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**Last year’s Theses**

Master’s Theses July 2010
Master’s Theses March 2010
Master’s Theses October 2009
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Graduation Theses March 2010
Research groups and professors within the faculty of Civil Engineering and Geosciences
Preface

For graduates is the master thesis the final part of their study. With their thesis they prove that they are ready to receive the title of Master of Science. The previous years of study at our faculty have given them the skills and the knowledge to complete this important task. All the theses presented in this book reflect the high quality of our graduates. They have not only addressed relevant problems of society, but also presented innovative solutions. Their theses reflect their capabilities and their readiness to start their careers.

For the faculty of Civil Engineering and Geosciences the presented thesis are important to prove the societal relevance and quality of our educational programme. The high standards we pursue at our faculty can be found in throughout this book. Relevant issues like coping with climate change, sustainable design and are skillfully addressed by our graduates. By also providing solutions they reflect one of the aims of our faculty, to contribute to the progress of society.

Currently I am very proud to present our graduates in this book, and I wish them good luck in continuing their valuable work in society.

Prof.ir. Louis de Quelerij
Dean of the Faculty of Civil Engineering and Geosciences
What is the graduation book exactly?

"Master's Theses Oktober” contains summaries of the theses produced by various students who obtained a Master of Science degree at the Delft University of Technology. The students in question graduated in “Civil Engineering”, “Transport, Infrastructure and Logistics” or “Offshore Engineering”.

The purpose of this publication is to inform professionals working in these fields about recent developments in teaching and research at the Faculty of Civil Engineering and Geosciences. In many cases, the subject of the Master's thesis is based on a request from professionals working in the field in question. In other cases, such individuals will collaborate in the realisation of a Master’s thesis. Alternatively, the thesis may be part of a wider research project within the department itself. The primary goal of the Master's thesis is to round-off a student's course of study at the TU, and to enable them to graduate as a Master of Science. As the regulations stand, this requires an investment of 22 to 26 weeks of study. The summary of every completed thesis is published in "Master’s Theses march 2009", whether they are merely average or truly outstanding.

The book’s layout
The summaries of the various theses are published per Master’s programme and specialisation:

- The Civil Engineering Master's programme has five specialisations:
  - Structural Engineering
  - Building Engineering
  - Hydraulic and Geo Engineering
  - Water Management
  - Transport & Planning

- The Offshore Engineering Master’s programme

- The Transport, Infrastructure and Logistics Master’s programme

All of the summaries have a similar layout. Call the department in question if you require further details about a specific thesis (the phone number is given at the end of each summary).

The section containing the new summaries is followed by a comprehensive list of those produced last year. The layout of these summaries reflects that of the previous publications.

A Master's programme spans several different departments, each of which corresponds to a specialisation within the programme in question. At the end of this book is a comprehensive list of specialisations, which includes the names of their respective professors.

The aim of the book
The main purpose of publishing these Master's theses is to ensure that the outside world is better informed about the research that is carried out at the Faculty of Civil Engineering and Geosciences. It is also hoped that this book will enhance communication with professionals working in this field, and help them to become better informed about the capacities of current graduates.

Further details
Contact the department in question if you require further details about one or more of the published summaries (the phone number is given at the end of each summary). A small charge is sometimes levied to cover the costs of printing and posting a thesis. It is not always possible for us to send complete theses. If you so wish, you can also make an appointment to view a particular thesis.

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Civil engineering theses

*Structural Engineering*
Structural Failure in the Netherlands

Introduction

In recent years, a number of construction accidents happened in the Netherlands, such as the collapse of balconies in Maastricht, of a theater in Hoorn and of a parking deck in Tiel. This led to the wish to screen structural safety. Both on technical as on legal side, there have been written lots of articles and there have been reports published about collapses in general, about roof collapses, about analysis of cases from anonymous sources and from news sources. All these studies have limitations. This present study provides a broader and more reliable point of view about structural damage. Through this study I hope to make a contribution to the debate about structural safety in the Netherlands.

Research

The main goal of this research is to determine the causes of structural damage. The results of this research are being compared with results of other research such as the ABC Pilot. In addition, the research examines how legislation and regulation play a role in ensuring structural safety.

This study presents 151 cases of structural damage of various kinds and identifies their causes. The source of data is Dutch case law (decisions of the Raad van Arbitrage voor de Bouw, the Stichting Arbitrage-Instituut Bouwkunst and the Commissie van Geschillen van het KIV). In this research, the term "structural damage" is defined as damage which leads to an unsafe situation or a situation where serviceability requirements are not met. It encompasses besides structural collapse, cases of instability, foundation settlements, excessive deformations, cracking, premature deterioration of materials (for example corrosion) and leakage (of roofs, facades and basements).

Results

Analysis of the data shows that two different types of errors can be distinguished which are very common: design errors and execution errors. 34% of the structural damage caused by design errors. These failures include calculation errors, failure to consider relevant loads and drawing errors. 32% of the structural damages is caused by construction errors. These failures include premature removal of temporary supports, non-conformance to design intent and inadequate assembly by construction workers. 20% of the structural damage is caused by a combination of design and construction errors.

This research also shows that there are some shortcomings in regulations, but they do not significantly take part in the causes of structural damage. Also, legislation appears to be complex for many parties in the construction industry. Furthermore, the current liability system has some drawbacks.

By comparing the results with other studies it appears that there are some similarities and differences. ABC-pilot shows big similarities concerning type of error and construction parts. "Veiligheidsproblemen met gevelbekleding" and "Instortingen van lichte platte daken" shows that often causes are similar to the present research.

Recommendations

1. improvement of checking of the design and inspection on the building site;
2. investigation of the possibility to install a compulsory registration of structural damage which will be reviewed by an independent organisation;
3. investigation of the underlying causes (human factors) of structural damage;
4. investigation of a several aspects of modifications during design, construction and usage;
5. investigation of several aspects of the duty to warn.

Student: W.F. Boot

For more information you can contact the section Structural Engineering, tel. 015 2783174.
In this thesis project it has been researched and established that it is technically feasible to create Special Nodes using Ultra High Performance Concrete (UHPC) as the construction material which contains fibre reinforcement but does not contain passive reinforcement. A Special Node is a structural element that connects incoming members in a frame structure, has a complex 3D-geometry and has geometrical distortions in the form of holes.

For this purpose a computational structural design tool that is called VisionNode, has been developed. VisionNode creates Special Nodes through computational optimisation which is performed by a genetic algorithm. The algorithm is incorporated in VisionNode and continuously exchanges data between a geometric-modeller, which creates the geometry of the Special Node, and a Finite-Element-Model, that determines the technical feasibility of that Special Node. The goal of the optimisation process is to create structural nodes with a complex 3D-geometry and geometrical distortions in the form of holes while optimising for material efficiency and satisfying the structural capacity of the material UHPC. Material efficiency is achieved by reducing the volume of the Special Node and the structural capacity is determined through a Mohr-Coulomb-Failure-Check. The result is an optimum design of a Special Node in UHPC that satisfies all structural checks and has a minimal volume.

Through the interactive graphical-user-interface of VisionNode, users can create a Special Node based on their design preferences and design modifications. Users can specify where material must be used and where no material must be used in the Special Node. This way the holes in the node can be created. VisionNode operates according to expectations. As a result, Special Nodes in UHPC can be created using the computational structural design tool.

The Special Nodes in UHPC are manufactured though fully automated 3D-milling of the concrete mould using polystyrene as the mould material. When the mould has been created, the UHPC mixture is poured in the mould and the Special Node is created. The computer model that is needed for the 3D-milling machine is produced by VisionNode.

In the two figures, a Special Node in UHPC created with VisionNode is presented. The geometry of the Special Node is shown in Figure 1 and the corresponding Finite-Element-Model is shown in Figure 2.
Corrosion of steel reinforcement in 12 years old concrete: Inspection, evaluation and electrochemical repair of corrosion

The purpose of this research was to study the behavior of corrosion in concrete specimens after 12 years old. In 1998, concrete prisms were cast with four different cement types, three different water/binder ratios, two different cover depths and two different chloride-rich admixtures. Then, several concrete specimens were exposed to separate environmental conditions: salt/drying or carbonation. These differences have influenced the rate of corrosion with regard to the characteristics of each concrete mixture and exposure.

The main aim behind this project was to use as much as possible non-destructive testing (NDT) in order to preserve the highest quantity of specimens for further research. Three different aspects were studied in this project with regard to corrosion of steel in concrete. First, labels in concrete specimens were lost due to weathering over time; therefore, inspection of concrete specimens was carried out in order to identify the most probable concrete mixture in all specimens. This stage of study involved a combination of non-destructive testing by the means of visual inspection, electrochemical measurements and statistical analysis. Results showed that it was possible to identify cement types in specimens exposed to salt/dry cycles and mixed-in chlorides. However, for carbonation specimens this approach did not gave the same confidence in results.

The second stage of study includes on-site electrochemical measurements over three different time periods, November 2009, February and April 2010. These measurements involved properties like corrosion potential, concrete resistivity and corrosion rate. Results show that in chloride exposure, either salt/dry cycles or admixed-in, specimens containing blended cements (CEM II, CEM III and CEM V) performed better in terms of these properties. In carbonated specimens, Portland cement concrete showed better performance than the rest of concrete mixtures. Influences of environmental conditions, temperature and relative humidity were also studied. It seems that corrosion rate is favored when drier (10 ºC and 80% RH) in overall specimens.

Finally, an electrochemical repair technique of Cathodic Protection was proposed in order to study the effect of current in steel bars actively corroding. Special attention was placed in the electrical current demand of steel bars according to their previous corrosion state and different concrete composition. Also, destructive analysis of concrete after CP treatment was carried out to study the visual state of steel reinforcement, the chloride content in concrete and the size of corrosion pits. Results show that the initial current demand and overall charge flow through steel bars during the treatment period are related to the state of steel deterioration by corrosion rate means. Tests done in order to measure the pH in corrosion products did not gave reliable results; therefore, an improved test set-up is required. Chloride content profiles show that even after the loading of chlorides in salt/dry specimens stopped during year 1999, internal diffusion of chloride has been still occurring.

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Design of walls with linear elastic finite element methods

Introduction
The introduction of Eurocode EN1992-1-1 allows structural engineers to derive the required reinforcement for wall-type structures directly from their in-plane stress fields. The required membrane forces can be determined efficiently by means of linear elastic finite element analyses. One of the major advantages of this recently approved method is its economical attractiveness. Compared to hand calculations software is capable to analyze complicated structures within a very short timeframe. Besides, the required amount of reinforcement which follows from this method is more economical compared to for example the strut-and-tie method. The method deviates however considerably from common design methods such as the beam- or strut-and-tie method. Especially the assumption that reinforced concrete can be approached as an isotropic linear elastic material can be called into question, since load transfer mechanisms may develop which deviate considerably from the ones that can be expected in cracked concrete. This gave reason to examine this method in further detail.

Approach
The design of reinforcement with linear elastic finite element methods (LE-FEM) was analyzed in further detail by considering single- and two-span specimens, loaded at midspan. These specimens are characterized by a relative limited amount of reinforcement bars which have to reach the supports. In addition, due the assumed linear elastic isotropic material behavior the development of a tension arch can be observed in the in-plane stress field to transfer the applied loads to the supports. Required reinforcement for the considered specimens was positioned similar to the output of LE-FEM, taking all relevant code provisions into account. In a subsequent step the structural behavior of the considered specimens was analyzed in the non-linear finite element program ATENA, which is capable to simulate the behavior of reinforced concrete numerically. To make a clear comparison with the design process a similar reliability index was taken into account during the non-linear analyses.

Conclusions
A study into the reinforcement design with LE-FEM by considering single- and two-span specimen led to the following main conclusions:

- Assumed linear elastic material behavior of concrete during reinforcement design with LE-FEM does not approach concrete behavior in an accurate way.
- No direct relation is found between the limited amount of longitudinal reinforcement which reaches the supports and the observed failure mode. Concrete crushing in the compressive zone, caused by flexural deformations, turned out to be the normative failure mode.
- Reinforcement designs according to LE-FEM do not meet requirement related to crack control in the serviceability limit state. It is not possible to determine the stresses in the required distributed reinforcement without the application of advanced (non-linear) methods, since there is no direct relation between the applied load and stress development in individual reinforcement bars.
- Design of structures with LE-FEM which are loaded by a compressive force and contain symmetrical reinforcement, such as columns, results in undeserved optimal reinforcement configurations since eccentricities are left out of consideration.
- Redistribution of two-span specimens in case differential support settlements appear is insufficient to withstand settlements which are allowed by the codes.

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V-shaped pylon concept

A study of the mechanical behavior and design consequences of a cable stayed bridge with V-shaped pylons

In all concepts suitable for bridge designs with large spans the cable is one of the key construction elements. Where in the suspension bridge and the arch bridge concept the cables between the deck structure and the main structural component (respectively the main cable and the arch) are more or less vertical, in the cable stayed bridge concept the cables are inclined. This inclination leads to longer and less effective cables. A concept exist where the cables in a cable stayed bridge become shorter and more vertical, this is the so called V-shaped pylon concept. In this concept the vertical pylon is replaced by two pylon legs that have a V-shape, the tips of the pylon legs are connected to each other by a cross member. Due to their inclination one of the tips of the pylon is located above the main span and the other above the side span. The cables are connected at these tips and thus are shorter and more vertical. In this thesis a theoretical study was performed on the mechanical behavior and design consequences of the V-shaped pylon concept. The thesis focus on the design of an asymmetrical cable stayed bridge with a main span of 300 meters, a side span of 132 meters and a pylon height of 132 meters above the deck and 32 meters below the deck.

Before calculations were made with a FEM model first the V-shaped pylon concept was analyzed analytically. A general analysis of the mechanical behavior of a cable under an angle was made, which showed the dramatic decrease in effectiveness for cables under large angles. Next the effect of the V-shaped pylons on the cable system was analyzed, which concluded that it would lead to a general increased vertical support stiffness of the deck structure. This increase in stiffness leads to a decrease in maximum deformation, rotation and curvature (related to bending moment) of the deck, the deformation is decreased most, rotation and curvature less. This decrease in deformation, rotation and curvature can be beneficial because of comfort restrictions, for instance in the case of railway traffic. With the use of two inclined pylons instead of one vertical, stability is influenced negatively. As the surface of the cross section for each pylon leg is halved, either the overall stability is reduced by more than half or the local stability is reduced. Leading to either global buckling or local buckling issues. The cross member transverse a large tension force, as it transfers the tension force from the cables in the main span to the anchor cable. For the cross member it was chosen to use S355 or S460 as construction material, if a cable would be chosen as the cross member element, elongation would be up to 3.2 times higher than in the case of S355 construction steel, resulting in a reduced stiffness and higher bending moments in the pylon legs.

From a simple FEM model it was concluded that a rotation of the front pylon in the range of 15-30 degrees would lead to the best results, using these results a second more detailed model was made. The more detailed model used the real loads from traffic and the cables were tensioned to obtain a horizontal deck under the permanent loading. The cross sections were chosen such that the design stresses were not exceeded. From the results it was concluded that with increasing rotation of the front pylon the amount of material for the cables was reduced, while the amount of material for the cables was increased. At an angle of 20 degrees the best results were found, the cost of the bridge only increases lightly while deformation, rotation, curvature, bending moment and normal force in the deck are reduced. With higher angles the costs increase more rapid as the extra cost for the pylons are not compensated by the decrease in cable cost.
The feasibility of full 3D modeling of concrete viaducts

For the strength assessment of concrete viaducts using non-linear finite element analysis, the appliance of volume elements is considered to be more efficient in the modelling stage then using shell elements. These volume element models give a comprehensive representation of the structure although performing these types of analysis results in long computational time. This study focuses on the feasibility of such a model in terms of modelling effort, analyzing time and implementation possibilities.

This study is carried out in co-operation with TNO DIANA and the Dutch Ministry of Transport, Public Works and Water Management. The Finite Element software and servers of TNO DIANA are used to model and analyse the viaduct. The Ministry has provided a real case viaduct where cracks/damage were observed during inspection. In a prior research a shell element model has been made and analysed, focussing on the area where cracks were detected. These results are compared with the volume element model of this study. The objective is to make the model as comprehensive as possible.

In order to determine which type of analysis is best suitable for the large scale model, 14 smaller models, representing a particular part of the viaduct are made with varying solid element types, integration schemes and sizes to examine the models behaviour. The outcome of this preliminary examination is used in the large scale model.

Whilst performing the main analysis of the large scale model it was ascertain that the initial model based on the preliminary examination was to comprehensive to compute. The initial model is consequently scaled down several times. This resulted in three feasible variations of the model, containing only linear hexahedral elements. Performing linear static analysis, one of these variations was considered as the most accurate option in comparison to the initial model.

Manual mesh operations in combination with the workarounds that have been developed for the reinforcements are rather inefficient. Constructing the model with hexahedral elements was therefore more time consuming than initially assumed. The final model contains 237367 hexahedral elements and 951351 reinforcement particles. The net computation time takes more than three weeks. Scaling down the mesh in combination with the several runs to complete the analysis will result in a computation time of months rather then weeks. Instead of making the initial model as comprehensive as possible to explore the limitations of volume element analysis, it is more appropriate to commence with an unelaborated model.

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Autogenous and drying shrinkage

Autogenous shrinkage in concrete is a phenomenon that has been known since the beginning of the twentieth century, but of which only in recent years the practical importance has been recognized. Despite the growing interest in autogenous deformation, the mechanism behind it remains poorly understood. More and more relationships and influences become increasingly well known and we know how to deal with this phenomenon.

But despite this progress, in practice still some problems are occurring that we cannot explain. For example, in Japan, but also in the Netherlands, some concrete structural members performed with blast furnace slag cement (BFS) show several cracks. Possible this cracking can be ascribed to autogenous shrinkage. This is remarkable given that a water-cement ratio (w/c) of over 0.40 was applied, and according to conventional ideas no significant autogenous shrinkage should occur. These conventional ideas are based on the use of ordinary portland cement (OPC). These case studies are the reason to explore whether or not these conventional ideas is a good way of thinking.

Several experiments has been conducted to investigate the autogenous and drying shrinkage at a w/c of 0.45. Thereby three types of cement has been used: Portland cement and two Blast Furnace Slag cement with a different fineness. In the figures beneath the results are shown.

The graphs show some remarkable results. First of all, the autogenous shrinkage is much larger than expected and can not be neglected as assumed. Furthermore, existing literature, as well as the Eurocode, is based on the presumption that autogenous shrinkage does not increase any more after 91 days, which is clearly not in accordance with the results. And as last, the graphs show no clear difference between the two different finenesses of BFS, which was expected.

In the thesis there has been made a comparison with the measured values and the Eurocode. Furthermore, it has been shown that the measured autogenous and drying shrinkage can led to cracking under certain circumstances. This has been done with the software program called HEAT.

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Phenomenological modeling of ice induced vibrations of flexible offshore structures

In the exploration of worldwide gas and oil fields the arctic regions are nowadays also taken into consideration. Moving towards this harsh environment brings new challenges for design. Offshore structures in arctic regions, Figure 1, need to be designed to withstand the large forces which are exerted by drifting ice sheets and ridges.

Occasionally vertically-sided offshore structures experience sustained vibration due to drifting ice sheets crushing against them. These vibrations, more commonly known as Ice Induced Vibrations (IIV), may lead to fatigue problems, safety issues and uncomfortable working conditions.

As a consequence of the complexity of the ice crushing process that takes place in the course of IIV, to date only phenomenological models exist of ice failure in the course of IIV. These models are capable of predicting the onset and severity of these vibrations. In this study a number of improvements are proposed to existing phenomenological models in an attempt to answer the following particular questions:

(i) Can IIV occur at high ice sheet velocities?
(ii) What are the conditions for IIV to occur not at the fundamental frequency but at a higher natural frequency of the structure?
(iii) Can an initially a-periodic ice loading cause IIV?

The proposed model is based on the assumption that at a certain interval of ice velocities the dependence of the mean crushing strength on the ice velocity is descending. Both the discreteness and randomness of ice failure are taken into account. The structure is described as a generalized beam with coordinate-dependent parameters that allow for tuning of both the modal spectrum and modal damping.

Using the proposed model it is shown that an initial a-periodic ice loading can trigger IIV both at low and high ice sheet velocities. IIV at higher modes of structural vibration can be predicted as well if the modal damping of those modes is small relative to that of the lower modes. The obtained results are used to formulate what a more practically applicable fracture mechanics based model needs in order for it to be able to predict the occurrence of IIV. It is concluded that a negative branch in the dependence of the mean interaction force on the ice sheet velocity when an ice sheet interacts with a immovable structure is the key component.

This final statement is checked by developing a simplified model for ice IIV. A lattice model is introduced for the ice sheet in combination with a simple oscillator representing the structure. The interaction mechanism introduced in the model is that of Coulomb-Streibeck friction at the ice-structure interface. This simple model shows to predict synchronization based on the existence of a negative branch in the dependence of the mean interaction force on the ice sheet velocity when immovable structures are considered.

Figure: Offshore platform in partially frozen sea

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The effect of the introduction of the eurocode on the safety level of existing platebridges

Due to the increase in traffic, structures are loaded more heavily. Trucks become more heavy and the intensity is increased. In order to make sure that structures are safe under these heavier loads, new codes are written. These codes have translated the 'real loads' into fictive loads which represent most situations. The codes for the design of bridges are also changed. Due to more research, the methods for the calculation of forces which can be withstand by the structure are modified. The structures are designed more economically nowadays.

To check if an existing platebridge is still safe under the new codes, a calculation has been performed in this study.

In this study a post-tensioned platebridge in the N34 near Sleen (province of Drenthe) is recalculated. This bridge has been build in 1971. The loads are applied according the VOSB1963 and the structure is calculated via the RVB1967. The recalculation will take place with the new Eurocodes (introduced in 2010) and also by the recent replaced VBB1995 (loads) and VBC1995 (structure). The study focusses on the ultimate limit state, but is also checking the service limit state.

The moment capacity is nearly the same in all codes. The capacity on shearforces is changed enormously. This is because of a change in the calculation methods. In the Eurocode a smaller angle of the concrete strut is allowed, this means a bigger bearing capacity. In the older codes the amount of shear capacity of the concrete and steel can be summed up, in the Eurocode the steel has to carry all the load when the concrete is not sufficient.

In all three calculations, the area around the bearing on the middle pier is not safe regarding shearforce, see figure 1 and 2. For this reason an extra calculation has been carried out. Here the calculation of the Eurocode is carried out with a higher concrete strength and a bigger distribution of the loads. The higher concrete strength is possible because the original strength is based on the 28 days strength. The hardening of the concrete is an ongoing process, so the strength of the concrete will be higher than assumed in the original calculation. A bigger distribution of the loads is a subject of research in the Stevin laboratory. From early results a bigger distribution of 4 times the internal lever arm d is allowed (instead of the nowadays assumed distribution of 2 times d).

After these extra calculations, it becomes clear that the structure is safe. The bigger distribution of loads is most effective on the shear capacity and a bigger concrete strength is most effective on the moment capacity. This can be seen in figure 3.
Civil engineering theses

Building Engineering
Damage investigations in concrete buildings

Forensic engineering plays an important role within the building world. It takes charge of buildings, which esthetically or functionally deviate from their intended state. This task includes assessing and consequently conserving the structural integrity of buildings and in doing so, guarding the safety of the public.

Through learning about damages in buildings and understanding the nature of the investigations into those damages, the aim of this thesis was to assess to what degree the characteristics of the investigations were suited to the nature of forensic engineering. The hypothesis that prompted the research was: ‘The currently governing, standardization and control mechanisms implemented in the expertise area of damage research in buildings, could be developed and optimized in order to better match the nature of forensic engineering and in doing so counteract its inherent pitfalls’. A collection of methods, partly determined by the subject area and partly by the findings during the investigation process, was used to research this hypothesis. Firstly, a literature study of the typology of damages in concrete buildings laid the ground work, providing an introduction into the nature of damages in concrete buildings and thus equipping the thesis candidate with enough knowledge to venture into the practical world. The nature of damage investigations was then investigated in a more practical manner by taking part in a damage investigation lead by experts of the Torroja Institute in Madrid, Spain. Issues that surfaced during this thorough, yet specific experience, were then researched on a more global basis by interviewing several experts active in Holland.

The findings were that there was no system in place, in either countries, that regulated or provided effective guidance to damage investigations. Lead by this, the evaluation resulted in recommendations tailored specifically to the nature of the building world. As these recommendations proposed that the building world take a step into the new, the examination of forensic engineering in other disciplines helped shape the recommendations and aided in the confirmation of their benefits as also the realistic assessment of their consequences. In addition, inspiration was gained from complementing areas of knowledge such as that of human error. Finally, the thesis culminated in the formulation of a two-fold method of control, catering to both the scientific as also the creative nature of damage investigations.

1. An obligatory investigation protocol, which guides the shape of the investigation, providing a standard framework in which to perform the investigations.
2. A set of procedural requirements aimed at stimulating quality control of the investigation.

This set of recommendations is aimed at making investigations more transparent and homogenizing the quality of their outcomes by providing both control, as also guidance and support. In the light of the responsibility that forensic engineering carries within society, these recommendations seek to render added protection to all parties involved in damage investigations; such as the client, the investigator as well as the general civilian. The future challenge will lie in completing the initial recommendations given in this thesis and integrating them into the European standards, next to the other regulations governing the building world.

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Sustainable Facade for the Energy museum

Introduction
The design of facades lends itself strongly for an approach where sustainability is an important criterion. In this master thesis the main focus was the design of sustainable facades for an energy museum, which will be located on the pier of Scheveningen.

Problem Definition
The facades can play an important role in this matter, while it strongly determines indoor climate e.g. building physical aspects like thermal insulation, sound insulation, ventilation, moisture and light entrance. Sustainability is not yet a term, which is described in the building decree for the design of facades. However, it is a very important theme of this moment. The ultimate scenario would be if facades, in this thesis the facades for the Energy museum meet all the requirements concerning energy and comfort and contribute to the environment.

Research
My research focused on the development of sustainable facades for the energy museum. To achieve my goal, a special approach was developed to solve the described problem. The approach was divided in the following phases:
The first phase consisted of a review to several aspects within sustainable construction. A review on sustainability in general, a review on commonly used facade materials, a review on ‘renewable energy’ followed by a review innovative solutions for facades, divided in control systems and building technical systems.
In the second phase practical examples of buildings, which can be called sustainable, were considered. Measures, which were met within these practical examples, were taken into account while designing the energy museum.
The third phase was concerned with the architectural, structural and conceptual design of the energy museum.
The final phase consisted of the actual research. The choices of sustainable measures for the energy museum, which were made in the conceptual design, were researched.

Results
1. The review on materials showed that for the facades of the energy museum the material concrete could be very advantageous and offers the possibility to create facades with multiple functions. A function as an intermediate between the inside and outside climate, a structural function and besides that the facade would consist of a heating and cooling system.
2. The review on renewable energy showed that solar power and wind power were the two forms of renewable energy, which could be efficient to apply in the energy museum.
3. The review on innovations on facades showed that a smart solar shading systems and the appliance of triple glazing for the north facade, which is completely made out of glass, to prevent heat losses are innovative solutions which work very well for the energy museum.

Conclusions
The conclusion can be drawn that material usage and energy consumption are by far the most important aspects in the field of sustainable construction. Energy use determines the eventual results for 75 till 85%, materials about 15 till 20% and water usage for 2 to 3%. Optimization by optimizing individual components is not sufficient at this point within the construction industry. An integral approach, combining the right measures for a specific building with a particular function is the right way towards sustainable construction.

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Structural feasibility study and design of a portable stadium

Introduction
Many stadiums are built for large tournaments like the European Championship, World Championship, and Olympic Games. These stadiums need large investments and will be used below their capacity after the tournaments, to be able to cover the maintenance costs. A portable stadium could avoid the vacancy and optimise use of material and site.

Project objective
The design concept should be a 30,000 seat football stadium with optimal lines of sight. The stadium needs to be deconstructed, transported and built within 8 months. To have the right to exist, a portable stadium needs to have obvious benefits over a fixed stadium. Thus, in the structural feasibility study, the following values should be taken into account: functionality, appearance, time and costs.

Research
The main aspects which have been researched are the following:
- The quality of the lines of sight from the grandstand in relation to the structure; the slope of the grandstand, the distance to the field and the height of the grandstand all influence the lines of sight and the needed dimensions for the structure.
- Possibilities of shallow foundation; the capacity of the shallow foundation depends on the depth of the foundation slab and the subsoil. In Europe the possible locations for shallow foundation are limited to the 80% best subsoil.
- Different structural options; the elaborated options are all based on the principles 'direct stability' and transportability. By folding, shifting, rotating or angling the structure, the stability is directly created during construction and the volume to transport is decreased (no need for temporary stabilisation materials).

Results
The design concept is based on 3 dimensional frames supported by double hinged columns. The columns can be folded towards the girder for transportation. The grandstand elements (3 rows = 1 element) are placed on top of the girders and span 2 frames.
- Functionality: the stadium is flexible in use by the possibility of relocating additional functions and the stadium use if loose modules. The stadium can be adjusted for different capacities and has optimal lines of sight.
- Appearance: the stadium will be experienced as a fixed stadium. The stadium can have a unique appearance at every location by different cladding around the stadium.
- Time: the time to construct, deconstruct and transport will be realized within the limit of 8 months. The time is decreased by building with relatively few elements, and by the foldability of the main structure. Unfolding of the frames leads to direct stability.
- Costs: the costs are minimised by decreasing the volume to transport and simplifying the construction (the construction of the frames is standardised).

Conclusions and recommendations
By the design concept the structural feasibility of a portable stadium is proven. A roof structure and a detailed foundation design should be included in a further research. A further financial feasibility study should be done, to prove if a portable stadium can compete with fixed stadiums and portable grandstands from a financial point of view.

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This report describes the present collaboration between architects and engineers. An automated collaboration concept is proposed and elaborated. The result is the development of a prototype of the Parametric Collaboration Tool which has been implemented on a high-rise design during the early design stages.

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Design tool for determining the sustainability of structural designs

Introduction
Building activities have a great impact on the environment. The bearing structure contributes for around 60% to the environmental costs due to material use in a building and thereby for a large part of the total environmental costs for a building. This impact can be reduced by means of ‘Sustainable Construction’.

Problem definition
At this moment, a comparison between structural designs are based on the cost and time of construction, the integration of architectural and installation design and the required construction height. Sustainability is not taken into account in this comparison. For the development of ‘Sustainable Construction’, it is necessary to indicate the degree of sustainability of the various structural alternatives for a building. The current tools for measuring the sustainability of buildings, such as GreenCalc+, GPR Gebouw and BREEAM-NL, are very extensive and not suitable to evaluate the sustainability of different constructive alternatives.

Research
My research focused on the development of a method and design tool for the determination of the degree of sustainability of structural designs. The approach was divided in three phases:
1. Analysis of the problem: study to the present assessment tools and the influence of the bearing structure on the sustainability of a building.
2. The development of the method: Determining the basis for comparison (annual environmental costs) and determining the total environmental costs of a building, based on the structural design, and its estimated service life. The estimated service life is calculated on the basis of the specific building characteristics.
3. Implementing the method into the design tool, written in Java, and testing the tool by determining the sustainability of four structural designs, made for an office.

Results
1. A method for determining the sustainability of a building, based on the structural design. Improvements over the current assessment methods:
   - A more detailed calculation of the environmental costs of a building through a detailed calculation of the material quantities in the bearing structure.
   - A better approximation of the lifespan of a building.
2. An easy to use design tool to determine the sustainability of structural design variants.

Conclusions and recommendations
A flexible designed building, ready for future changes in use of the building, can have a long lifespan. For an accurate assessment of sustainability it is therefore required that the life of a building is determined on the basis of the specific building characteristics and not only on its function. The developed method is able to evaluate the flexibility and the lifespan of the building. It’s recommended that the calculation of the estimated service life of a building will be further developed and calibrated. Further the aspect of dismountable building has to be integrated in the assessment method.

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Crack formation in structural slabs on underwater concrete

A research into the influence factors of crack formation in structural slabs on underwater concrete to come to a practical advice for reduction of crack formation.

In the Netherlands, dive under structures, tunnels and parking garages are constructed using structural slabs on underwater concrete. The underwater concrete is a temporary structure, which is levelled by an intermediate layer of concrete or sand. Foundation piles protrude both the underwater concrete and the structural slab. This way of construction is used with more or less success in the past 30 years.

Crack formation is usually a problem, which is time consuming and costly to repair and gives the project a bad image. Many measures to reduce or prevent the forming of cracks have been invented. The type of measures that should be taken and the effect of the measures is uncertain. This has lead to serious debate amongst experts in the building industry.

This research aims to objectively judge measures to prevent crack formation in structural slabs on underwater concrete. The major uncertainty is crack formation due to climate influences. To analyse the problem of crack formation, Finite Element Modelling is performed. The influence of the annual temperature fluctuations was researched in a thermal model. The degree to which deformation of the structural slab is restrained is looked at in the structural model. The results of the model give insight in the influence factors on crack formation in structural slabs on underwater concrete.

The effectiveness of the measures is expressed in the reduction in probability of crack formation and costs. The most important conclusions are:

- An intermediate layer of sand should always be applied; this reduces both the probability of crack formation and the costs
- The underwater concrete should be designed as thin as possible; this reduces both the probability of crack formation and the costs
- The best way to reduce the probability of crack formation is the application of Gewi piles instead of prefab piles, but this can cost several millions on a large scale project.
- Sections should not have lengths over 20 m; this reduces the effect of crack prevention methods significantly.
- Adding reinforcement can cost several millions on a large scale project, but is inefficient for prevention of crack formation.

Apart from the above conclusions, this research states methods to estimate the stresses in any form of structural slabs on underwater concrete. Also it relates stresses to the probability of crack formation. This makes it possible to perform a quick hand calculation to obtain the probability of crack formation in structural slabs on underwater concrete.

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3.

Civil engineering theses

*Hydraulic Engineering*
“Layout design for greenfield port Filyos”

**Introduction & objective**

On a national level need has arisen for Turkey to realise a new large capacity gateway port. At the Black Sea coast in the province Zonguldak a flat area is available at the delta of the regional river Filyos. According to a previous feasibility study this location is considered optimal for the port. The extent of the captive area is promising. There is expected cargo transport demand from the metropolitan area of Ankara and of the planned local industry. Furthermore, the site conditions and possibility to connect with the hinterland are favourable at Filyos.

The objective for the thesis study is to develop a port layout that offers capacity for the forecasted throughput at adequate operational conditions. To guarantee that the requirements with respect to operational conditions are met, several engineering solutions are implemented in the design. The operational conditions for merchant vessels depend to a large extent on the possibility to manoeuvre in the harbour and to load and unload at berth. These conditions are amongst others influenced by the climate of wind, waves and currents. Focus laid in this thesis study is on the wave climate in the harbour and at the berths. A well considered allocation, orientation and shape of the harbour entrance and berths is therefore essential.

The other focus is laid on the dry infrastructure. Sufficient space for storage and through transport of cargo is required. Furthermore, advisory is needed with respect to the superstructures and the use of human resources.

**Analysis**

In order to design the port layout a thorough analysis is carried out in the thesis. The various boundary conditions for the project are analysed and reported. Amongst others, an overview is provided of socio-economic developments, hinterland connections and forecasts of throughput & vessel sizes for various scenarios. Furthermore, physical conditions are analysed, which are primarily based on obtained survey data. Where information about boundary conditions lacked, starting points are used of which a separate overview is provided. For the main requirements of the project an overview is made, which completes the boundary condition analysis.

In order to develop the layouts, minimum component dimensions are required in combination with an overview of the preferred shape, orientation and location. For this purpose different design guidelines are followed. In order to derive required dimensions in time phasing of the project is chosen.

**Layout development and evaluation**

Three significantly different alternatives are considered in the project including phasing for the medium term (until 2020) and long term (until 2030). These layouts are evaluated on the basis of the following requirements: nautical accessibility and safety, loading and unloading ability at berth, through transport and storage ability, robustness and coast morphological impact. The best layout is selected for further refinement on basis of a qualitative evaluation and on analysis of capital costs. Costs have turned out to be decisive in the selection of the best alternative.

**Refinement of layouts**

The most promising alternative of the previous step is refined with respect to the inner harbour configuration. Different terminal and berth positions and orientations are considered, resulting in two variants of the layout alternative. The layouts are given a quantitative value with the use of an MCE, which are based on model simulations and engineering judgement. A coast morphological model (UNIBEST CL+) and a wave model (SWAN) have been setup for this purpose. Both the resulting values and estimated capital costs of the different layout variants turned out to be close to each other. The layout with the highest ratio of value over cost is selected as best.

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During the construction of breakwaters contractors often encounter undesired reshaping of exposed core material. This reshaping is comparable to the deformation process of berm breakwaters in which the outer profile reshapes into a more stable s-curve. In the case of oblique waves this deformation is enhanced by a longshore transport of stones leading to even more loss of material and damage.

Throughout the years few formulas were derived for both processes which describe the behaviour of berm breakwaters as well as gravel beaches reasonably well. These formulas however turned out to be inadequate when it comes to describing the behaviour of core material. In particular the influence of the wide grading of quarry run, commonly used as core material, is to a large extent unknown and generally not described in the available relations.

To investigate this influence of the stone grading on both the two-dimensional deformation and longshore transport new physical model tests were carried out in the wave basin at Delft University of Technology. In total 12 tests were executed in which two different gradings, three different angles of wave attack and two different wave spectra were tested.

Data collected from the tests included wave and profile measurements together with the displacements of stones, originating from two colour beams which were applied in the middle of the trunk. These data along with visual observations eventually led to a conceptual model describing stone movements in both transverse and longshore direction. Using Matlab three-dimensional profile and erosion models were generated from which the different profile parameters were determined. With respect to the distance from origin, for each test an exponential relation was derived to describe the stone displacements. After determination of the area of uniform transport these exponential relations were used to calculate the total longshore transport by means of extrapolation and multiple integrations.

Subsequently all parameters found were compared to the formulas currently available for both processes. Regarding the deformation parameters the test results produced the best fit with the formulas derived in [Merli 2009]. Still on several occasions a deviant relation was found concerning the influence of wave obliquity. In addition, the formulas became less accurate for the narrow grading used in the tests, which fell outside the range tested by Merli. However, for the crest height of the deformed profile test results deviated completely from the available formula as no influence was found whatsoever for all tested parameters. Here the deviation was contributed to a higher instability of the part above the initial deformation, partly due to the steepness of the slope.

On the subject of the longshore transport clear trends were found describing the influence of the varying parameters. Both a higher wave load and wider grading lead to an increase of the longshore transport. For the wider grading, however, this increase gave a rather distorted image, as not all fractions in the mixture were transported evenly. Due to segregation the coarsest fractions were mostly transported in the transverse direction while the finer fractions were transported further away in the longitudinal direction. Alternatively, computation of the longshore volume transport proved to be more representative. Regarding the effect of wave obliquity an increase in angle of wave attack of 30° to 45° was accompanied by a decrease in longshore transport; though this decrease was less than already available formulas indicated. However despite the fact that it describes a completely different trend concerning this particular influence, the best fit was found after multiplying the relation derived by [Alkhani 1996] with a factor 100.

Full text of the report is available via: http://repository.tudelft.nl/view/ir/uuid%3Acc04f91a-4f2d-4c6c-9c8e-a803a258f500/

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Experimental research on spatial distribution of overtopping

The overtopping empirical formulas calculate the discharge only at the top of the crest of a coastal protection structure. On the other hand, the tolerable overtopping discharges are defined at certain points behind the crest where the total overtopping is reduced. The scope of this thesis is to find an empirical formula to describe the distribution of overtopping at the space behind the crest.

This thesis comes as a further investigation on the work conducted by v.Kester [2009] for regular waves. In this research, a physical model was developed on which irregular waves are tested. Because of the duration of the tests and the amount of collected water (significant lose of water during the test), a completely new measuring system was designed.

Five influencing parameters (variables) are considered on this research: wave height, wave period/steepness, slope angle, crest freeboard and crest permeability.

The entire overtopping process is analysed separately for the total overtopping discharge, the overtopping discharge directly behind the crest and the distribution of overtopping behind the structure.

In the analysis of the data collected from the measurements, the impact of the varying parameters is investigated leading to useful conclusions and better understanding of the entire process. Additionally, the experimental findings are analysed and compared to the relative existing methods.

Based on the TAW [2002] method which is proposed by the EurOtop Manual [2007], a prediction formula is developed which defines the entire process of overtopping:

\[
\frac{Q}{\sqrt{gH_{mo}}} = (0.2 - 0.133 \cdot k) \left( \frac{\gamma_0 \cdot \xi_0}{\tan \alpha} \right)^\nu \exp \left[ -\frac{R_c}{H_{mo} \gamma_0 \cdot \gamma_1 \cdot \gamma_2 \cdot \gamma_3 \cdot \xi_0} \right]
\]

\[\gamma_c = -0.164 \cdot \frac{x}{B} + 0.677\]

This formula is a generic version of TAW [2002] formula in which a new reduction factor \( \gamma_c \) is introduced in order to describe the decay of the overtopping and thus predict the discharge at any certain distance behind the crest:

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For a proper management of rivers and river bends in particular, it is important to have good models to predict the flows through bends. It is important that those models are well validated with experimental data to demonstrate the accuracy of the models. This research comprises a validation of the Delft3D-FLOW model which is often used in practice. For the validation, detailed measurements of flows through a sharp bend (radius/width < 2 a 3) flume, performed at the EPFL (Lausanne, Switzerland) and Large Eddy Simulations (LES) conducted at the TU Delft are used. The objective of this study is to analyze to what extent Delft3D-FLOW is able to reproduce the hydrodynamic processes in sharp open channel bends.

Two cases were analyzed, a horizontal-bed and a fixed, fully developed equilibrium-bed. From the comparison of the simulations and the measurements, it turned out that especially the transverse velocity (secondary flow) is underestimated by Delft3D-FLOW. Some phenomena did not appear in the predictions of Delft3D-FLOW, while they were clearly visible in the measurements and the LES, e.g. the outer-bank cell, which is a cell rotating in a direction opposite to the primary cross-stream secondary circulation.

An investigation of the downstream vorticity balance shows that there are two processes dominating. Firstly, the centrifugal effects are the main driving mechanism for the secondary circulation. The other important mechanism is the anisotropy of the turbulence as it causes the outer-bank cell to come into existence. The LES model predicts the turbulent quantities well over the horizontal-bed but some discrepancies are found in the comparison with the experiments on the equilibrium-bed. For both cases Delft3D-FLOW under predicts the turbulence quantities.

It is concluded that an improved modelling of near bed turbulence as well as anisotropic turbulence modelling is needed to accurately model the flow through sharp open channel bends.

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Distribution of the depth averaged cross-stream circulation strength which is a measure for the strength of the secondary flow. Left according to the measurements; right according to Delft3D-FLOW
Analysis of the Carbon Footprint of coastal protection systems

Carbon Footprinting is a method of determining the environmental impact of a product or service. It focuses only on pollutions to the air by greenhouse gases. There is a strong focus on these gases caused by intergovernmental alliances that restrict the amount of emitted gas. These agreements have been made as a result of the widely accepted idea that an increase of the emission of the greenhouse gases will have a negative effect on the global climate.

The basis of the research is a case study situated in at the shore of Scheveningen, and concerns five different coastal protection systems to be analysed. To all of the designs an amount of carbon dioxide per running meter will be attributed: A Carbon Footprint. The five designs concern a beach nourishment and a dike with an altering revetment of concrete columns, riprap, asphalt and elastocoast. The case study provides a broad view of some of the most common protections at the Dutch coast. The outcome makes a direct comparison between the systems, based on the same boundary conditions, possible.

All activities that consume energy and that are contributing to the production of a final product, together form the emission of a product. An amount of energy is, dependent on the energy source responsible for a specific emission. Emissions linked to a certain energy source are therefore very influential in the ultimate emission of a whole product. Different databases however stick to different values for these specific emissions. The differences in specific emissions combined with a number of other factors cause a deviation in emissions of similar products.

When the ‘Cradle-to-Grave’ principle is applied for the before mentioned five designs at Scheveningen the following ranking can be found: concrete columns, beach nourishment, riprap, asphaltic and lastly the elastocoast revetment.

Because of the large range in emissions the only conclusion that can be drawn from the Carbon Footprints determined in this thesis is the ranking presented here. Because of the uncertainty in the applied emissions, established in this research, no absolute figures should be adapted from this work.

![Figure 1 Emissions for energy generation according to five different databases](image)

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An analysis of vessel behaviour based on AIS data

From December 2004 onwards every seagoing vessel over 300 Gross Tonnage (GT) is obliged to be equipped with an Automatic Identification System (AIS). Nowadays also inland vessels are increasingly using AIS. The main functions of AIS are collision avoidance and an aid to navigation. Also coastal authorities (security) and Vessel Traffic Services (traffic management) use AIS. The system is also valuable for search and rescue actions and in maritime modelling.

Maritime models use AIS data mainly to determine the traffic input. AIS data also improve the insight into the nautical networks that have to be modelled. In port areas, AIS data is not often used for these purposes, as in these areas the traffic image is disturbed by vessels that are not AIS equipped. AIS data can potentially be used to investigate individual vessel behaviour, but no extensive use is made of this yet.

Roughly two types of maritime models exist. One type simulates the overall nautical traffic and the other uses individual vessels. A problem for the models that simulate vessel behaviour is the so called human factor. Most models try to simulate this behaviour using Fuzzy-technology or Bayesian networks.

A case study is performed to see if an analysis of AIS data can describe vessel behaviour in the Port of Rotterdam area. As case area, the path between the North Sea and the Amazonehaven (Maasvlakte I) is used. The vessel path and speed, as well as the influence of vessel size, wind, current and visibility is determined. The influence of the vessel size is taken into account, by creating five different classes (<10,000; 10,000-40,000; 40,000-70,000; 70,000-100,000; >100,000 dwt).

There are significant differences between the size classes, as well for the vessel path as the vessel speed. In general, larger vessels sail more to the middle of the channel and sail slower. They also have a more narrow distribution over the waterway. The vessel position and the vessel speed are normally distributed over the waterway. There is no significant relationship found between the location in the cross section and the vessel speed.

Also the influence of the external circumstances wind, current and visibility are examined. All three are found to have an influence on both vessel path and speed. Except for the visibility no significant differences in influence are found between the different size classes. In the Maasmond, high cross winds and cross currents lead to a deviation from the average path in the direction the external influence is working and to a lower speed. In general, wind and current from behind the vessel lead to a higher vessel speed.

The case area is split into several parts, to obtain more generic rules. In every part, the generalised vessel distribution and vessel speed distribution are derived in a number of cross sections. The influence of the external circumstances is generalised as well. These cause a shift in the normal distributions over the waterway. Finally, the interaction between vessels can be analysed by using AIS data. In this thesis an example of this is given.

Four currently existing maritime models (Samson, HarbourSim, Martram and Dymitri) are tested to the output of the case study, to see if the results can be implemented. None of the models can immediately implement the results. In Martram, the results can be implemented by making only a small amount of adjustments. HarbourSim needs to be adapted more, mainly to include the vessel (speed) distribution over the waterway. It is very difficult to implement the results in the other two models, as they are not meant for nautical traffic simulation (Samson) or have a different approach for simulating (Dymitri).

There are three important recommendations for future research. First, different types of vessels should be investigated, as in this thesis only container vessels where taken into account. Secondly, more research should be performed to obtain a better insight in the influence of the external circumstances. In this way, external influences can be described more precise and also relationship between them and the vessel size might be derived. Finally, the vessel-vessel interaction should be examined. This clearly is the next step in describing the vessel behaviour in a port area.

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Tidal influence on sediment transport and bed level in the river Merwede

The area of the Merwedes is a transition zone between a tide-dominated area and a river-dominated area. With increasing river discharge, the influence of river flow dominates in this part of the Rhine-Meuse Delta. The composition of the river bed of the Merwedes is also a transitional area, because of the presence of both sand and mud. It is unknown how sediment transport and morphology in this area are influenced by the complex interaction of tidal flow and river flow.

To be able to explain the morphological changes in the area of the Merwedes and to be able to anticipate on these changes, there is a need for better understanding of the hydraulic and morphological processes. This study contributes to a refinement of the system description of the Rhine-Meuse Delta by determining the influence of the tide on sediment transport and bed level in the river Merwedes.

The aim of this graduation research is to gain insight into the contributions of tidal flow and river flow to sediment transport and bed level changes in the Merwedes, with a view to application of the obtained knowledge to Room for the River projects in this reach. The Room for the River project 'floodplain excavation Avelingen' has been chosen as case study.

Three methods have been used to gain insight in the contribution of the tide to sediment transport and bed level changes in the Merwedes:
1. Analysis of simulated flow
2. Analysis of simulated sediment transport
3. Analysis of simulated bed level changes

The following ranking has been determined with respect to the relevance for one-dimensional morphological modelling of the Merwedes which is based on the analysis of simulated sediment transport and simulated bed level changes:
1. Including variations in river discharges
2. The choice of an accurate sediment transport model
3. Including the tidal influence in the Waal and Merwedes
4. Including salt intrusion in the Rhine-Meuse Delta
5. Using a spring-neap cycle instead of a less detailed tidal cycle as sea boundary condition

These adjustments improve the simulation of the autonomous development of the bed level of the Merwedes. This ranking applies to the yearly sediment transport (or the expected value). However, the ranking of modelling aspects varies between the Merwedes at specific river discharges.

Both variations in river discharge and the tidal influence should be included in morphological studies of the Merwedes, because of interaction between river flow and tidal flow. The influence of the tide on sediment transport in the Merwedes can best be represented by a spring-neap cycle. However, a less detailed tidal cycle is a reasonable approximation of the tidal influence on sediment transport in the Merwedes.

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During the winter 2009, beach and dune nourishments have been executed at Vlugtenburg (Holland coast) in order to reinforce the coastal defense. Natural processes such as wind and waves are expected to take care of effective and efficient redistribution of the sand throughout the system. The present study is part of the sub-project Monitoring Program Delfland Coast which main goal is to provide measurement data for process-based modeling of the interactions between the foreshore and the dunes.

Based on field measurement realized in November 2009, this MSc thesis aims to find an efficient procedure to monitor the aeolian transport (transport by the wind) of sediment over a beach. These measurements involved innovative devices and methods. Four saltiphones were deployed at different locations on the beach. A forced deposition area was build up and the deposited volumes were monitored using a laser scanner.

An analysis of the problems to use formulas derived from wind tunnel experiments in the modeling of transport on the field is carried out. It is followed by the derivation of a model describing the relation between the transport measured with saltiphones and the wind speed for specific conditions. However, no relation is derived between the transport measured with saltiphones and volumes transported and an extrapolation of the model to the whole beach remains incomplete. Finally, the existences of a fetch effect and a cross-shore decrease of the transport are measured, though not accurately quantified.

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Keywords: field study, aeolian transport, saltiphone, Bagnold’s equation, fetch effect, laser scanner, Delfland coast.

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“The influence of core permeability on armour layer stability”

The study describes a theoretical approach of a physical description of the influence of the core permeability on the armor layer stability. In the widely used stability formulas of VAN DER MEER [1988] the influence of the core permeability is described by anotional permeability coefficient $P$ (see figure). Caused by the empirical character of these stability formulae a physical description is not available for the notional permeability factor. In practice this leads to ambiguities in determining the value of this factor.

To give this factor a physical description a volume-exchange-model was introduced to express the effect of core permeability on the external wave run-up process. This volume-exchange-model couples the external with the internal process. The external process is described by a wave run-up model. In this model the wave run-up wedge approach of HUGHES [2004] is linked to the wave kinematics in front of the structure. The internal process is described by the ‘Forchheimer’ equation for the water flow through a porous medium.

In this study it is assumed that the notional permeability factor $P$ is highly related to the volume-exchange-model. By coupling the volume-exchange-model with the notional permeability factor this relation is investigated. This coupling is realized by work out the volume-exchange-model for the four defined ‘notional permeability structures’. In case of a vertical structure transition the elaboration of the volume-exchange-model works well. For a sloped structure transition the volume-exchange-model is subject to a phase difference between the separate layers. This phenomenon should be studied more extensively. However, in both cases (sloped and vertical structure transition) the correlation between the $P$-factor and the so-called run-up reduction coefficient $c_r$ (followed from the volume-exchange-model) is clearly visible. With this correlation it is possible to choose a value of the notional permeability factor $P$ that is based on a physical description. Besides this, the study also shows that the permeability of the structure not only depends on structural properties, as stated by VAN DER MEER [1988], but also on the hydraulic parameters. With this consideration the dual permeability notation in the stability formula (for surging waves) is explained.

This report gives a proposal to separate the $P$-factor from the stability formulae by incorporating the influence of the permeability in the stability formulae in the run-up reduction factor. However, without an additional test program this is in the present form of the volume-exchange-model not possible. Therefore, this report ends with suggestions for recommended tests.

**Keywords:** Rubble mound breakwater, Core permeability, Notional permeability, Porosity, Turbulent friction, Run-up reduction coefficient, Volume-exchange-model

![Diagram](image)

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The immersed tunnel technique is a common used technique for river crossings in the Netherlands, but also in the United States and Japan. 80% of the immersed tunnels are built in these 3 countries. The design of the immersed tunnels differs for the different countries, because of the possibility of seismic loading on the tunnel structure. This seismic loading can occur at the west coast of the United States and in Japan, because of their position close to tectonic earth plates.

The immersed tunnels in the Netherlands are built with elements of 100-150 meter consisting of segments of 20-25 meters. For transportation these segments are pre-stressed forming one element, after immersion on the river bottom they are released again. In this way the tunnel is flexible and can follow the settlement differences of the river bed. The water tightness in the joints is secured with rubber sealing profiles in the segment joints (W9U) and compressible rubber profiles in the immersion joint (Gina).

In areas where risk of seismic activity is severe, the immersed tunnels are built different. The pre-stressed tunnel elements are kept as one element, the same as they are for transportation, to prevent joint opening and leakage. This results in large deformations in the immersion joints and Gina gaskets and stresses in the tunnel structure. For this reason a research is performed on the behaviour of the segmental immersed tunnel subjected to seismic loading and especially on the sensitive segment joint.

Most earthquakes are created by the movement of tectonic plates. The release of energy involved with this movement creates seismic waves which will propagate through the soil. When these waves reach an immersed tunnel, it will respond to the soil movements with a certain behaviour. The design seismic wave that causes the tunnel to deform is the shear wave (S-wave). When this wave propagates parallel to the tunnel axis, the tunnel will bend in lateral direction causing the snaking effect. This can occur in horizontal and vertical direction, but the horizontal direction is determining. When the wave reaches the tunnel under an angle of 45 °, the tunnel can be deformed in axial direction. This is called the worming effect.

Both the worming and snaking effect are modeled to determine the influence of the different seismic design parameters like the wave length of the seismic wave, the construction depth and the tunnel element length. Other important model properties are the stiffness of the rubber gaskets in the segment joints and the immersion joints. All the properties and loads due to the seismic soil movement are included in two different beam models to determine the worming and snaking effect for a representative immersed tunnel.

The modeling of the worming and snaking effect shows that the gasket properties and the seismic wave length are the most important parameters. The compressibility of the Gina gasket and the elongation capacity of the W9U determines the total axial deformation of the immersed tunnel. For the snaking effect the rotation capacity and the number of Gina gaskets are of importance. The segment joints act relatively stiff and are of less importance until their moment capacity is reached. Then joint opening and leakage could occur. It can be concluded that the propagation speed and wave length of the seismic wave are important factors when modeling the worming and snaking effect of immersed tunnels. It is not clear from literature what the seismic design wave is for tunnels in soft soil. This needs to be investigated further to make a final judgment on the behaviour of the segment joints. For the used design parameters the tunnel can withstand the worming effect, but snaking could cause joint opening and leakage based on the free-field approach. For the snaking effect a soil-tunnel- interaction approach should be performed to determine the real tunnel response and make a final judgment of the behaviour of the segment joint.

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Numerical modeling of sediment transport over hydraulic structures

Hydraulic structures are present in the designs of different Room for the River projects in the Netherlands. Examples are longitudinal weirs, groins, summer dikes and weirs in the inlet of a side channel. Morphological simulations with Delft3D are frequently carried out to investigate the effect of such projects on for example hindrance for shipping and dredging costs. It is important that also around hydraulic structures the physical processes are correctly modeled in these situations.

A three-dimensional flow situation has been designed, which resembles the flow over a longitudinal weir. In Delft3D, all bed-load transport and suspended-load transport that reaches the weir also passes the weir, because the weir parameterization has only a hydraulic effect. In FLUENT, this is not the case for bed-load transport. The distribution of bed-load transport strongly depends on the particle diameter. This difference shows that the parameterization of weirs in depth-averaged Delft3D models gives significant errors in the prediction of sediment transport over hydraulic structures, especially when bed-load transport is dominant.

The sediment transport over the weir in Delft3D can be tuned by an increased bed level around the (parameterized) weir somewhere between zero bed level and crest level. The required height can be obtained using a rule of thumb, which has been developed in this study. This rule of thumb gives an estimation of the distribution of sediment over the zones behind and in front of hydraulic structures, given a certain distribution of discharge.

The objectives of this study are:
1. Assessing the performance of the current way of Delft3D modeling of sediment transport around hydraulic structures in three-dimensional flows.

The performance of Delft3D has been judged by comparing the results with the results of the numerical model FLUENT. The modeling of laboratory experiments of flow and sediment transport over hydraulic structures gave confidence to use FLUENT as an instrument to judge the performance of Delft3D in modeling three-dimensional flow and transport over hydraulic structures.

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Cross-shore morphological response on Chaland Headland due to Hurricanes Gustav and Ike

Louisiana’s barrier islands suffer from substantial sediment loss due to subsidence, sea-level rise, oil and gas activities, and marine and wind induced shoreline erosion. As result of the continued erosion, the barrier shorelines have been breached at several locations. One of the projects constructed through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) was the Chaland Headland Barataria Barrier Island Restoration Project. This barrier island is located 80km south of New Orleans. The restoration work included 931,000 m2 of constructed beach and 1,028,000 m2 of created marsh, which elevated the barrier island height to protect and create dune, swale and intertidal marsh habitat. One and a half years after finishing the restoration project Hurricane Gustav impacted Chaland Headland on September 1, 2008 followed by Hurricane Ike 11 days later on September 12, 2008. While analyzing the pre- and post-hurricane profiles along the 10 available survey transects, different types of overwash responses were identified on the west side, the center of the island and the east side.

This thesis focused on the influence of vegetation on these changes and whether they are the only factor that was responsible for the different overwash types that are observed. Therefore, a 2DV profile model in Delft3D-FLOW was applied to investigate the cross-shore morphological response. The boundary conditions and model parameters are determined on the basis of the available data, whereas the wind and wave conditions from Hurricane Gustav and Ike were modeled with the Delft3D-FLOW and SWAN numerical models. The main uncertainties of the defined boundary conditions and model parameters were analyzed on their sensitivity. This has lead to a well-calibrated profile model that reproduces the measured post-storm profile, see Figure 1.

With the calibrated profile model, three vegetation cases (vegetated levees, backbarrier marsh vegetation and dune vegetation) were studied. The vegetation module applied in Delft3D-FLOW characterizes the vegetation as a number of cylinders at the bottom. A better reproduction of the observed variation in morphological response on Chaland Headland was obtained with the applied vegetation module. The model results showed that vegetation is a dominant factor in morphological response and determines the overwash profile type. The main findings based on the model results are:

- Vegetated levees in the backbarrier marsh causes overwash obstruction, which leads to dune height preservation.
- Dune vegetation causes dune accumulation.
- Marsh vegetation has limited the amount of overwash deposits to translate landwards.

![Figure 1: Bed level changes after Hurricane Gustav and Ike.](image)

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Cobble Sea Defence: Hydraulic Interface Stability of Sand underlying a Single Filter Layer

A cobble sea defence appears to be an easy constructible protection, with relatively low total costs of ownership. Flume tests show that sand under such single layered constructions is stable. However, it is not exactly known how the hydraulic loading of a breaking wave is reducing in the filter. Two datasets containing pressure measurements in a revetment were available for identification of this reduction:

- A dataset of a test performed in the Großer Wellenkanal (Hannover), for improvement of the understanding of all relevant processes in Elastocoast revetments (obtained from the Braunschweig University of Technology).
- A dataset of tests in the Delta Flume, for the verification and optimization of the cobble shore design of the ‘Maasvlakte 2’ (obtained from PUMA). The dataset of the Großer Wellenkanal test was analysed to increase the insight in the behaviour of pressures in a filter resulting from (breaking) waves and to explain processes and results of the Delta Flume model tests.

Hydraulic loading at the top of a revetment exist out of two types of loads; impact and non-impact loads. The impact load, resulting from plunging waves, can be distinguished in an impact peak and a quasi-static part. The impact peak is very high (>10 kPa), last for only a fraction of time (<0.2s) and reduces completely in the filter. The non-impact load and the quasi-static part of the impact load reduce less and are responsible for the hydraulic loading at the interface of sand underlying a thick, single filter layer. Although large influence was expected for turbulence generated by breaking waves it does not have an important role in the hydraulic loading that eventually reaches the interface.

The parallel gradients at the interface are only the result of pressures in- and decreasing with the wave period. The maximal destabilizing perpendicular gradients are frequently accompanied by a maximal parallel gradient. The main loading mechanism at the interface results from the run-down; during run-down the largest parallel and perpendicular gradients are generated.

Predicted gradients acting on the interface between gravel and sand in the Delta Flume models are higher than traditional stability criteria. Therefore, an erosion process of the sandy embankment would be expected for the tested Delta Flume models. However, erosion was not observed. The stable interface in the Delta Flume tests can thus not be explained from the pressure reduction resulting from the analysis of the measurements in the Delta Flume models itself. The damping observed in the Großer Wellenkanal and the non-distorted interface in the Delta Flume models give strong indications that the reduction observed in the gravel material of the Delta Flume models is not representative for the performance of the gravel layer, resulting in a conservative prediction of gradients at the interface of gravel and sand.
The area of New Orleans was hit by Hurricane Katrina in August 2005. A large part of the city got flooded due to bad design, construction and maintenance of the levee system. In order to increase the level of protection of the city, the levees are heightened and strengthened in the framework of the Hurricane and Storm Damage and Risk Reduction System (HSDRRS). On the long term the restoration of coastal wetlands is also part of the program.

Since the 1930’s wetland erosion in coastal Louisiana has been recorded. The main cause of the erosion is the canalization of the Mississippi River, land subsidence and sea level rise, and salt water intrusion by alteration of drainage patterns. One way of initiating wetland restoration is the construction of diversions. The Violet Diversion is the largest diversion planned in the Pontchartrain Basin. Water from the Mississippi River is diverted into Lake Borgne and the Biloxi marsh in order to decrease salinities in those target areas. In order to get more insight in the impact of the diversion on salinity (gradients), hydrodynamic and salinity modeling of the Pontchartrain Basin is desired. Due to lack of data and time, model calibration on salinity was not accomplished. The goal of this study is to model a dynamic equilibrium of yearly averaged salinity in the Pontchartrain Basin. The lessons learned from this study can be a start for subsequent modeling efforts of the Violet Diversion.

In Delft3D-FLOW a grid was set-up to model tidal propagation in Lake Borgne. The grid consists of a little less than 53,000 nodes. The initial bathymetry and roughness are taken from the ADCIRC SL15 model. The model is forced with the amplitudes and phases of the ten most important tidal constituents. In order to calibrate the model, the tidal channels are enlarged and the bottom friction is decreased. The necessity of these changes was already proven by the application of the harmonic method on the Pontchartrain Basin, as well as the moderate results of previous model studies. The model is calibrated on tidal amplitudes (accuracy within 10%) and fluxes through the tidal passes (accuracy within 1%). Phases were considered less important. Salinity was implemented by simulating initial salinities and river discharges on top of the tide. Comparing 2D with 3D simulations, gravitational circulation occurs in the 3D modeling. This causes an increased salt water intrusion from the Gulf of Mexico towards Lake Borgne and the Biloxi Marsh. However, the salinities in this target area are too low in the dynamic equilibrium situation. This is explained by the underestimation of transport by tides and Mississippi River discharge towards Lake Borgne. Previous model studies proved that circulation around the continental shelf cannot be neglected for tidal transport. Also, the Mississippi River discharge can flow around the Birdfoot. Due to the choice of the model domain, that flow cannot occur in this study. Using the tide-calibrated model for salinity studies, it is recommended to model in 3D to simulate the gravitational circulation. Nontidal water level elevations and currents should be included in the boundary conditions. This can be achieved by enhancing the model domain to capture a larger part of the Gulf of Mexico and the Mississippi Birdfoot. Then the flow around the Birdfoot can also be simulated. Wind should also be added to the hydrodynamic simulations. The measured salinities and the target salinities show seasonal variation. Therefore future modeling should strive for real-time simulation by forcing the model with time-series. The diversion flow can then be varied per month or season.

Model a dynamic equilibrium of yearly averaged salinity in the Pontchartrain Basin

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Full text of the report is available via: [http://repository.tudelft.nl/view/ir/uuid%3A5b7cdba3-4bfb-49e5-99b2-cf16423161ea/](http://repository.tudelft.nl/view/ir/uuid%3A5b7cdba3-4bfb-49e5-99b2-cf16423161ea/)

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Failure of rubble mound breakwater’s armor layer

One of the failure mechanisms of a rubble mound breakwater is the failure of its armor layer. In order to determine the stability of an armor layer, the design load has to be defined, which is in fact the wave that attacks the structure. Being a highly stochastic phenomenon, the wave action is not easily defined, while there is always some uncertainty inherent to its definition. In a deterministic calculation this uncertainty is totally overlooked, as the possible variations of the design wave height are not taken into account. In order to incorporate uncertainties into the design process, and therefore increase its reliability, probabilistic design methods should be applied. A commonly used approach is a semi-probabilistic computation on level 1, which introduces the application of partial safety coefficients, yet the indicated methods to derive and apply them do not clarify the uncertainties incorporated, adding an undefined degree of safety in the process, or end up with incorrect results under certain conditions. Another approach is a fully probabilistic computation on level 2 or 3. This type of design tackles explicitly a great deal of uncertainties, hence its results can be considered much more accurate. However it is not commonly used, due to the fact that there are not straightforward guidelines to support it, and therefore a number of critical decisions by the designers are required. The main objective of this study is to indicate the weaknesses of the existing design methods, and to suggest a design approach that is both attractive to designers and sufficiently reliable. This is achieved through application of the existing methods in an example case, whose features facilitate a critical assessment, and enable formulation of an improved approach. The chosen case is the jetties at the entrance of Galveston port, in the Gulf of Mexico, and the features of interest are the hurricane-dominated hydraulic climate and the fact that the structure is located in shallow water, meaning that the design load is determined by depth-limited waves. The design methods that are demonstrated are a classical deterministic design, a semi-probabilistic calculation on level 1 as proposed by PIANC in 1992, and a fully probabilistic calculation on level 3 with a Monte Carlo simulation. Based on the evaluation of the three design processes and their results, the new approach can be developed, which suggests a rational framework for deriving safety factors. According to it, a set of safety factors is generated which incorporate the same uncertainties as a fully probabilistic design; hence an equally reliable result is extracted. The final product is a guideline for code makers indicating the procedure to derive the safety factors and a guideline for future designers indicating the analytic steps for a proper use of the safety factors. In addition a large number of concluding remarks are summarized, which can contribute in optimizing the performed analysis. The concluding remarks refer in particular to the determination of hydraulic boundary conditions, the application of the design methods, the probabilistic model used for Monte Carlo simulation, the proposed design approach, and the safety factors derived with this approach.
Behaviour of nourishments in quasi 3-dimensional graded sediment models

Bed degradation in a number of Dutch river branches, like the Bovenrijn, can cause various problems in the near future. At low waters the navigation depth at the non-erodible layer near Emmerich can become too small. Other problems could be lower ground water levels and stability of structures in and near the river, like groynes. To diminish negative effects of bed degradation, nourishing material can be an effective solution. For a better understanding of nourishment behaviour and a better prediction of nourishment propagation, a tracer nourishment released in Germany in 1996 has been modeled and compared with field data. This tracer nourishment was released in the river Rhine at Iffezheim, Southern Germany, chainage kilometre 336. Propagation of this tracer has been recorded to approximately 60 kilometres downstream of the dumpsite. The model used in this research, is a quasi-3D model with a graded sediment module. Simulating with a graded sediment module is important, since the mixture of the tracer nourishment modeled is different from the original bed material and there is an interest in the difference in behaviour between the finer and coarser tracer fractions. A quasi-3D format is used, because spatial scales less than the river width and transverse sorting effects might be important, as well as the parameterization of important 3D effects, like spiral flow. For the description of sediment transport, a modified Meyer-Peter-Müller formula is used, the sediment balance of the river bed is described by the model of Hirano. Hiding and exposure effects are implemented by the formulation of Egiazaroff, modified by Ashida & Michiue. The bed load transport vector is adjusted by formulations for the effects of spiral flow and transverse bed slope. The roughness is calibrated against the water level for several relevant discharges. The sediment transport formula is calibrated against the yearly sediment transport. The discharge is schematized in two ways: either a constant representative discharge that yields the same yearly transport, or a hydrograph with five different discharge levels is used. Results of case studies show that the thickness of the active layer, hiding and exposure effects and the discharge schematization are important parameters for propagation of the tracer nourishment. Hiding and exposure effects appear to be quite different for a number of existing formulations. Simulation with a hydrograph instead of a constant representative discharge shows important differences: the propagation speed of specific sediment fractions is different. The coarsest fractions move just a little bit, but are still hardly mobile, though not completely immobile as in the computations with the constant representative discharge. Compared to the field data, the finer fractions propagate too slowly, but the coarser fractions hardly at all. To change this, relevant parameters that can be changed within the model concept used are the active layer thickness, critical Shields value and hiding and exposure relation. It is uncertain however, if the model concept used can represent a satisfactory approximation of the behaviour of all nourishment fractions simultaneously. A number of physical processes that occur in the river reach just downstream Iffezheim, are not included in the model concept. Significant dunes appear to be present in this river reach, introducing vertical and horizontal sorting processes and different hydrodynamic conditions. Furthermore, it is questionable if the critical Shields value should not be variable with the sediment diameter. Finally, navigation appears to be possibly important. Development of a model which takes into account these physical considerations, could be beneficial for prediction of sediment nourishments. On locations where a nourishment could be an ineffective solution, field data of the propagation of specific tracer fractions could give important information for rough estimations of nourishment behaviour.
The following research objectives were proposed: 1) Assess the morphological evolution and practical aspects of the sandgroynes constructed at the Ter Heijde coast and 2) Use the site specific knowledge from the Ter Heijde pilot project to create a future perspective of sandgroyne nourishments as a common applied method to nourish the shoreface. This master thesis describes the process of the monitoring campaign, the results of a morphological data analysis, the results of an initial model simulation set-up and a practical analysis. The sandgroynes have been absorbed in the coastal system, dominantly between the shoreline and the -5m depth contour. However the spatial scale of longshore sediment redistribution was larger than accounted for, driven by the intense wave climate. It is concluded that the sandgroynes can be an effective method for nourishing the shoreface, under flexible contract requirements that acknowledge the dynamics of the natural system.
Dong Lam Cement Factory is developing a new clinker plant in Thua Thien-Hue Province, Vietnam. The clinker has to be exported towards Ho Chi Minh City, where it is ground into cement and used for the construction industry. For the clinker production coal is needed and has to be imported. To make the in- and export possible a new dedicated seaport is required to allow for 15,000 dwt clinker vessels and 7,000 dwt coal vessels.

The objective is to design a port with sufficient capacity to handle the predicted cargo flow and which offers acceptable conditions for the ships to enter. The effective berth and hinterland capacity have to be determined such that, that turnaround times are within limits. To create safe conditions, the vessels need to have enough space for manoeuvring in the wet port area. These manoeuvres can be seriously disturbed by wind, wave, currents and siltation on the long term. To ensure the workability of the port these effects have to be limited.

To determine the effective berth capacity the queuing theory is applied. In phase 1 and 2 one clinker and one coal berth satisfy with effective capacities of respectively 700 and 175 t/h respectively. In phase 3 two clinker and two coal berths are needed with the same loading/unloading rates. To get insight in the environmental boundary conditions, field data is collected and analysed thoroughly. In Vietnam the wind climate is governed by the South-East Asian monsoon system, with a dominant SE direction and strong NNE winds. The wave climate is directly influenced by the wind climate and shows a similar pattern. With regard to extreme conditions, once a year a tropical storm lands in the vicinity of the port site. These storms are accompanied by strong wave conditions, coming from E to SE direction. Having frequent waves from the NNE and SE, littoral transport is generated in north- and southward direction. Nevertheless, the northward transport is clearly dominant. Currents are heading SE for most of the time. Four different layouts are developed for phase 3 of the project. Two of them are dismissed in an early stage, because of unfavourable conditions. The other two layouts – the ‘coastal’ and ‘offshore’ alternative, are evaluated with a cost-value approach. In this approach the value of each design is assessed by means of a MCA. The following criteria are taken into consideration: navigation, tranquillity at berth, coastal impact, sedimentation, ease of cargo handling, safety and flexibility. Regarding navigation and wind, wave and current hindrance, no significant differences are found. It turns out that the most important difference is found in the coastal impact. The coastal alternative will cause erosion along 7.5 km of coastline with a maximum retreat of 100 m. Instead, the offshore alternative affects ‘only’ 3 km with maximum retreat of 70 m. The other element of the cost-value approach is the costs. The investment costs for the coastal alternative are 64.1 M$, which include the dredging works, breakwater and quay construction. The costs for the offshore port amount 77.5 M$, which entails the dredging works, breakwater, jetty quay and trestle construction. The relative low costs for the coastal alternative are achieved by applying the cut-and-fill balance; the dredged sand is used as breakwater foundation. Maintenance dredging costs are 1.75 M$ and 0.9 M$ for respectively the coastal and offshore alternative. To finish the cost-value approach the value/costs ratio is taken for both port layouts. The coastal alternative (0.9) turns out to be a better port layout than the offshore alternative (0.77).
Probabilistisch diepteontwerp voor binnengebied haven Rotterdam

In dit rapport wordt een probabilistisch (diepte-) ontwerp gepresenteerd voor het binnengebied van de haven van Rotterdam. Ook worden de mogelijke faalmechanismen (bodemberoering en verminderd manoeuvreerbaarheid) bestudeerd. ALS referentie modellen zijn bestudeerd de modellen Harap en Protide van Rijkswaterstaat, en CADET van US Army Corps of Engineers. Deze modellen zijn echter toepasbaar in open wateren (buiten de haven) en verschillen hiermee, zoals in het rapport naar voren zal komen, met het model voor het binnengebied. Het probabilistische ontwerp bouwt inzicht te verkrijgen in de sterkte "R" (resistance) en de belasting "S" (sollicitation) van een systeem. De nautisch gegarandeerde diepte kan dan gezien worden als sterkte (R) in het model en het getij, de golven, squat en diepgang als belasting (S). De betrouwbaarheidsfunctie (Z) ziet er dan als volgt uit:

\[ Z = d + H_t - (T + S) \]

Met: 
- \( d \): nautisch gegarandeerde diepte (t.o.v. het reductievlak)
- \( H_t \): getijrijzing boven het reductievlak
- \( T \): diepgang ontwerpschip (afhankelijk van de dichtheid)
- \( S \): inzinking t.o.v. squat (trim en helling)

De parameters \( H_t, s, T \) zijn hoofdzakelijk deterministisch, maar hebben probabilistische componenten waarvoor kansdichtheidsfuncties kunnen worden bepaald.

Vervolgens kan de probabilistische analyse worden gemaakt met de volgende kans op falen (=bodemberoering):

\[ P_f = P(Z < 0) = a \]

Waarbij 'a' de aanvaardbare kans op falen is voor het binnengebied van de haven.

In deze studie worden twee zogenaamde faalmechanismen onderscheiden:
- Bodemberoering
- Verminderde manoeuvreerbaarheid/bestuurbaarheid

De verschillen tussen de twee faalmechanismen in de bepaling van de kielspeling is geïllustreerd in figuur 1.

In dit rapport wordt een probabilistisch (diepte-) ontwerp gepresenteerd voor het binnengebied van de haven van Rotterdam. Ook worden de mogelijke faalmechanismen (bodemberoering en verminderd manoeuvreerbaarheid) bestudeerd. Als referentie modellen zijn bestudeerd de modellen Harap en Protide van Rijkswaterstaat, en CADET van US Army Corps of Engineers. Deze modellen zijn echter toepasbaar in open wateren (buiten de haven) en verschillen hiermee, zoals in het rapport naar voren zal komen, met het model voor het binnengebied. Het probabilistische ontwerp beoogt inzicht te verkrijgen in de sterkte "R" (resistance) en de belasting "S" (sollicitation) van een systeem. De nautisch gegarandeerde diepte kan dan gezien worden als sterkte (R) in het model en het getij, de golven, squat en diepgang als belasting (S). De betrouwbaarheidsfunctie (Z) ziet er dan als volgt uit:

\[ Z = d + H_t - (T + S) \]

Met: d = nautisch gegarandeerde diepte (t.o.v. het reductievlak)
H_t = getijrijzing boven het reductievlak
T = diepgang ontwerpschip (afhankelijk van de dichtheid)
s = inzinking t.o.v. squat (trim en helling)
De parameters H_t, s, T zijn hoofdzakelijk deterministisch, maar hebben probabilistische componenten waarvoor kansdichtheidsfuncties kunnen worden bepaald.
Vervolgens kan de probabilistische analyse worden gemaakt met de volgende kans op falen (=bodemberoering):

\[ P_f = P(Z < 0) = a \]

Waarbij 'a' de aanvaardbare kans op falen is voor het binnengebied van de haven.
In deze studie worden twee zogenaamde faalmechanismen onderscheiden:

- Bodemberoering
- Verminderde manoeuvreerbaarheid/bestuurbaarheid

De verschillen tussen de twee faalmechanismen in de bepaling van de kielspeling is geïllustreerd in figuur 1.

Daarin zijn de hiervoor genoemde parameters gerelateerd aan het faalmechanisme. De statische inzinking is de marge voor de onzekerheid in diepgang, effect van zoet water en squat bij elkaar opgeteld. Zo is te zien dat niet alle factoren relevant zijn voor elk faalmechanisme. In geval van het faalmechanisme bodemberoering is logischerwijs geen rekening gehouden met de manoeuvreermarge. In geval van verminderd manoeuvreren wordt het aspect 'scheepsbewegingen in golven' niet in beschouwing genomen, vanwege het dynamische karakter van het aspect. De statische inzinking dient voor beide faalmechanismen in beschouwing te worden genomen.

De conclusies uit deze studie zijn:
- Het is mogelijk om ook voor het binnengebied de diepte op een probabilistische manier uit te rekenen;
- In het onderzochte gebied is het faalmechanisme "verminderd manoeuvreren" dominant ten opzichte van het faalmechanisme "bodemberoering";
- De probabilistische methode lijkt een voordeel op te leveren in de orde grootte van tienden meters tot zelfs meer dan 1 meter;
- Toepassing van een toelatingsbeleid binnen de probabilistische methode is noodzakelijk;
- De mogelijkheid bestaat om het toegepaste model uit te breiden tot een operationele tool.

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New Profile for the Amsterdam-Rhine canal

The aim of this thesis is to design a new profile for the Amsterdam-Rhine canal. The new profile needs to be well navigable and requires to have stable bank constructions. Simultaneously several social aspects have to be taken into consideration. The assignment is summarized as follows: Design a new profile of the Amsterdam-Rhine canal with a stable bank protection that takes future developments, durability and recreation into consideration.

The history of the Amsterdam-Rhine canal shows that the draft of the vessels that use this canal has increased from 3.30 to 4.00 meters. This four-metre draft has been permitted since 1988 and was based on the dimensions of the push tow units. In the late 90s of the past century, a new generation of inland vessels made its appearance. Around 2002 problems to the bank constructions due to erosion were detected for the first time, possibly caused by the new generation inland vessels. The number of bigger inland vessels, particularly those in the VIa category has strongly increased over the past years together with the engine power and cargo capacity of many vessels (increase in scale).

A representative canal section of the Amsterdam-Rhine canal, just north of Breukelen, has been chosen as research site. At this location erosion ranges from 0.20 to 1.70 meters within 15 meters distance of the sheet piles. The possible cause of this erosion has been further investigated in this report. Also research has been done to determine the governing hydraulic load, which is generated by governing vessels overtaking another vessel. The governing situation is defined as follows: a Rijnmaxship (135x17x4.00 m) overtaking a four barge push-towing vessel (198x22.8x4.00 m). In this situation, the return current is governing compared to a situation when loads from the main and bow thrusters are considered. The return current has been calculated with the 1D model DIPRO. DIPRO has also been used to validate the 2D model in Delft3D, to further elaborate the return current in the 2D model. The 2D model in Delft3D has been used to determine the maximum return currents around the two governing vessels. These values have been translated to the bottom of the canal by calculating the erosion. From these results can be concluded that canal profile (2) has twice the amount of erosion compared to canal profile (3). In this report canal profile (3) is recommended as the new normative canal profile for the Amsterdam-Rhine canal. Canal profile (3) is a combination of a box profile with a sloped upper bank and bottom, with in the middle a waterdepth of 7.60 meter. The depth in front of the sheet pile is 6.00 meter. The wet cross section is 751 m². The bank construction consists of a sheet pile with a slope.

The outcome of this thesis is a design for a new representative canal profile in the Amsterdam-Rhine canal. The normative hydraulic load (return current) causes minimum erosion to the canal bottom, which keeps the bank construction stable. Next to this the design proves that environmental and recreational purposes can be well combined in coherence with social developments.

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Albania has the following major sea ports: Durrës, Vlora, Sarandë and Shëngjin. The port of Durrës has the biggest share in the volume of import/export in Albania, nearly 75%.

Due to current development rates, limited possibilities for expansion and pollution in the city because of its vicinity to the port, projects are identified to construct a new port which will better meet increasing needs and demands. This gives a reason to do research on the possibilities of constructing port facilities at an alternative location. This new ‘port’ is designed in the Durrës area.

To design a new port, information is needed about future trade and traffic anticipated in the future. An effort was made to make some forecasts in order to render this report more realistic. The produced forecasts are bases on a combination of past data extrapolation, trade and traffic trends as well as insight in the situation of Albania and hinterland connections.

The master plan duration, which will be 25 years (2010-2035), is divided into three periods. Three different growth scenarios were taken into account. This report has been based on the medium growth scenario (4.3%, 3.8% and 3.1 % increase in the total trade of Albania in tons for the three time periods respectively).

Assuming a medium growth scenario, 1,807,000 tons of dry bulk will be handled in Porto Romano in 2035, 774,000 tons liquid bulk, 1,033,000 tons general cargo and 215,111 TEUs.

When Romano Port starts functioning, it is immediately able to accommodate container vessels up to 45,000 dwt. For dry bulk it is assumed that the port should be able to accommodate vessels up to 40,000 dwt. The General Cargo vessels which currently enter the port of Durrës have an average size of 4,000 dwt. Although in general the size of General Cargo vessels remains relative small the average ship is expected to increase up to 10,000 dwt in 2035, with a maximum of 15,000 dwt. The maximum ship size for the liquid bulk terminal is assumed at 25,000 dwt.

Taking into account the above forecasts, the future needs concerning terminal areas, berths and equipment were depicted. The container terminal will require a storage area of 440,000 m² and a berth length of 466 meter. Dry bulk needs an area of 62,000 m² and a berth length of 240 meter. General cargo will require a storage area of 84,000 m² and a berth length of 543 meter. For the liquid bulk terminal, no additional berth is required.

Ten alternatives were generated based on the future needs above. Three of them were discussed in more detail. Several affecting parameters were taken into account like extensibility, tranquillity, manoeuvrability etc. The comparison among these alternatives was conducted with the help of a multi criteria analyses. The objectivity of this method was verified by doing several sensitivity checks. Finally it leads to a final optimum port layout.

Two chapters are written about the breakwater and quay wall. After an analysis, where several breakwater types were discussed and a comparison between a caisson type and rubble mound breakwater was made, the rubble mound breakwater appeared to be the preferred solution. The breakwater armour layer is designed using a single layer of Accropode II elements. A concrete unit is selected because the required weight of the armour units is substantially larger than the available 2 ton rock in the quarry nearby. For the quay wall, an open pile construction has been selected.

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Civil engineering theses

*Geo Engineering*
Bentonite cavities in diaphragm walls

Case studies, process decomposition, scenario analysis and laboratory experiments

The increasing multiple use of space in build-up areas requires safe and sound underground construction techniques with minimal or manageable risks to the environment. Diaphragm walls were regarded to meet these requirements, until calamities in Rotterdam (2007) and in Amsterdam (2008) at Vijzelgracht station occurred. The connection in between individual diaphragm panels was of insufficient quality due to the presence of bentonite cake in between the panels; bentonite cavities. Due to these bentonite cavities leakages occurred, as a result adjacent historical houses were damaged and some of them were declared unsafe to live in. To prevent this from happening in the future, more knowledge should be available on the possible causes of bentonite cavities.

This graduation thesis elaborates on scenarios responsible for the presence of bentonite (filter) cake in the joints of diaphragm walls in order to determine important processes and parameters with a causal connection to the formation of bentonite cavities in diaphragm walls. Scenarios on the formation of bentonite cavities were developed using literature, case studies and interviews with diaphragm wall experts. These scenarios indicated the importance of rheological parameters of bentonite suspension during concreting and the interaction of (fresh) concrete or cementitious material with bentonite suspension. To investigate the probability of this scenario, laboratory experiments were performed in order to determine the influence of cement on the viscosity and the yield point of bentonite suspension.

Furthermore measurement techniques were tested in order to monitor bentonite filter cake build up and density development in laboratory experiments. For these experiments different techniques are used; electrokinetic phenomena, image analyses filtrate water measurement etc.

Usually bentonite filter cake is formed due to a pressure gradient over the filtration medium, while experiments revealed the formation of bentonite cake on cementitious material without this pressure gradient. This bentonite cake was probably caused by colloidal behaviour and (electro) chemical reactions in between bentonite and cement. Interaction of bentonite suspension with cementitious material results in higher viscosities and significantly higher yield points of this contaminated bentonite suspension. Although the causal relation of changed rheological properties and the formation of bentonite cavities during concreting is not demonstrated by experiments, the increased viscosity of bentonite suspension reduces the ability of concrete to displace this suspension during concreting.
The adaptation of the method URUP for the Netherlands

With the URUP (Ultra Rapid UnderPass) method short underpasses for cyclists and pedestrians below roads and railways can be constructed. With this method a tunnel boring machine (TBM) starts on surface, bores an underpass, and ends on surface. The cross section of the underpass has a rectangular shape. The URUP method can be useful in the Netherlands because in the coming years several hundreds of multi-level crossings will be made.

Schematic overview of the URUP method

Contractor Van Hattum en Blankevoort (VHB) learned about this project for the first time during the ITA congress 2009. VHB invited inventor Obayashi to cooperate to adapt the URUP method for the Netherlands. This thesis is part of the adaptation plan that VHB and Obayashi explored.

The aim of this thesis is to adapt the URUP method in a technical sense, such that it can be industrially executed for short underpasses for cyclists and pedestrians below roads and railways in the Dutch circumstances.

The minimum required profile of free space for a two way cycle path and a pedestrian path is 6.00 by 2.50 meters. Generally there is a high groundwater table present in the Netherlands. This high groundwater table causes buoyancy, a ballast layer of one meter is required to prevent buoyancy everywhere in the Netherlands.

The adaptation of URUP in the Netherlands is investigated by researching a representative case. The elements of the underpass are of prefabricated reinforced concrete, as requested by potential client ProRail. The elements are built in rings with a length of 1.0 meter. A longer length of the rings results in fewer connections; on the other hand it must be possible to transport the elements and to correct bore deviations. Two types of rings are applied, mirrored to each other – this gains more building accuracy. The joints in the ring are situated where the bending moments are relatively low. This is roughly at ¼ and ¾ of the span in the top slab. In the Goes case a 'steel box solution’ is chosen as connection method.

The costs for the URUP method are compared with the costs of the conventional methods in the Dutch circumstances. This compassion shows that the method URUP is two times more expensive as the conventional method.

Based on this research it can concluded that it is technically possible to adapt the URUP method for short underpasses for cyclists and pedestrians below roads and railways in the Dutch circumstances. But this method is only of economical interest when large number of underpasses need to be constructed in a short time and a minimal hindrance is of the essence.

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Process and stability of slow moving landslides

Summary Thesis report:
The stability of the slow moving Big Rock Mesa (BRM) landslide located in California (USA) was analysed. A detailed description of its geometry and soil structure is presented. For the stability vital shear zone and unsaturated zone were identified. The strength and permeability of the different layers that exist in the BRM were determined using computational methods and from literature data.

The stability of landslides is susceptible to rainfall and changes to the groundwater level. The corresponding pressure changes cause slopes to become unstable. In dry periods the landslide is stable and in wet periods displacements by deformations occur. For the BRM landslide the rainfall data and displacements recorded with inclinometers were analysed. A water balance was made for a critical and stable period to evaluate the hydraulic flow. Besides rainwater it is likely that also water from adjacent areas flows into the BRM mass. Most of the rainwater is stored in the unsaturated zone of the BRM, which has an average thickness of about 42.5 m. Only a part of this water disappears by run-off and dewatering. The water pulse in the unsaturated zone is slowly drained by the evapotranspiration. The groundwater level profile of BRM was determined from measurements and computed with a statistical program called Surfer.

The infiltration of water into the unsaturated zone reduces the suction. This suction is smallest over the vertical infiltration length of the water pulse. The water pulse propagates deeper into the unsaturated zone when rainfall increases. The reduction suction weakens the soil. Consequently, the stability of a slide increases with evapotranspiration and decreases with water infiltration. The stability of the BRM and the flow through the unsaturated zone was analysed with the finite element program Plaxis. However, due to the size of the BRM a full coupled analysis of deformations and hydraulic flow was not possible. Instead steady state calculations were performed. The flow through the unsaturated zone was compared with results from the one-dimensional flow program called SWAP. For the conditions of steady state calculation with suction the BRM is stable with a safety factor of 1.17. The safety factor of the BRM decreases slightly with increasing head on the hill side of the geometry. Suction in the unsaturated zone increases the safety factor by only 0.01. This suction decreases when water infiltrates. The calculated small influence of increasing groundwater table corresponds with inclinometer readings.

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Modelling horizontal soil deformations

In this thesis the predictability of horizontal soil deformations resulting from an embankment construction on normal or lightly overconsolidated soft soils was subject of discussion. Adjacent structures as a pile foundation can be adversely affected by these horizontal movements. An exceptional case has been reported by Fellenius and Johansson (1973) where the piles of a two-storey building have buckled due to excessive horizontal deformations. More recently, in 2006 the piles under the HSL railway track close to Leiden were deformed as a result of large horizontal movements in the soft organic subsoil.

The traditional models for predicting horizontal deformations are the analytical models Loof and Van IJsseldijk, which assume undrained linear elastic soil behaviour during loading. De Leeuw has converted these models in normalized tables. Other traditional models that are frequently used in the daily geotechnical practice are the Mohr Coulomb and Modified Cam Clay model. The cases in literature show that the relative error between measured and predicted horizontal deformation generally varied between 50% and 100% with these models. For contractors such as Boskalis, the introduction of the Design & Construct contract calls for an update of the standard models for predicting horizontal deformations. The use of the traditional models can be problematic in this type of contract, because strict deformation requirements are mostly specified. Therefore, there is an urge for the development of models with an improved reliability.

An attractive model that could be used is the model of Bourgens and Mieussens, which is based on the empirical relations of Tavenas et al. (1979). This model relates the settlements under the centre of the embankment to the horizontal deformations under the toe of the embankment. Other numerical models that have been considered in the finite element program Plaxis are the Soft Soil Creep, S-Clay1 (Wheeler et al., 2003) and Anisotropic Creep (Leonie et al., 2008). The last two models are used-defined; these can be implemented as a dynamic link library (dll) in Plaxis. These user-defined models both use a rotational hardening rule to account for anisotropy during plastic straining.

The predictions of these models are validated with the in-situ measurements of two distinctive case studies. The first case study deals with the construction of a new road embankment near the existing A2 highway in Abcoude. The subsoil at this location mainly consists of fibrous peat. The other case study is about an embankment construction on a layered soil profile of sand and clay layers for a LNG export facility in Brass Nigeria. The results indicate that the best fits and lowest variation coefficients are obtained with the S-Clay1 model. This model is very suitable to simulate the horizontal soil deformations during the construction of an embankment. It performs less well in the long-term, because creep is not included.

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Civil engineering theses

*Transport & Planning*
Dynamic Speed Limits:  
Extension and Application

The ambition of the national road network authority is to achieve more flexibility and increased performance of the existing road network. A possible way to do this is by applying dynamic speed limits. To allow one to make a statement about the broader application of dynamic speed limits a study of literature has been conducted. This reveals in which circumstances dynamic speed limits can have a positive effect on traffic flow and in which circumstances the total time spent is minimized. It showed that the control approach is most important for a positive effect on traffic flow. The first control approach is focused on preventing traffic breakdown or resolving existing jams by reducing the flow by means of speed limits. When dynamic speed limits are combined with ramp metering, traffic inflow can be reduced further and traffic jams around on-ramps can be resolved better. In the second control approach the speed limit is increased just before the peak hour from 80 km/h to 100 km/h. In this way congestion can be postponed. This control approach is especially useful in 80 km/h-zones where merging is difficult because of homogeneous traffic. Using this knowledge, a new control approach has been developed in which dynamic speed limits are combined with ramp-metering. This control approach can help to solve more jams compared to a control approach with dynamic speed limits. Also, a method has been developed to select locations which are suitable for the implementation of dynamic speed limits to improve traffic flow. The method consists of three parts; determination of the type of jam, selection of locations and determination of the approach. Possible type of jams could be wide moving jams, bottlenecks near on-ramps or congestion in 80 km/h-zones. It depends on the type of jam in which way locations are selected. Because most of the approaches are focused on solving wide moving jams, the method is tested in a case study for this type of jams. First, a global selection of locations is made. After data processing of ten random stretches in Monigraph it appears that on eight out of ten stretches wide moving jams occur. To get a better view of the selection, it is necessary to process more data of stretches in Monigraph. The stretches on the A2 between Holendrecht and Oudenrijn and the A15 between Hendrik Ido Ambacht and Gorinchem are considered in greater detail. The frequency of wide moving jams is higher on the A2. After determining the solvability of wide moving jams, by using dynamic speed limits and ramp metering, the total time loss reduction is greatest on the A2. In percentage terms the gain on the A15 is higher, because of the lower frequency of traffic jams. Due to the very low flow rates at some on-ramps and the presence of other jams near on-ramps, the effect of ramp-metering was very limited. It is possible that these jams can also be solved by using dynamic speed limits and ramp-metering. To improve the developed control approach with dynamic speed limits and ramp-metering it is recommended to take into account every on-ramp and off-ramp upstream of the wide moving jam. In this way the control schedule is more realistic and more jams can be solved. When the control approach is used in practice, it is recommended to measure the flow rates with detection loops at on-ramps. The next step is to use a simulation model and a practical test with the application of dynamic speed limits to be able to predict the effects of dynamic speed limits.

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E-mission. Ontwikkeling van een Decision Support tool voor verkeersmmissies bij bedrijven

**Student: Jorrit Konings**

Allochtonen onderweg

**Student: Rik Verhoeven**

Return of water in the city

**Student: Jan de Vries**

**Theses Offshore Engineering**

Outline design of a semi-submersible wind turbine installation vessel

**Student: Andreas Croes**

Technical feasibility of offshore wind turbine installation with a spudpile vessel

**Student: Jasper van der Dussen**

Reducing Seafastening Time for Jacket Removal Projects in the North Sea

**Student: Jan Pieter Duvekot**

Integrated Design Methodology for a Monopile Support Structure for Offshore Wind Turbines using Numerical Optimization

**Student: Paul Godfroy**

Feasibility of tripod support structure for Offshore Wind Turbine in deeper waters

**Student: Atikunde Lawal**

An alternative solution for joining and installing tendons of a tension leg platform

**Student: Reinier op ten Noort**

Wake influence on tidal turbine performance and tidal farm arrangements

**Student: Moritz Palm**

Improve Set-down Operations during Removal Activities in the North Sea

**Student: Tom Piscaer**

Torsion in offshore wind turbines and the effect of torsion on a jacket support structure

**Student: Maxim Segeren**

Friction forces in pigging: a predictive model

**Student: M. Tillemans**

Validation of Hydrodynamic Load on Stinger of Pipelaying 0vessel Solitaire

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Pieter Schelte - Jacket Lift System: Dynamic Analysis of the Initial Lifting Phase

**Student: Florian Wasser**

Optimizing Heerema’s pipe supply process for future pipelay projects

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The added mass effect in centrifugal pumps

**Student: J.M. van Wijk**
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Civil Engineering Theses

Structural Engineering

Comparison of load redistribution in concrete bridges by theoretical and Finite Element approach  
Student: Bilal Ahmad

Impact of initial investment on repair and maintenance strategy  
Student: M.E. Becht

Achieving neutral stresses in renewed railway switches and crossings  
Student: S. Boogaerdt

The ultimate load carrying capacity of laterally restrained concrete decks  
Student: Godfrey Chamululu

Building acoustic aspects of IFD-units, Research to the nowadays quality and possibilities for improvement  
Student: A.M.J. Hietland

Numerical analysis of load-carrying capacity of thin-webbed post-tensioned T-beam using ATENA  
Student: Enny Kurniawati

The durable hybrid bridge. The use of fibre-reinforced plastics in concrete bridges  
Student: A.J. Langedijk

Maximum possible diameter of the Great Dubai Wheel  
Student: Wout Luites

Dynamic nonlinear finite element analysis of structures subjected to explosions  
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Development of a mix design method in the laboratory for mixes with Recycled Asphalt Pavement in the drum mix facility  
Student: Girum Mengiste Merine

Maintenance strategies for the TANZAM highway in Tanzania  
Student: A.K. Mwinchande

Fiber Reinforced Cementitious Composite Tailoring through 3D Lattice Fracture Simulations  
Student: Herry Prabowo

Stability design for frame type structures  
Student: R.P. Veerman

Hybrid concrete elements in a marine environment  
Student: N. Waterman

Building Engineering

The appreciation of the thermal indoor environment in practice  
Student: Dennis Faas

Sustainability, Flexibility and Costs of High-rise  
Student: Ing. S.C.B.L.M. van Hellenberg Hubar

The extent to which the EMVI instrument has contributed to the achievements of the business objectives of Rijkwaterstaat  
Student: C. Otto

Living Apartment Concept  
Student: C. Sekanyambo

Tool to design masonry double-curved shells  
Student: T.J. van Swinderen

Improvement through insulation: insulation on the interior of existing dwellings  
Student: R.M. Tersteeg

A supply-driven approach applied to the Contractor’s organisation  
Student: Martijn Verster

Regeneration of zeolites used for ammonium removal from anaerobic groundwater  
Student: Y. Mikkers

Transport & Planning

Towards Sustainable Urban Water Management in Brazil  
Student: Elwin F. Bakker

Development of District Heating Networks in Urban Areas  
Student: Daan van Beekum

Towards an optimal (re-) construction of motorways  
Student: Christophe Egyed

Calibrating a traffic microsimulation model with a phase based algorithm to make the trajectories suitable for traffic emission predictions.
Student: Frank de Groen  
Verbetering vervaardigingproces GVVP's

Student: R.J. in ’t Hout
Optimization traffic control using route information

Student: Jun Li
Assessment of the relationship between observed crashes and simulated conflicts at intersections

Student: Paula A. Marchesini
Reducing Travel Time Loss in Financial Services

Student: J. van Rossum
Optimal configurations for designs of bus stations

Student: Wouter Schakel
Network Performance Degeneration in Dynamic Traffic Assignment

Student: Bart Simon
Vrouwezand, island in lake IJsselmeer

Student: E.A.J. Vendrik
A dynamic traffic assignment model based on social costs

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A disaggregate freight transport model of transport chain and shipment size choice on the Swedish commodity flow survey 2004/05

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The effect of fluid velocity on eigenfrequencies of FPSO piping systems

Student: Sietze Douwe Akkerman
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Method for real-time touchdown point measuring during pipeline installation

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Formulation and Quantification of the Distributed Collinear Triad Approximation

Student: Matthijs Benit
Stability of a single top layer of cubes  
*Student: R. van Buchem*

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*Student: Myron van Damme*

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*Student: Thijs Damsma*

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*Student: R.E. Ebbens*

A Numerical Study on Design of Normal & T-Head Coastal Groins  
*Student: Sepehr Eslami Arab*

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*Student: Ramon de Groot*

Wave physics in a tidal inlet – Part I & II  
*Student: Paul J. van der Ham*

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*Student: B. Hiemstra*

Implementation of a wetting and drying algorithm in a finite element model  
*Student: Anna Kroon*

Using Texel Inlet as a sediment transport belt  
*Student: J.W.A. Lakeman*

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*Student: Leslie Mooyaart*

King Abdullah Economic City Port Master Plan, Kingdom of Saudi Arabia  
*Student: J Nammuni nee Krohn*

New Orleans Storm Surge Barrier  
*Student: Ruud Nooj*

Failure of Peat Dikes due to Drought  
*Student: Nterekas Dimitrios*

Modelling the 1775 storm surge deposits at the Heemskerk dunes  
*Student: A.D. Pool*

Loads on underwater concrete floors and tension piles due to swell  
*Student: Rogier Schippers*

Generating electricity from waves at a breakwater in a moderate wave climate  
*Student: J.E. Schoolderman*

Constructing a parking garage underneath historical city canals – a case study  
*Student: Pieter Schoutens*

Analysis of wave impact on the elastoCoast® system  
*Student: R.W. Sluijtsmans*

Evaluation of Material Models for Liquefaction  
*Student: Anteneh Biru Tsegaye*

Water jets surrounded by an air film  
*Student: F.R.S. Vinke*

Movable water barrier for the 21st century  
*Student: Floris van der Ziel*

Stability of morphological cells to dredging-dumping activities  
*Student: Nicolas Zimmermann*

Effect of the concrete density on the stability of Xbloc armour units  
*Student: B.N.M. van Zwicht*

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Water use of jatropha  
*Student: Roel Blesgraaf*

A new perspective on continental moisture recycling  
*Student: R.J. van der Ent*

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*Student: Zhen Fang*

The influence of clay cracks on the rainfall-runoff process  
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Optimization of the rainfall-runoff response in urban areas by using controllable drains  
*Student: David Haro Monteagudo*
Improved disaster management with use of Statistics Netherlands data  
*Student: J.T.M. Kuilboer*

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*Student: H. van der Laan*
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Civil Engineering Theses

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The feasibility of an integral bridge, with in detail the adiabatic shrinkage
Student: F. de Beukelaer, BEng

Modulaire Autobrug; In Vezelversterkt Ultra-Hogesterktebeton
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Influence of misalignment on the fatigue life of welded connections
Student: K.J.A. van Doremaele

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Student: M. van Bemmel

Sediment Budget Analysis of the Santa Barbara Littoral Cell
Student: J. Brocatus

"sustainable Management of contaminated Sediment"
Puerto Dock Sud - Buenos aires - Argentina
Student: K. M. Croonen

Building Engineering

The Great Dubai Wheel The structural feasibility of the world's first multifunctional centre less Ferris wheel
Student: J.A.N. Bolleboom

Climate Plus Dwellings Thesis on the energetic behaviour of dwellings with greenhouse and new innovative heat exchangers
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An optimised internal transport principle for a high-rise building
Student: J.W. Colsen

Prefabrication of concrete shells
Student: Eline den Hartog

Structural Shape study Al Ghubaiba Ferry Terminal
Student: J.G.L. (Jasper) Janssen

Building pits with permanent prefabricated concrete strut systems
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Student: J. Langedijk

Bio-physical impacts on fine sediment dynamics in an idealised Wadden Sea basin
Student: C. van Oeveren

Non-hydrostatic modelling of large scale tsunamis
Student: P.B. Smit

Sediment Transport in the Westerschelde Delta
Student: F. Verduin

Possibilities for an engineering consultant as project developer and investor
Student: J.P. Verschuure

Sustainable energy dam :Research into possible improvement of dam/dike safety by application of sustainable energy on dams/dikes
Student: D. Wondergem
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Watermanagement

Influence of temperature on filtration in membrane bioreactor
Student: M. Benschop

Reuse of softening pellets for remineralizing desalinated water
Student: L. Gao

Emission trading in Dutch water quality management
Student: C.B. Kamphuis

Quantifying vegetation cover changes from NDVI time series and determination of main causes for the Nile Basin
Student: S. van der Kruijs

Countering threats from micropollutants to European drinking water quality
Student: P.J.M. van Overveld

A method for simulating wetland hydro-dynamics in regional climate models
Student: M. Smoorenburg

On the applicability of discharge measuring techniques in partially filled conduits
Student: H. de Man-Van der Vliet

Offshore Engineering Theses

"The HydroBLIMP" Buoyancy driven subsea lifting
Student: T. Bakker

Surge Motion Damping Methods for Soft Yoke Mooring Systems
Student: J.B.T. Brinks

Concept development for side-by-side offloading of Liquefied Natural Gas
Student: P. Cuppen

The Braceless Semi Submersible
Student: V.J. Nolting

Numerical Simulation of Suction Pile Lowering
Student: H. Siegersma

Scaling Offshore Energy Converters
Student: B.M. Visser

Transport & Planning

Optimization of the evacuation of regions by car
Student: O.L. Huibregtse

Modelling the Influence of Travel and Traveller Characteristics on Multimodal Travel Behaviour
Student: M.P.T. Koenis

Modelling railway dispatching actions in switching max-plus linear systems
Student: Dirk van der Meer

The effect of precipitation on travel time prediction and the influence on the reliability of travel times.
Student: Michiel Soetens

Amsterdam: dynamic, liveable and reachable An analysis of the effects of AMFORA
Student: N. van der Velden

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### Research groups and professors within the faculty of Civil Engineering and Geosciences

#### Design and Construction

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<th>Telephone 015-27</th>
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<td><strong>Construction Mechanics Research Group</strong></td>
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<tr>
<td>Construction mechanics</td>
<td>Prof. J.G. Rots</td>
<td>83799</td>
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<tr>
<td>Dynamics</td>
<td>Prof. A.C.W.M. Vrouwenvelder</td>
<td>84782</td>
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<tr>
<td>Numerical mechanics</td>
<td>Prof. L.J. Sluys</td>
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<tr>
<td><strong>Materials Science and Sustainable Construction Research Group</strong></td>
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<tr>
<td>Acting chairman</td>
<td>Prof. K. van Breugel</td>
<td>84954</td>
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<tr>
<td>Fund. and Applied Materials Science</td>
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<tr>
<td><strong>Road and Rail Construction Research Group</strong></td>
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<tr>
<td>Road Construction</td>
<td>Prof. A.A.A. Molenaar</td>
<td>84812</td>
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<tr>
<td>Rail Construction</td>
<td>Prof. C. Esveld</td>
<td>87122</td>
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<tr>
<td><strong>Building and Civil Engineering Structures Research Group</strong></td>
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<tr>
<td>General Construction Design</td>
<td>Prof. L.A.G. Wagemans</td>
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<tr>
<td>Concrete structures</td>
<td>Prof. J.C. Walraven</td>
<td>85452</td>
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<tr>
<td>Concrete modelling &amp; materials</td>
<td>Prof. K. van Breugel</td>
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<tr>
<td>Building physics and installations</td>
<td>Prof. J.J.M. Cauberg</td>
<td>83387</td>
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<tr>
<td>Timber structures</td>
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<td>Steel structures</td>
<td>Prof. J. Wardenier</td>
<td>82315</td>
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<td>Prof. F.S.K. Bijlaard</td>
<td>84581</td>
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<tr>
<td>Steel construction of buildings</td>
<td>Prof. J.W.B. Stark</td>
<td>82303</td>
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<td>Building Technology</td>
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<td>Utility buildings</td>
<td>Prof. J.N.J.A. Vamberský</td>
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<td><strong>Product Design Research Group</strong></td>
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<tr>
<td>Methodical Design</td>
<td>Prof. H.A.J. de Ridder</td>
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<td>Building Informatics</td>
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#### Hydraulic Engineering

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<td><strong>Fluid Mechanics Research Group</strong></td>
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<td>Fluid Mechanics</td>
<td>Prof. G.S. Stelling</td>
<td>85426</td>
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<tr>
<td>Environmental hydro informatics</td>
<td>Prof. A.E. Mynett</td>
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<td>General Fluid Mechanics</td>
<td>Prof. J.A. Battjes</td>
<td>85060</td>
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<tr>
<td><strong>Hydraulic and Offshore Engineering Research Group</strong></td>
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<td>Probabilistic design and</td>
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<tr>
<td>Hydraulic Structures</td>
<td>Prof. J.K. Vrijling</td>
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<td>Coastal Engineering</td>
<td>Prof. M.J.F. Stive</td>
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<td>Ports and Inland Waterways</td>
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<td>River morphology &amp; River Engineering</td>
<td>Prof. H.J. de Vriend</td>
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<td>Offshore Engineering</td>
<td>Prof. J. Meek</td>
<td>84777</td>
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## Water Management

### Sanitary Engineering Research Group
- **Sewerage**: Prof. F.H.L.R. Clemens 83347
- **Waste Water treatment**: Prof. J.H.J.M. van der Graaf 81615
- **Drinking Water**: Prof. J.C. van Dijk 85227

### Water Resources Research Group
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- **Water Resources**: Prof. N.C. van de Giesen 87180
- **Geohydrology**: Prof. Th. N. Olsthoorn 87346
- **Water Resources Management and Earth Observations**: Prof. Bastiaanssen 87346

## Transport & Planning
- **Transport Planning**: Prof. P.H.L. Bovy 84611
- **Traffic and Transport Management**: Prof. H.J. van Zuylen 82761
- **Traffic and Transport Facilities**: Prof. I.A. Hansen 85279
- **Infrastructure Planning**: Prof. F.M. Sanders 81780
- **Traffic Flow Theory and Simulation**: Prof. S.P. Hoogendoorn 85475

## Applied Earth Sciences

### Applied Geology Research Group
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- **Production Geology**: Prof. S.M. Luthi 86019

### Resource Engineering Research Group

#### Petroleum Engineering Research Group
- **Oil- and Gas production systems**: Prof. P.K. Currie 86033
- **Reservoir Technology**: Prof. W.R. Rossen 86038
- **Reservoir Engineering**: Prof. C.P.J.W. van Kruijsdijk unknown

#### Applied Geophysics and Petrophysics
- **Geophysical Imaging Methods**: Prof. W.A. Mulder 83666
- **Integrated Time-Lapse Methods**: Prof. R.J. Arts 85190
- **Technical Geophysics**: Prof. C.P.A. Wapenaar 82848
- **Reservoir Systems & Control**: Prof. J.D. Jansen 87838

### Geo Engineering Research Group
- **Soil mechanics**: Prof. F. Molenkamp 85280
- **Groundwater mechanics**: Prof. F.B.J. Barends 85423
- **Foundation Engineering**: Prof. A.F. van Tol 85478
- **Underground Space Technology**: Prof. J.W. Bosch 82844
- **Geo environmental engineering**: Prof. J. Bruining 86032