a concrete structure could be extended far greater by reusing it in elements. In this way, the great advantage of a concrete structure, its long life span, can be fully utilized and no new cement is required. When it can no longer be used in buildings, the concrete can fulfil its useful function under a road.

In the Dutch built environment, it is common to pour concrete on site in formwork to construct a structure. Especially in residential building construction. These structures do not really fit in the circular philosophy in terms of reusing elements, due to their monolithic character. This might be one of the reasons that the use of on-site casted concrete decreases. However, the current building stock consist of many monolithic concrete structures that might be demolished in the future. In this study, it is considered whether these residential monolithic structures could be reused in elements. To narrow down the study, the focus is on story floors, because they occupy the largest volume in a structure.

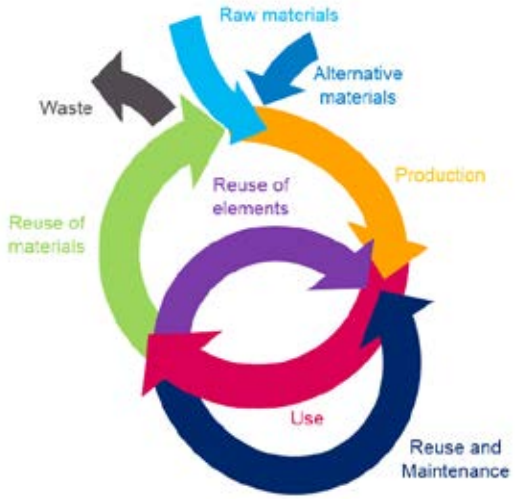

Figure 1: Circular economy

The frameworks of the research is determined with a literature study. The examined floors originate from residential buildings that are constructed between 1960 and 1990, because of their large presence in the current built

stock and they are currently being demolished the most. Slabs reclaimed from these buildings might have a limited capacity regarding to fire resistance, a limited available span, and a limited load bearing capacity. For these reasons and due to the high level of standardization, it is chosen to apply the reclaimed slabs as story floors in terraced houses (grondgebonden eengezinswoningen). With help of a case study is examined how reclaimed slabs can be applied in new terraced houses according to the current standards. Taken as a starting point is that the new floor structure must be demountable according to the philosophy of circular construction. The release of the reusable slabs is assumed to be done with a sawing method similar to making savings in monolithic floors. If monolithic floors will be reused in large quantities, as described in this research, the deconstruction method is the first thing that needs to be improved. Special attention must then be given to equal mutual distances between saw cuts or another method of making a cut.

The study resulted in a step-by-step plan to determine whether a monolithic floor can be reused, based on minimal design rules for the new application, and a set of principle details to apply reusable slabs in terraced houses. The report can be used as guide for the engineering of a reused monolithic floor applied in a terraced house. The step-by-step plan logically starts with the collection of information about the geometry and materials applied in the original floor. In subsequent steps, this information can be checked visually or with tests. Ultimately, the precise geometry and the location of the reinforcement is known for the new application. This information can also be documented directly in a material passport to advance future reuse.

A floor in general has two primary functions, namely: to transfer vertical loads to the supports and to distribute horizontal loads to the bracing walls. The transfer of the vertical loads mainly depends on the capacity of the floor slabs to resist negative clamping moments and on the capacity of the main reinforcement. In residential construction, walls and floors are often stacked directly on top of each other. The floor is restrained to rotate freely, because the loads from the walls and upper stories also have to pass through the floors. This may cause negative clamping moments at the support. The resistance can be provided by the tensile strength of the concrete or the present top reinforcement. To ensure the capacity of the main reinforcement, a certain anchorage length is needed from the face of the support. Because slabs are cut, the reinforcement continues until the end of the slab and the available anchorage length is equal to the support length (*Figure 2*).

For the distribution of the horizontal loads, the floor slabs need to collaborate as a diaphragm. To create shear resistance between the slabs demountable connections with anchors can be applied. In existing floor systems consisting of slabs, like hollow core slabs, the sides are profiled to withstand horizontal and vertical shear forces with a concrete filling. The reusable slabs could be improved by creating profiled sides that interlock or a special filling could be used to increase shear resistance.

The most drastic parameter is the span of the floor slabs. This not only has a great influence on the capacity of the reusable floor, but also on the design in which the slabs will be reused. The smallest span of a standard terraced house is 4.2 meters. If the reusable span is smaller, an intermediate support needs to be applied. Due to the variety in spans and capacity of floors in existing buildings, it is not possible to standardize the dimensions of a reusable slab. Despite that standardization of geometry is preferred for a second-hand structural elements market. In order to create a market for the reuse of monolithic concrete floors, there must be room for variation in the span. In general, more design creativity with smaller spans applies to the reuse of structural elements.

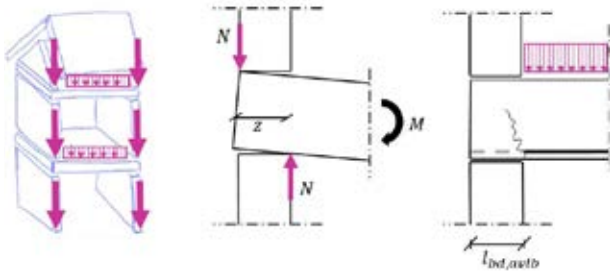

Figure 2: Vertical loads may cause negative moments due to stacking of walls and floors. Limited anchorage is available for the main reinforcement.

Due to limited architectural requirements and applied loads, it is in many cases possible to apply floor slabs reclaimed from monolithic floors in terraced houses up to two stories and an attic. If more stories are applied or the loads are increased with for instance a flat roof, it is possible that the anchorage of the main reinforcement must be improved or negative moments at the supports must be decreased.

When it comes to limiting raw material use and CO_2 production, the reuse of floor elements seems to have a positive impact. This positive impact depends on the measures that need to be taken in the structure to accommodate the reuse of floor slabs. It is possible extra material needs to be added to provide the elements with an opportunity to a next life or the rest of the structure must be more robust to compensate for the floor its capacity. However, the impact of a structure on the environment cannot only be assessed on the amount of material that is used, the equipment that is used to reclaim the slabs and the transportation is also of influence. In general, reuse of elements or materials should not be a goal but a method to reach a lower environmental impact.

Reuse of monolithic concrete floors, in the manner described in this article, is a solution to deal with the current building stock in a circular economy. For future, more circular proof, concrete structures, the disassembly of a structure must be simplified. Even if elements are not reused for a next life, demountability improves the labor intensity of demolition and decreases dust and noise pollution to the environment. However, as long as the costs of concrete are low and the raw materials are not perceived as scarce, the reuse of concrete elements is not yet very attractive. ◄


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Structural optimization of shell structures with material nonlinearity

By: Gido Dielemans

Over the years, popularity of shell structures have come and gone. One of the most noteworthy periods in shell development was defined by Felix Candela and Heinz Isler. At first, experimental determination was used to analyze the behavior of shells. With the development of the Finite Element Method, the field of engineering is further advanced. This numerical analysis can include all sorts of geometrical and material effects. The latter of these effects have not yet been researched much in conjunction with optimization of shell structures.

Previous research has shown various methods and optimizations and compared them to one another. In the case of structural optimization with linear assumptions the optimized result has proved to be dangerous, as the structure may have less structural capacity than the original when optimized in thickness. This has been shown by Lee&Hinton (2000).

In addition to the optimization parameters, that have shown to be of great relevance for the usability of the optimization result, we have to account for imperfections in the process. Shells are especially vulnerable for deviations in the final shape and thickness. The result of including imperfections into the optimization has shown we can reduce the imperfection sensitivity drastically. This research was done by Reitinger&Ramm (1995). *Figure 1* gives an overview of optimization objectives of shape optimization of a cylindrical shell.

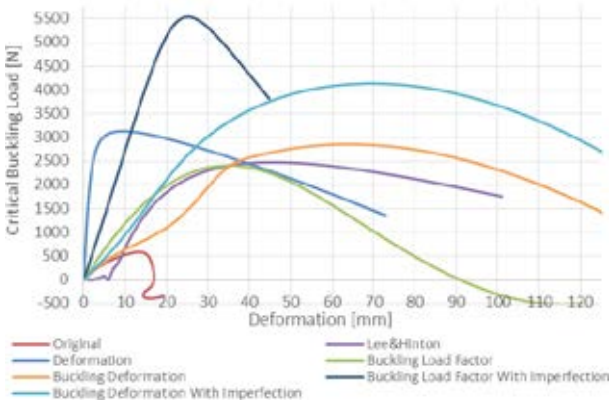

Figure 1: Results of shape optimization of a cylindrical shell with three objectives: deformation of the perfect shell, deformation of the imperfect shell, and mean critical buckling load of the perfect and imperfect shell.

Accounting the material nonlinear effects into the optimization of shell structures has not been excessively analyzed. Therefore, this research is being done to determine if there are dangers in shells that have not been optimized, with inclusion of nonlinear material assumptions. ◄

Shear behavior of concrete-to-concrete interfaces

By: Lars Croes

The partial collapse of the parking garage at Eindhoven Airport caused concerns about the structural safety of existing precast slab floors. In Eurocode 2, the shear capacity of an unreinforced concrete-to-concrete interface is based on the visual characterization of the surface roughness. To re-evaluate this relationship between surface roughness and shear behavior, shear experiments have been designed. These shear experiments plot the shear stress capacity as a function of the compressive stress perpendicular to the interface. The starting point of the trend line of the experimental data at $x = 0$ indicates the initial cohesive shear strength of the concrete bond, expressed as $c \cdot f_{ctd}$ in the Eurocode. The slope of the function indicates the influence of friction, expressed as $\mu \cdot \sigma_n$ in the Eurocode.

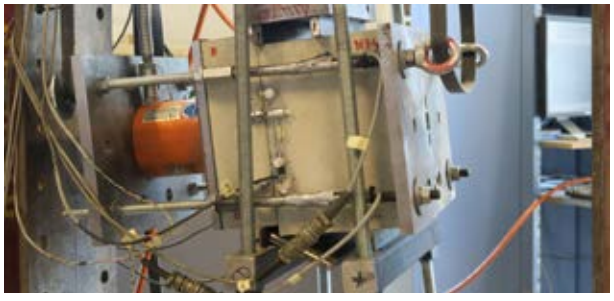

Figure 1: Shear specimen after failure

These coefficients of cohesion and friction are based on a qualitative inspection of the surface roughness. To compare the shear behavior of the shear specimens to the interface roughness, a quantitative evaluation of the surface roughness is performed by performing 1,500 depth measurements of the interface. A multitude of roughness parameters are derived from these roughness distributions. Within each experimental series, with six to nine specimens per series, bond strength tests, cube compression strength, and splitting tensile strength are performed. The analysis of the experimental results in respect to the material and interface parameters, together with a FEM analysis of the experimental setup, shall be presented in the final thesis. ◄

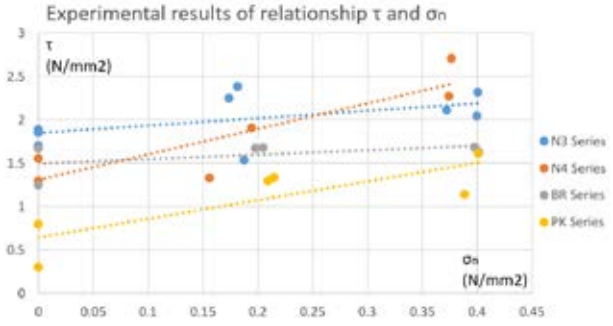

Figure 2: Regression analysis of experimental results

Angelique van de Schraaf

The experience of...

By: Angelique van de Schraaf MSc
Structural Engineer at B-invented

In 'The experience of…' a person from the business community tells their story about the experience in and around the Build Environment. This time it is Angelique van de Schraaf, who graduated in 2016 from the TU/e, with a master Structural Design. Now, she is a structural engineer at B-invented.

After graduating, I spend some time thinking about what I was looking for in a day-to-day job. Two things were important for me: sustainability and optimization of the construction industry. I found out that B-invented fits really well within this description and I started working there as a structural engineer in January, 2017. In the role of structural engineer I work within the foundation and construction partner department (see the text in the blue square).

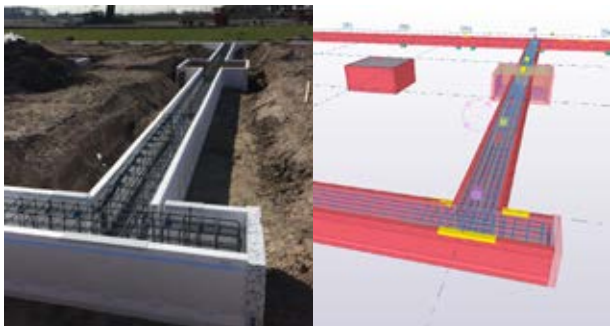

Figure 1: The prefabricated element on site during the construction phase and the 3D model in Tekla during the design phase

Foundation
The foundation department B-smart is a subcontractor, which means for all functions involved it is important to keep in mind the construction process. As a structural engineer, I design the foundation and calculate the required reinforcement, which involves a lot of optimization. The situation in practice is sometimes different than our schematization. Therefore, the engineering team has to check the current situation as soon as possible to ensure that the work and planning on the construction site suffers as little as possible from these differences. Due to the standardized system, the work contains repetition and that offers many opportunities for optimization. As a structural engineer, you can go deeper into the matter, because this will earn itself back in practice.

Construction partner
For a construction partner, the focus is mainly on collaborating with engineers, installers, and architects to arrive at an optimal design together. Much consultation is devoted to optimization and the correctness of the assumptions. As structural engineer, I check the reports of the subcontractors. Of course, they also try to optimize their design. My job as main structural engineer is to ensure that the structural integrity and robustness are not compromised.

Not only on paper, but also on the construction site the quality must be guaranteed. This makes the checks on the building site extremely important.

Diversity
I mostly enjoy the variety between these two functions. The main difference between being a structural engineer for the foundation unit and for the construction partner is the process span. The substructure requires a process span of only four weeks. After that, you go on to the next project and you do not actually see the finished project. As a structural engineer at a construction partner, you sometimes spend three quarters of a year or more working on a project and including the execution it can be years. During the process, changes have to be made to the original structural design for various reasons until there is an integrated design that includes all disciplines.

The most important tip I can give someone is that you have to think carefully about what kind of company you want to work for, there is a big difference between designing and working for a contractor. I had always imagined myself as an all-round structural engineer to start with. However, I got an advice that starting with a specialism can actually have benefits for designing buildings later on. If one knows how to handle a project on a detailed level it is easier to get insight into the bigger picture as an all-round engineer and you will know exactly what to look out for! ◄

B-invented
B-invented is an engineering company that believes that the building industry should be more durable, more economical, and more creative. Especially the problems of work pressure, material scarcity, and inefficiency of the building process.

B-invented is one of three companies (B-smart, B-invented, and B-happy) that stands for improving the building industry. B-invented specializes in realistic and constructible engineering. B-smart is our foundation company in which we combine engineering and realization of the foundation with our own foundation system. And we have our own construction company called B-happy that realizes complete structures. The engineering and building is combined into a no nagging guarantee. Their moto is "To build what makes you happy"!

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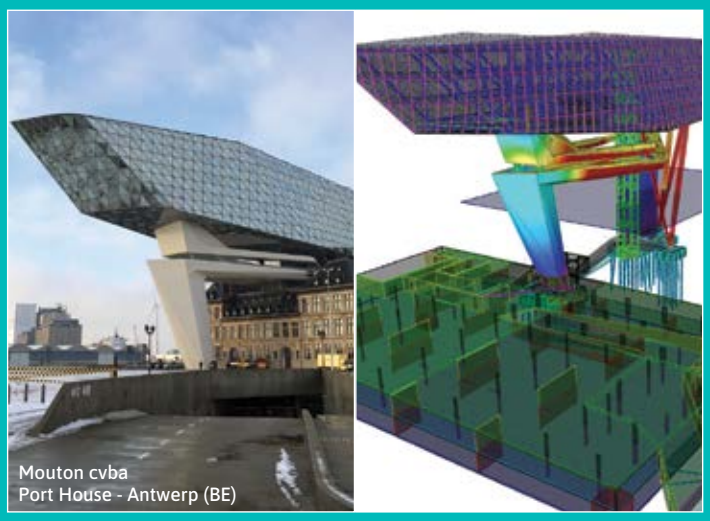
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Modeling damage formation of oil paintings

By: Gijs Eumelen MSc
PhD candidate October 2017 - October 2021

Deterioration of historical oil paintings is a major problem for art conservators. An enormous amount of oil paintings, ranging from the sixteenth century until now, show signs of deterioration. Most of the deterioration of these paintings is the result of the formation of metal soap and craquelure.

Metal soap is able to form from a chemical reaction between the pigments and the oil binder in paintings. It is known that metal soap can cause several problems. These problems can be both visual and mechanical. One of these problems is the formation of protrusions. A protrusion is a metal soap crystal that has broken through the surface. Disfiguring it, leads to damage and flaking of the paint. Craquelure, on the other hand, is a fine network of cracks that has formed on the painting. This is a result of fluctuations in the climate conditions.

The aim of this PhD research is to obtain more insight into these problems from a mechanical point of view. In order to do this, a numerical model is developed that can simulate the growth of a metal soap crystal and the formation of craquelure, as both phenomena also interact with each other.

Currently, two aspects of this problem are investigated. The first one is related to information about the material properties of the historical oil paintings. The second one is related to the modeling of metal soap formation inside a paint layer.

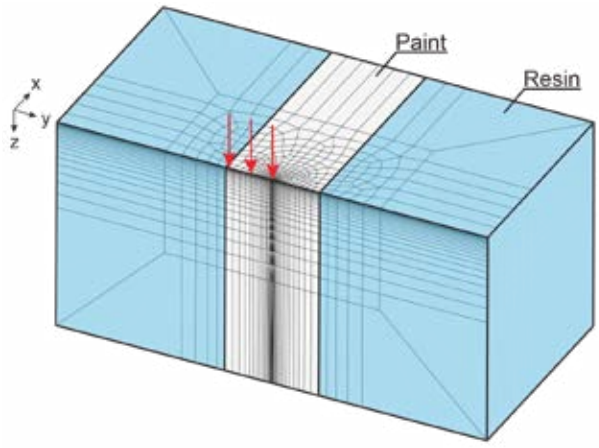

Figure 1: Three dimensional finite element model based on experimental setup from The Getty Conservation Institute

To accurately model the mechanical behavior of a material, it is essential to have information about the material properties so these can be used as input. For historical oil paintings, obtaining these is not straight forward. It is undesirable to perform a tensile test on a sample of, for instance, a Rembrandt. However, the correct material properties might be obtained from small scale paint samples by means of nano indentation tests. These samples are embedded in a resin, this results in the fact that the measured stiffness of the paint differs from the actual stiffness.

In order to assess the influence of the resin on the experimental data, a three dimensional finite element model is developed (*Figure 1*). This model is used to assess the influence of different stiffness mismatches of the paint and the resin. The finite element model is also used to study the influence of the indentation location. The results of this model will eventually be compared to experimental results from The Getty Conservation Institute in Los Angles.

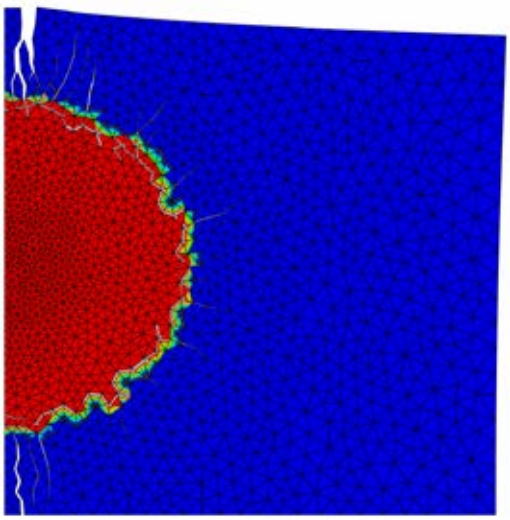

Figure 2: Final result of a simulation showing damage formation in a paint layer (blue) as a result of the growth of a metal soap crystal (red)

To model the formation of a metal soap crystal inside a paint layer, two models are coupled together. The first model is a diffusion model that accounts for the chemical reaction caused by the pigments and the oil binder. The second model is a mechanical model to assess the damage formation by metal soap on historical oil paintings (*Figure 2*). This coupled model is solved by a staggered approach. Here, the results of the chemical model are used as input for the mechanical model and vice versa.

These two models provide the first steps in understanding the mechanical behavior of historical oil paintings. However, a lot more work needs to be done before the results of this research can be used to help with the formulation of conservation guidelines. This is all being done so that everyone, now and in the future, can enjoy the beauty of these paintings. ◄

New on floor 9

By: Monique van Gaalen and Ginny Vissers
Secretaries Structural Design at Eindhoven University of Technology

Ginny and Monique have worked as secretaries at different units at the Built Environment department for a few years now, but since this academic year, they are representing the secretariat of Structural Design at floor 9. They are ready to help you with any questions regarding your study, so get to know them below, or visit them on floor 9!

First of all, thank you for the invitation to write something about us. We are two new members at the secretariat of the unit Structural Design. Monique works 40 hours a week and Ginny 20 hours. We started in July, in the more quite period of the year. We have used this time to arrange the secretariat together with Karin van Nisselrooij of the unit Construction Management and Engineering (CME) and Ingrid Dekkers of the unit of Information Systems in the Built Environment (ISBE).

Figure 1: Ginny Vissers

Monique has worked as a secretary at the unit Architecture Urban Design and Engineering (AUDE) for seven years and Ginny at the unit of Building Physics and Services (BPS), where she worked for four or five years. Nathaly Rombley was the secretary before us and she went to the unit BPS. A change of secretaries at the Department of Built Environment!

What Monique says about Ginny: "Ginny her quality is the warmness and compassion she puts into the things she does."

What Ginny says about Monique: "Monique's special quality is her spontaneously and accurate handling of things. She is very good at all student affairs and sometimes very up to the point. But she always has a service with a smile."

What Monique says about Ginny: "Ginny's quality is the warmness and compassion she puts into the things she does."

What Ginny says about Monique: "Monique's special quality is her spontaneously and accurate handling of things. She is very good at all student business and sometimes very up to the point. But she always has a service with a smile."

In her spare time, Monique plays a lot of tennis (tournaments and competition) and she also joins classes at the Students Sport Centre at the campus. She loves to cook and to spend time with her family. Ginny is a yoga teacher in her spare time. She teaches five hours a week in Eindhoven North. She also likes to walk her dog through the nature, preferably with friends. Her favorite spots are the Joe Mann and the Dommel valley. She is married and has three children, which are still living at home.

Figure 2: Monique van Gaalen

Please do not hesitate to come to the secretariat when you have any questions or other things. You all are more than welcome to visit us! ◄

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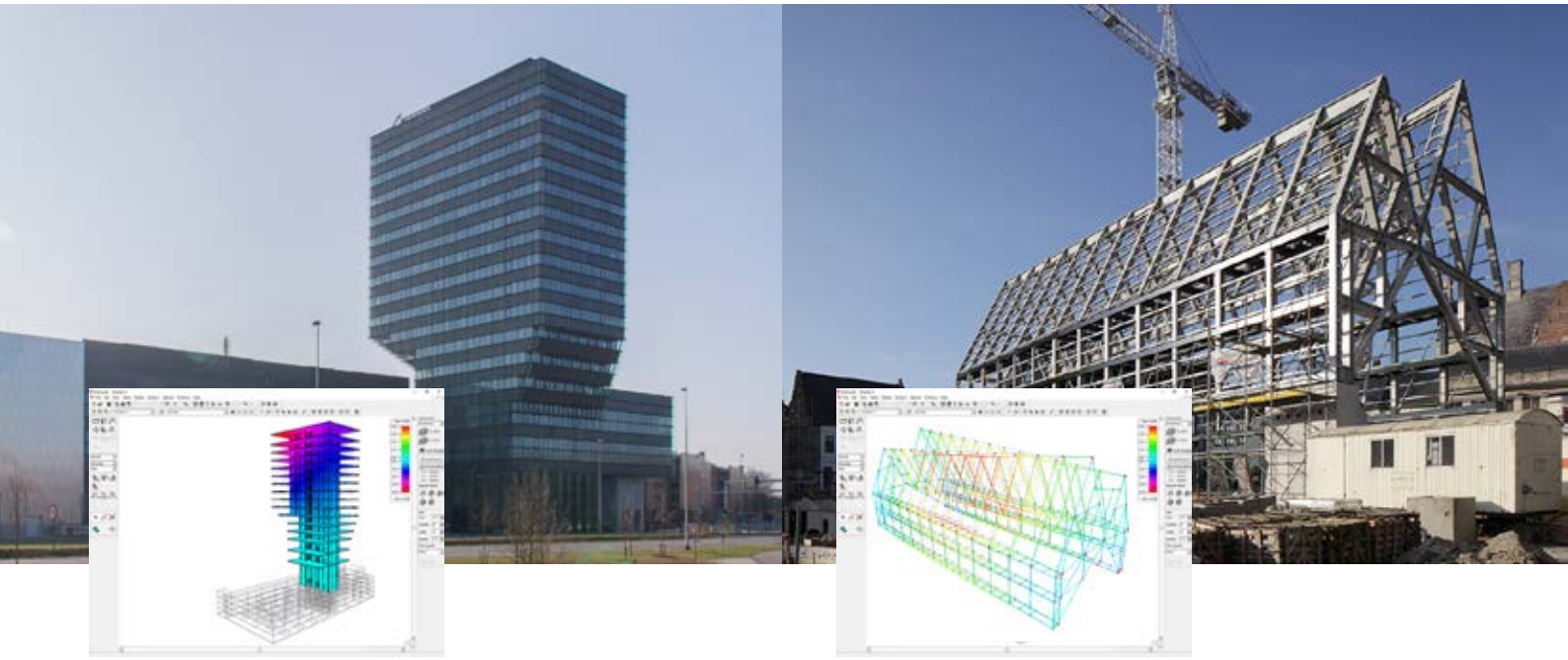

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KOers Puzzle

By: Jelme Pennings, Tim Schellekens, and Derk Bos
Creative KOers members

In the previous edition of the KOers-puzzles, the submission of Jason Al Juma was the closest one to the answers. Therefore, he won the previous edition of the KOers puzzle and a box of apple pastries! In this edition, there are some new puzzles and new chances to show your structural engineering skills. Submissions can be send to: KOers@bwk.tue.nl

Question: Tim's wet toes
Tim (70 kilograms) is walking over a solid steel beam (*Figure 1*) with a width of 300 millimeters and a height of 50 millimeters. The steel beam (S235) has a free span of 50 meters and a free height of 3 meters above a river. Will Tim be able to cross the river without getting wet toes? And with his heavy laptop of 8 kilograms?

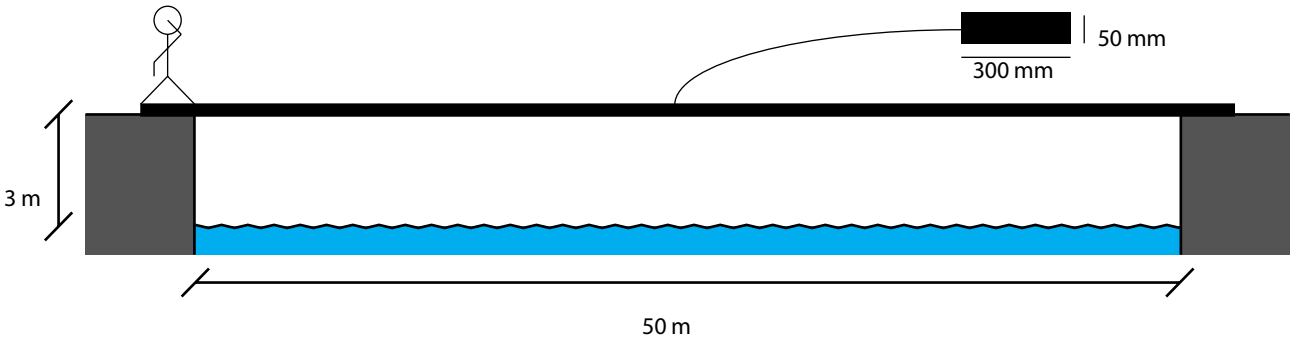

Figure 1: Tim at the start of the steel bridge

Question: Dominique and the vibrating bicycle
Dominique loves cycling at the campus of the TU/e. Lately, however, she is experiencing excessive vibrations during her trip. Even though she did not mind it so much, she wanted to do something about it, because she was regularly distracted by it and she wanted to keep the traffic at the campus safe. Since a pair of shock absorbers were too expensive, she decided to add a mass-spring system to her bike (*Figure 2)*. This system can reduce vibrations, analogous to a tuned mass damper as used in high-rise buildings under earthquake excitation. However, she has no idea how she has to 'tune' the mass-spring system to level out the vibrations of her bike. Can you help her?

The problem can be modeled as a two degree-of-freedom system, shown in *Figure 3*, in which:

m_1	= mass of bicycle and Dominique	m_2	= mass of mass-spring system
k_1	= stiffness of bicycle	k_2	= stiffness of mass-spring system

and $u_1(t)$, $u_2(t)$ = (translational) degrees-of-freedom. The forcing function which makes the bicycle vibrate is given by: $F = F_0 \sin(\Omega t)$

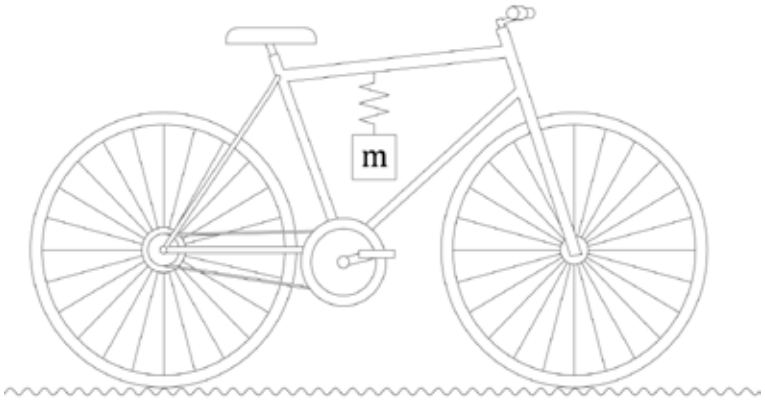

Figure 2: The bike of Dominique

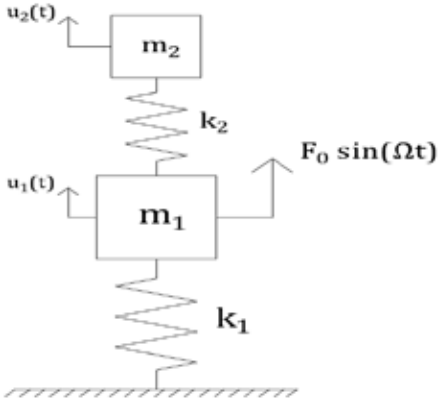

Figure 3: Two degree-of-freedom system

Column

Addicted to hydrocarbons

Hans Lamers

Renovation is a hot topic. The stock of older buildings, particularly houses, is still growing while the necessity for lower energy use for houses becomes more and more urgent. In the Netherlands, we have to abandon the use of natural gas in our homes. Of course, renewable energy is the magic word.

Our small planet, with a population over 7 billion people, produces a lot of carbon dioxide. This greenhouse gas absorbs long wave radiation and heats up the atmosphere. Maybe you have noticed that the summer of 2018 was exceptional warm. An indication of global warming? The emission of carbon dioxide is a kind of indicator in terms of criticizing human activities. You can draw up for example the carbon footprint for travelling one kilometer by car or travelling one kilometer by train and compare these values. Before the industrial revolution, around the year 1880, the carbon dioxide content was 280 parts per million. In 2016, this content was already 45% higher, reaching the value of 407 parts per million. Rather shocking, is it not?

So housing, transport, industrial activities, in fact everything that uses fossil fuel is on the eve of a fundamentally important transition to a carbon dioxide neutral society. What will be the best option for the older houses? Renovation or demolition? The answer depends on a series of pre-conditions. One of them is the choice of the time window to be considered. My gut feeling tells me that renovation fits better to a short term approach whereas for long term solutions an innovative way of thinking and a complete new green design is more desirable. So let us all think, brainstorm, be creative, and change the world not only for the better but for the best.

Colophon
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