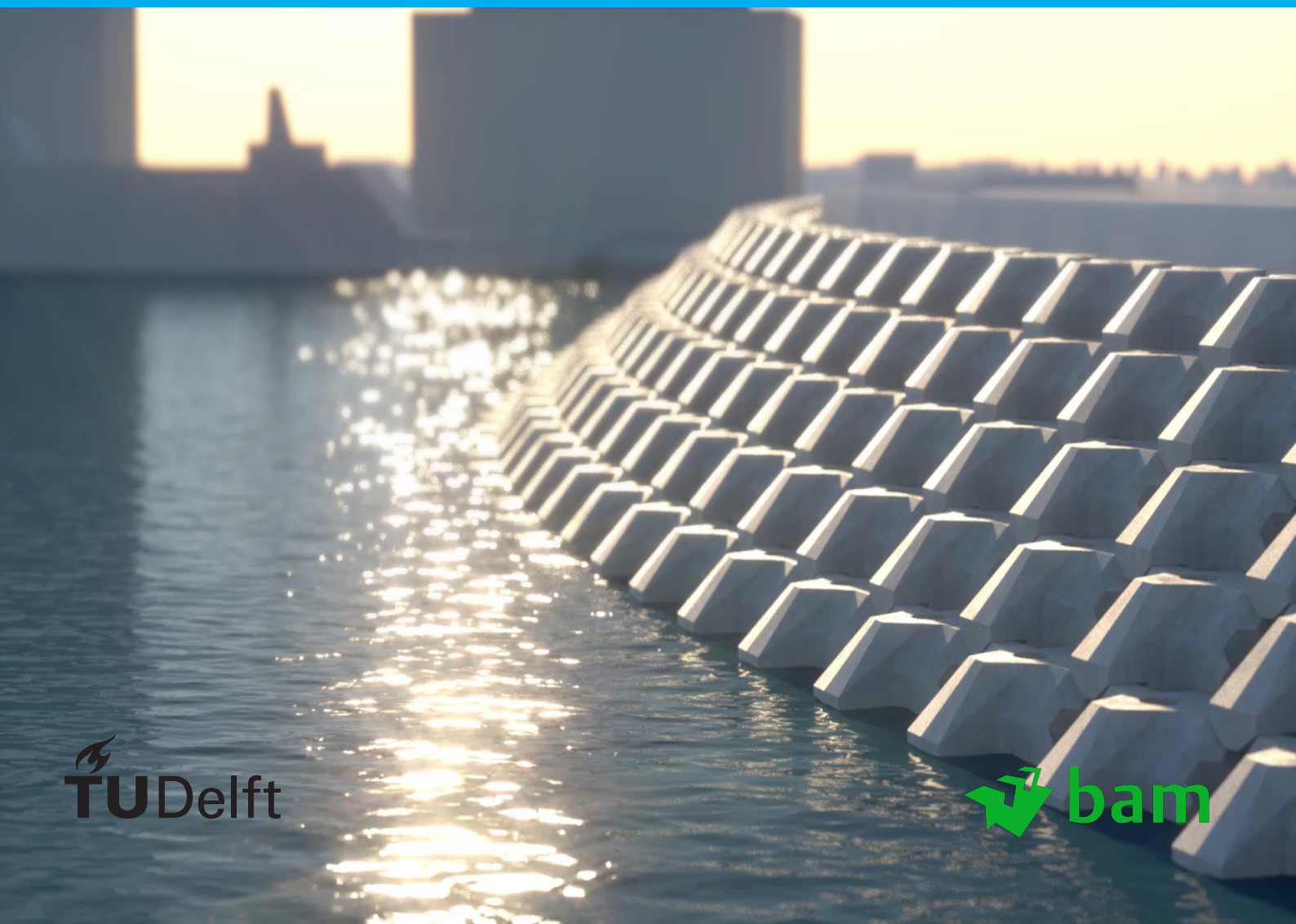
Assessing the Important Factors for Obtaining Technological Dominance in the Concrete Armour Unit Industry

Master Thesis
CME2001

L.J. Batenburg



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Master Thesis CME2001

by

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Preface

This master thesis is written to fulfill the master program Construction Management and Engineering at the Delft University and Technology and came to rise in cooperation with the subsidiary of the Royal BAM Group named BAM Infraconsult. Prior to my graduation thesis, I worked as a research intern at the water department of BAM Infraconsult. The experience and the knowledge gained there gave inspiration to research the concrete armour unit industry from a market perspective and identify important factors for technological dominance.

I would like to express my gratitude to my company supervisors Bas Reedijk and Pieter Bakker. I have really enjoyed working for BAM Infraconsult, and I would like to thank my company supervisors for sharing their knowledge and experiences in this industry and for giving me this opportunity.

Furthermore, I would like to express my gratitude towards my supervisors Geerten van de Kaa, Tom Dolkens and Daan Schraven. As my chair supervisor, Geerten shared his constructive feedback and helped me shape this thesis. Tom, my main supervisor was always available to share thoughts and for answering all my questions. Also, I would like to thank Daan for his constructive feedback on my graduation process. Lastly, I would like to thank you all for your flexibility in times of COVID.

Also, this study was not possible without each of the experts all over the world willing to participate in this study. I would like to thank you all for your time and for all the opinions you have shared with me about this industry.

Lastly, I would like to thank my girlfriend and my parents for their support in this process. Without you working from home would be very depressing!

L.J. Batenburg
Gouda, December 2021

Executive Summary

The concrete armour unit industry exist for more than 70 years, in this period various units were developed. The first units derived their hydraulic stability on their own weight, later the units got more complex shapes and got interlocking capabilities. The first interlocking units were placed in a two-layer configuration, like Tetrapod and Dolos. Later the industry shifted to a one-layer design where concrete use became less since fewer units were needed. The industry standard of one-layer gave rise to various new armour units, like Core-Loc and Xbloc.

Up to the present, this industry is mainly studied from a technological perspective where the hydraulic capabilities and design formulae are extensively researched (so called 'hard factors'). However, some units became very commercially successful in terms of units placed but others did not. In this highly technological industry, no market research is done in order to study which factors led to commercial success.

In this study, an effort is made to investigate which factors are responsible for becoming successful in this branch. To do so, the concept of technological dominance is linked to this industry. Technological dominance is a technology management concept wherein a market similar technologies are 'battling' for the allegiance of the market. Eventually, the market selects a particular design and becomes dominant.

Over the years scholars identified factors that contribute to obtaining technological dominance and collected those in a framework. In this study, the framework by Van de Kaa et al. (2011) is chosen. This framework consists of 29 factors that influence the outcome of a technology battle.

The methodological approach for this study is to select relevant factors regarding this industry by interviewing 4 key experts. The identified relevant factors are then carried into the next round of interviews, where a broader group of 14 experts were asked to rank these factors according to the Best Worst Method.

The Best Worst Method (BWM) is a multi-criteria decision-making tool, designed by Rezaei (2015), where the decision-maker expresses their preference by making pairwise comparisons. This method gives more reliable weights and requires fewer pairwise comparisons in respect to other multi-criteria decision-making tools, like AHP.

The results yielded by this method suggest that the factor 'brand reputation and credibility' are among experts considered as the most important factor for technological dominance regarding this industry. Furthermore, 'hydraulic stability' is in this branch considered second most important for obtaining technological dominance. Also, factors like 'marketing communications' and having a large network of stakeholders are considered very important. Based on the results, there can be concluded that in this technological branch soft factors can be more important than hard factors.

This implies that in order to be successful in this industry actors should focus more on building a reliable and well-known brand reputation. In this branch, actors have proved that a strong brand name can help to extend the commercial lifespan of an armour unit with expired patent and can help to speed up the adoption of new armour units.

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Introduction

The first concrete armour unit was developed in the 1950s by the Laboratoire Dauphinois d'Hydraulique (now Artelia) in France, this unit was called the Tetrapod. According to P. Bakker et al. (2003), the main advantages of Tetrapod are the improved interlocking and the larger porosity. Which improves the overall performance in terms of wave dissipation and wave run-up. Tetrapod was designed to be placed in a randomly two-layer configuration. This implies that each unit is placed randomly in two layers on top of each other, where stability is obtained from the weight and the interlocking of each unit. From the 1950s until the 1980s a large variety of other armour units were developed. However, the vast majority is implemented in a small number of projects.

In the 1980s the focus shifted more to develop single layer amour units. This gives a large reduction in concrete use because fewer concrete units have to be cast. The first company that developed a single layer armour unit was Artelia (Sogreah at that time). In 1981 they patented an armour unit called Accropode, which had a great economical advantage over the two-layer competition but the same hydraulic performance. This product was a large success, over 200 projects up to this date are done with Accropode (Artelia, 2020).

Since the early 2000s, the Royal BAM Group has been involved in the armour unit business. Prior to that, they were doing projects involving armour units of the competition. With that experience, Royal BAM Group developed and patented their own armour unit called Xbloc. Which should be technologically better than the dominant Accropode (P. B. Bakker et al., 2004; Muttray et al., 2003). Artelia presented shortly after Xbloc was presented an updated version of Accropode, called Accropode II.

The most recent development in the concrete armour unit industry was In 2018 when BAM patented a new armour unit called XblocPlus, which is more aesthetically appealing and more resilient to high waves compared with the competition (Jacobs et al., 2018). This new armour unit is unique in the market, where the vast majority of concrete armour units are randomly placed XblocPlus is placed uniformly in a brick pattern.

Related to the concrete armour unit market is the topic of climate change is and an important driver for innovation. Innovative technology is an significant response to operational and realistic adaptation and mitigation of such threats posed by climate change (Nwankwo et al., 2020). Because of climate change the global sea level is rising, since higher temperatures cause the melting of polar ice and the expansion of seawater. A secondary effect of climate change is that seawater becomes warmer and more and heavier storms will occur (Easterling et al., 2000). These developments affect coastal areas in particular, especially in geographically vulnerable regions where people live in poverty. These areas are for example low lying islands. A study projects the sealevel rise at the end of the 21st century to be between 30-69 centimetres in a low emission scenario (Bamber et al., 2019). This results in major changes in coastlines and inundation of low lying areas, such as river deltas and low lying islands (Nicholls and Cazenave, 2010; Pachauri and Reisinger, 2007). Areas affected by climate change are potential markets for concrete armour units. Since these units help to protect coastal areas from overtopping of high waves and prevent erosion of the coastline (CIRIA, 2007).

1.1. Research Problem

In the concrete armour unit industry, armour units can be divided by their placement pattern. Units can be placed random or uniform. Muttray et al. (2003) specified 5 generations by their shape and the governing stability factors in the category of randomly placed units:

- First-generation armour units (stability factors are weight and to very limited extend interlocking, typical examples are Cube, Modified Cube (1959) and Antifer Cube (1973));
- Second generation armour units of simple shape (stability factors are weight and to some extend interlocking, examples are Tetrapod (1950), Tribar (1958) Tripod (1962) and Akmon (1962));
- Second generation armour units of complex shape (governing stability factor is interlocking, examples are Stabit (1961) and Dolos (1963));
- Third generation single layer armour units (governing stability factor is interlocking, examples are Accropode, Core-loc and A-Jack, Accropode II and Xbloc (Muttray and Reedijk, 2009));

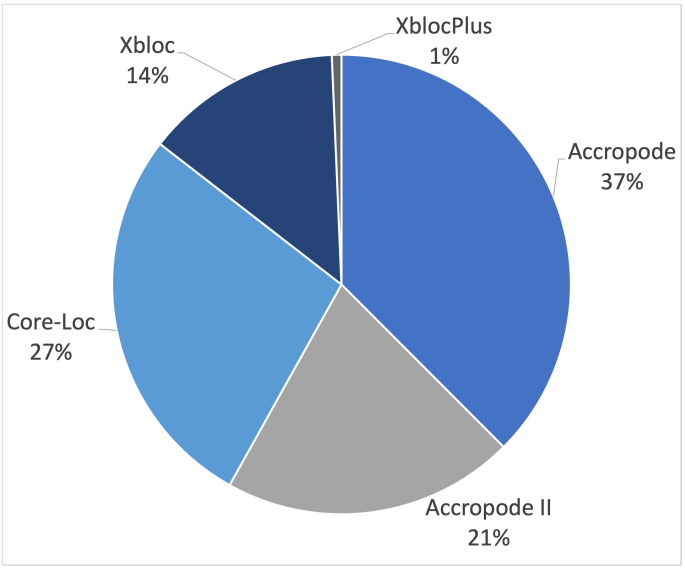

Figure 1.1: Distribution of projects with armour units between 2000-2021

During the past 70 years of development in the concrete armour industry, there can be multiple battles identified in the market of concrete armour units. The first armour unit which achieved dominance was the Tetrapod, this was the first interlocking concrete armour unit. The dominance of Tetrapod declined when the same manufacturer developed the first single layer concrete armour unit, namely Accropode. After around 20 years of dominance, Artelia brought an improved version of Accropode to the market, called Accropode II. Since the patent of Accropode has expired (Chevallier, 1980) and Accropode II is on the market, there is a decline in the number of projects done with Accropode. Where from 1980 to the early 2000s were its peak years (Artelia, 2020). After the patent of Accropode was expired the newer Accropode II was patented and almost simultaneously Xbloc came on the market (Muttray et al., 2003).

From 1980 to the present information is publicly available of the track record of various concrete armour units. These units are Accropode, Accropode II, Ecopode and Core-Loc, developed/sold by Artelia (Core-Loc is developed by the USACE and commercialized outside the American States by Artelia). The units Xbloc and XblocPlus are developed by the Royal Bam Group. Artelia, formerly known as Sogreah and Laboratoire Dauphinois d'Hydraulique, is the industry leader in the total number of projects done with their armour units, which is around 360 (Artelia, 2020).

When Xbloc, Core-Loc and Accropode II came on the market there was more choice in concrete armour units (see figure 1.2). This choice in similar products has resulted from 2000 to the present that no product has reached a percentage of over 50% (see figure 1.1). This indicates that the market of

the last generation of randomly placed armour units has not moved to a dominant design yet according to Anderson and Tushman (1990). But there is no consensus in the literature on which armour unit in this generation technological superior (Bruce et al., 2009; Muttray and Reedijk, 2009). Which is the research problem of this study, no research is done about which factors are responsible for dominance in this industry. Therefore the research objective is to find out which factors are of importance.

Figure 1.2: (Commonly used concrete armour units (left to right: Accropode, Core-Loc, Xbloc, Accropode II and CubiPod)

1.1.1. Research Objective

In the previous section, it can be concluded that since the existence of concrete armour units three technological battles have taken place. The first battle took place between the 1950s and 1980s, where the first interlocking units were developed. Eventually, the Tetrapod was the dominant armour unit. The second battle took place between the 1980s and 2000s, this battle was about the single layer armour units where the French Accropode eventually became dominant. The third battle started around 2000 with a new generation of single-layer armour units. This battle as described in the previous section is still going on and no armour unit has reached dominance yet. The question is if any of these units will reach dominance since the patents expire after 20 years.

As described in the Introduction the latest development in the concrete armour unit industry is XblocPlus. This could be the start of a new technological battle in the industry of concrete armour units. The aim of this research is to investigate which factors for technological dominance affect the technology battle between the key products in the market of concrete armour units. Where the identified key products are the concrete armour units of the last technological battle and XblocPlus.

In order to study which factors for technological dominance in the concrete armour unit market are important, the factors of the framework developed by Van de Kaa et al. (2011) are used. Where each factor is checked for its relevance and importance in the eyes of the experts. The importance of each relevant factor will be determined by an MCDM (Multiple-Criteria Decision-Making) tool, the tool of choice is called BWM (Best-Worst Method) developed by Rezaei (2015). With this method, the relevant factors are weighted for their importance and conclusions can be drawn about which factors are most important for dominance in the concrete armour unit market. This research approach is therefore a deductive study, where the concept of dominant design is checked for its validity in the concrete armour unit market.

1.2. Relevance

So far, the literature gives no clear answer about which factors are of importance for technological dominance in the concrete armour unit industry. However, there is a scientific and practical ‘need’ for the exploration of important factors in the industry of concrete armour units. The scientific ‘need’ is based on the fact that there is no application of the concept of technological dominance on this industry. The practical relevance is that there is an urgency for the improvement of coastal infrastructure due to climate change. This course of events plays the development of concrete armour units an important role (Park et al., 2019).

1.2.1. Scientific Relevance

The scientific contribution of this thesis is the application of the dominant design concept by J. M. Utterback and Abernathy (1975) with the corresponding battles in the concrete armour unit industry. In this study, the important relevant factors identified by the framework composed by Van de Kaa et al. (2011) will be weighted in an MCDM. To date, none of these factors are applied on this industry and checked for their validity. The more industries this concept is challenged with the more it becomes

validated, this applies for the concept of technological dominance and for the Best-Worst Method. On the other hand, the concrete armour unit industry is in the literature mainly from a hydraulic performance point of view studied. Such as stability, durability and design aspects (CIRIA, 2007; Jacobs et al., 2018; Muttray and Reedijk, 2009; J. W. Van der Meer, 1987; J. Van der Meer, 1999; Van Gent et al., 1999). Since the topic of coastal infrastructure is more present than ever because of climate change, there is an urgency to gain a better understanding of how the market of concrete armour units behaves. Therefore the aim of this research is to close the gap between the dominant design literature and the concrete armour industry and give a better understanding about both topics.

An additional gap exists in the fact that the cases studied in the dominant design literature generally consist of a large group of various clients, such as companies and consumers (Mi et al., 2019). But the concrete armour unit industry consists of a small group of large clients, which are mostly government agencies and design firms. Therefore this study is contributing to the dominant design literature by validating if the important factors also comply with a different clientage.

1.2.2. Practical Relevance

The outcome of this study contributes practically to the companies who are involved in the concrete armour industry. Various stakeholders could benefit from the results about which factors are most important for dominance in this industry and which product is most likely to win the next technology battle.

Manufacturers and inventors of concrete armour units could gain valuable insight into the important factors for winning a technology battle with their concrete armour unit. This could help R&D departments to adapt their long term strategy for the development of new units.

Design firms and consultants in this industry are responsible for the design and the concrete armour unit of choice. If this study can point out a potential dominant product characteristic in the future, the decision of which armour unit to use for a project is made easier. This will also satisfy the client since the decision for the 'best' armour unit is made.

1.3. Research Questions

In order to execute this master thesis, a main research question and 2 sub-questions are formulated. The sub-questions are about information needing for the solving of the Best Worst Method, where the key products consist of the unit mentioned in figure 1.1.

1.3.1. Main Question

How do factors for technological dominance affect the technology battle between the key products in the market of concrete armour units?

1.3.2. Sub-Questions

Sub-Question 1

Which factors for technological dominance are relevant for the outcome of the technology battle between the key products in the concrete armour unit market in the opinion of the experts?

Sub-Question 2

What is the importance of each of the relevant factors for technological dominance in the technology battle between the key products in the concrete armour unit market in accordance with the Best Worst Model?

1.4. Research Method and Data Gathering

In order to answer the research questions about the important factors for technological dominance, three consecutive research methods are proposed. The first proposed method is a literature study about the dominant design concept and about the concrete armour industry. The second proposed method is conducting two rounds of interviews, where in the first round a rough selection of factors done by a small selection of experts in the industry. The goal of the first round is to explore the case-specific factors of technological dominance in the eyes of the experts. The second round is conducted

under a broader group of interviewees, where the selection of factors determined in the first round is ranked in order to process it into the BWM. The last proposed method is the Best Worst Method (BWM), in this last stage the gathered information about the important factors of technological dominance is used as input for the BWM. The output of this method gives an insight into the importance of the relevant factors. In the following sections, each method is discussed more extensively. A schematized overview of the proposed research approach can be found in figure 1.3.

1.4.1. Literature Study

This desk study is conducted in two fields, the first field is in the dominant design area. First founded by J. M. Utterback and Abernathy (1975). Based on this research further studies are done by M. A. Schilling (1998), Suarez (2004) and Van de Kaa et al. (2011). The aim of researching the literature is to discover important factors about various cases of dominance. The literature study in the second field, which is about concrete armour units, is mainly about the hydraulic capabilities of each unit. However, the goal is to find relevant technological factors which can be related to the important factors for technological dominance drawn by the framework by Van de Kaa et al. (2011).

1.4.2. Interviews

The interviews will consist of two phases, the first phase is held under a small group of experts and the second phase is done under a larger group. The format of this interview, which is to determine the important factors and rank those, enables other companies to give open answers without disclosing any company secrets such as future developments and new projects. Important for the first phase is that no more than 9 relevant factors are picked, this is because an expert cannot make sensible comparisons. The reason behind this is that the short term memory is not able to memorize more than 9 items (Miller, 1956). The experts which are approached can be divided in four groups:

- Inventors
- Management
- Consultants
- Academics (professors, lectures or other relevant academic staff from the Delft University of Science)

Preferably the number of people interviewed in the first phase will consist of four experts, from each group 1. In the second phase more experts are interviewed, this larger group preferably exists of 12-16 people. This means that of each group is desired between 3 and 4 experts are interviewed, which gives a representative overview of the industry.

1.4.3. Best Worst Method

This multi-criteria decision-making (MCDM) method is designed by Rezaei (2015), the goal of this method is to select the most important alternative by selecting the best and the worst criteria. These criteria are selected by the researcher and the decision-maker. The process from input to output consists of 5 steps, the first step is to select the criteria. This is done in the first round of interviews accompanied by the factors found in the literature, as mentioned earlier the amount of factors is limited to 9. The second step is to determine the best (e.g. the most important), and the worst (e.g. the least important) criteria. In this stage the decision-maker selects the best and the worst criteria, without making a comparison. After the second step the preference of the best criterion all over the other criteria is determined, by means of pairwise comparison. The fourth step is the other way around, the preference of all the criteria over the worst criterion is determined, again in a pairwise manner. The fifth and the last step is solving a maximin problem that gives the outcome of the most optimal weights.

Prior to the development of the Best Worst Method, technological dominance and decision making was assessed by the Analytic Hierarchical Process (AHP), studies like Van de Kaa et al. (2013) and Van de Kaa et al. (2014) used this approach. When the Best Worst Method was developed it proved to be a more efficient MCDM tool in comparison with AHP (Rezaei, 2015). The BWM leads to more consistent comparisons, therefore more reliable rankings and reaches consensus in a natural way. This is because the best and worst alternatives are identified before making pairwise comparisons. This method is therefore contributing to a more reliable decision making about which factors are of

importance for the concrete armour industry. This makes the BWM more suitable for this study than the AHP.

1.5. Thesis Outline

The proposed general outline of this master will consist of 6 chapters, a more schematized view of the setup of this thesis can be found in figure 1.3.

1. **Introduction**
   In this chapter the topic is introduced and the background of the problem is being described.
2. **Literature Review/Theoretical background**
   The introduced research problem will be further explored in the available literature about the important factors in reaching technological dominance
3. **Methodology**
   The research methods used will be explained in more detail in this chapter
4. **The Concrete Armour Unit Industry**
   In this chapter the details of this industry will be discussed. Various products will be analyzed on their hydraulic capabilities
5. **Results**
   Here will be the outcome of the interviews and output of the BWM treated
6. **Discussion, Conclusion and Future Research**
   In the last chapter the research questions are answered and the results will be processed into concluding remarks with discussion and recommendations for future research

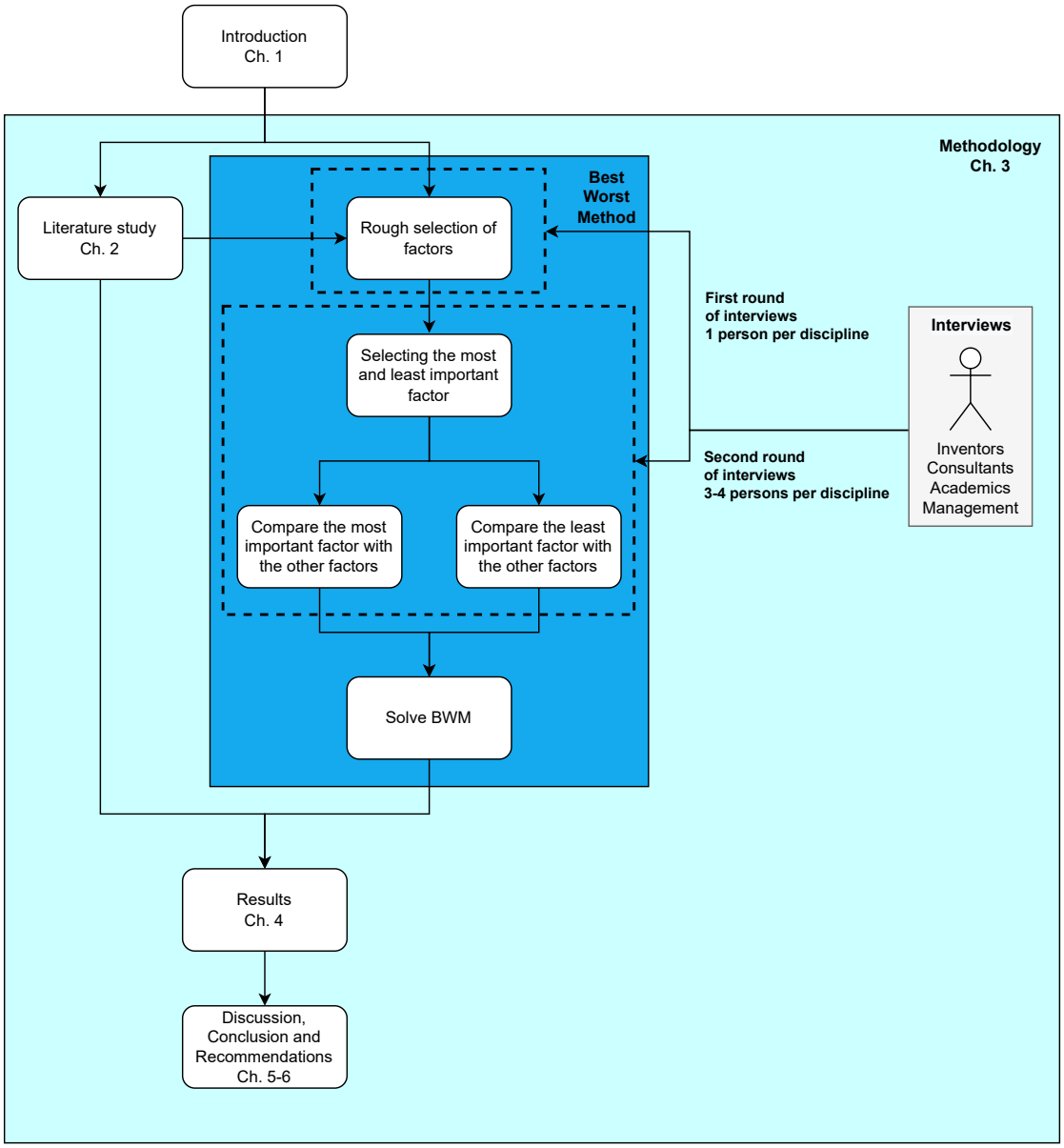

Figure 1.3: Research approach schematized

2

Theoretical Background

In this chapter, the literature about the concept of technological dominance and the relevant literature about concrete armour layers will be reviewed. These concepts form the academic foundation of this master thesis.

Firstly, the concepts of technological dominance and dominant design are discussed. Technological dominance is a technology management concept about similar technologies which are 'battling' for technological dominance in the market. Various empirical studies with different theoretical approaches contributed to this concept and determined relevant factors which influence the outcome of a technology battle. Thereafter, the proposed framework is being discussed which is used in the interviews and in the BWM. Subsequently, the process of how a technology becomes dominant is being elaborated on.

Secondly, a connection is made between technological dominance and the concrete armour unit industry where historical developments are being reflected on the literature about technological dominance. The purpose is to establish if there are elements of technological dominance present in the concrete armour units industry based solely on the literature. Additionally, important technical aspects of concrete armour units are discussed. The purpose is to determine if there are specific product characteristics that are important from a technical point of view, which could contribute to technological dominance.

2.1. Different Streams and Perspectives on Technological Dominance

The concept of technological dominance finds its origins back in 1975 when it was first introduced by Utterback and Abernathy. In their paper, they pose ideas for an integrative theory that will predict differences in the innovative process between various firms and industries (J. M. Utterback and Abernathy, 1975). However, in their paper the term dominant design is not mentioned, they refer to 'a dominant strategy'. In a later published paper, one of the original scholars acknowledged that the 1975 paper was the original source of the concept of technological dominance (J. M. Utterback and Suárez, 1993). J. M. Utterback and Abernathy (1975) studied various industries and discovered that the nature of innovation changes over time. When companies enter a new industry, the focus is primarily on technological innovation. This results in various designs being implemented that are competing in the market. Eventually, one specific design wins the allegiance of the market, which marks the emergence of a dominant design. Abernathy, Utterback, et al. (1978) argued that when a dominant technology emerges, this affects the innovation of the entire industry, where the focus shifts towards process innovations. Companies are putting more effort into increasing the efficiency of their production line and making their products more standardized.

J. M. Utterback and Abernathy (1975) were among the first who described the phenomenon of a technology becoming dominant in the market. This dominant technology was first identified in a single design. Later scholars from different disciplines started to research technological dominance in other industries. This led to studies from different perspectives, where Utterback and Abernathy studied it from an evolutionary economics perspective, other scholars studied it from a network economical, an institutional economical and technology management perspective.

From the evolutionary economists' point of view, the adoption of a technology by the market is a result of a process of natural selection (Arthur, 1989). Where technology evolves incrementally over time until there is a major technological breakthrough presented in the industry. Such a breakthrough can be referred to as a 'technological discontinuity' and can have a significant impact on the industry, in terms of an increase in uncertainty (Tushman and Anderson, 1986). Bower and Christensen (1995) add that discontinuous technologies result in new markets or applications. Which are eventually competing for dominance in the market (J. M. Utterback and Abernathy, 1975).

Other scholars have stressed that market characteristics, like network externalities, are of importance for the outcome of a technology battle (Arthur, 1989). These network externalities are defined as the benefit an individual user derives from a technology increases when the group of users becomes larger (Katz and Shapiro, 1985). In industries that are characterized by network externalities often results in a technology that becomes the winner in the industry that takes all the market share and locks out other similar technologies (M. A. Schilling, 2002). Other network economists have emphasized that not always the most technologically superior technology becomes dominant (David, 1985).

Institutional economists pinpoint the importance of the strategic positioning of the firm. They argue that strategic choices can affect the outcome of a technology battle (Cusumano et al., 1992). The focus of this theoretical approach is on the characteristics of the firm, where firms use certain strategies to position their product in the market. Such strategies can be in the field of pricing, appropriability and distribution of the product (Hill, 1997; Teece, 1986).

The latter category of scholars have studied this phenomenon from a technology management perspective. Suarez (2004) argues that the technology management academics were the first who studied technological dominance in a more systematic manner. He states that although good effort has been made by previous scholars, no framework was made yet where different theoretical approaches of technological dominance were incorporated. Although Suarez acknowledges the contribution of the prior work of M. A. Schilling (1998) for example, he does not refer to it as a framework. Where Van de Kaa et al. (2011) and Den Uijl (2015) refer to it as a framework that has contributed to their proposed framework. Van de Kaa et al. (2011) refers to the frameworks by Lee et al. (1995), Suarez (2004) and M. A. Schilling (1998) as authoritative frameworks that integrate the different concepts present in the technological dominance literature, as discussed above.

The framework by Lee et al. (1995) was the starting point of research to categorize important factors for the emergence of technological dominance. Lee et al. (1995) acknowledges based on prior research (Rosenbloom and Abernathy, 1982) that the process of innovation to economic success can be seen as a 'black box'. In their paper, they argue that the 'black box' comprises a number of factors that can be categorized in; external conditions, technological factors, non-technological factors and complementary assets. Lee et al. (1995) states that within this 'black box' technological and non-technological are interacting with each other, but does not mention any factors. However, Lee et al. (1995) acknowledges that technological superior technologies are not guaranteed to obtain dominance. They describe that understanding this 'black box' guides firms to implement a strategy for the successful development of innovation. Without this understanding, firms are not able to develop an adequate innovative strategy. However, Den Uijl (2015) criticizes this paper for being too abstract with a limited number of factors, which makes the strategic value of this framework questionable.

M. A. Schilling (1998) studied the phenomena of technical lockout. This process of technology adoption could potentially lockout a firm's technology when it is not able to compete with the dominant standard, and therefore be rejected by the market. M. A. Schilling (1998) proposes two types of technical lockout scenarios. Type 1 is defined as a scenario where the firm produces products in a market that has not moved to a dominant design yet, but when it does this product gets rejected by the market since it is not the dominant one. Type 2 is defined as that the company being unable to conform its products to the existing dominant standard in the market. Here M. A. Schilling (1998) identified factors internal and external factors that are of influence, again here is marked that products that are technologically superior do not always become dominant. Suarez (2004) makes also the division between internal factors (firm-level factors) and external factors (environmental factors). Both are of importance for obtaining dominance in the market. However, their difference is in the fact firm-level factors can be influenced and managed by the firm and environmental factors can hardly be managed, they are simply there.

Van de Kaa et al. (2011) follows the same reasoning as the previously mentioned scholars (Lee et al., 1995; M. A. Schilling, 1998; Suarez, 2004) where a distinction is made between firm-level and environ-

mental factors. Van de Kaa et al. (2011) classifies the firm-level factors in two categories, characteristics of the format and the format support strategy. Both categories found their basis in the institutional economics literature. Additionally, the environmental factors are marked as market characteristics, which were being studied from an evolutionary and network economics perspective. In the next section, the framework by Van de Kaa et al. (2011) will be further elaborated on.

2.1.1. Different Facets of Technological Dominance

As described in section 2.1 the concept of technological dominance is studied from various perspectives, this led to the identification of different facets of technologies that won the allegiance of the market. Den Uijl (2015) mentions three different facets where technological dominance is found; dominant designs, standards and platforms.

Dominant designs were the first facet identified in the technological dominance literature by J. M. Utterback and Abernathy (1975). As described in section 2.1 they found that the nature of innovation changes over time and when a dominant technology emerges the whole industry is affected. Over the years the definition of dominant design has been further evolved by various scholars. Srinivasan et al. (2006) collected definitions of dominant design in the extant literature. Hereby is argued that the definition of dominant design evolved from being "broad and tautological" to more specific. Srinivasan et al. (2006) argues that the definition of dominant design in the papers by J. M. Utterback and Abernathy (1975) and Abernathy, Utterback, et al. (1978) can be described as dominance obtained in a product category by a single product design. Anderson and Tushman (1990) added to this definition that a design is dominant when the market share is over 50% in four consecutive years. J. Utterback (1994) concludes that when a product design becomes dominant in the market, the competition must adhere to this design. Suarez and Utterback (1995) refer to a specific path along an industry's design hierarchy which results in dominance among other design paths. Later they defined that a dominant design a product category is dominant when it defines the product category's architecture (Christensen et al., 1998).

In technology management literature another facet is being identified. This stream focuses on standardization. The concept of standardization is defined as an alignment in the market to harmonize activities in a uniform way, this could be either an implicit or an explicit agreement (Farrell and Saloner, 1992). In order to establish a standard, a 'battle' between various similar standards takes place. This battle is a market-driven process, where the market eventually adopts a standard. Standards can be categorized into compatibility standards, quality standards, safety standards, and measurement standards (Den Uijl, 2015). In the technology management literature, the compatibility standard is the most elaborated standard. Compatibility standard is in the literature also referred to as a technology standard (Krechmer, 1996). A few examples of standards are USB and Wifi. Before USB and WiFi became a standard in the industry, multiple manufacturers were competing in this standard battle. Arthur (1998) argues that the Internet boom contributed to the rise of 'standards wars' and network effects. David and Greenstein (1990) described the process of standardization in their paper, they distinguished four ways where a standard agreement could be established. Those are:

1. Unsponsored standards
2. Sponsored standards
3. Standards agreements by voluntary standards-writing organizations
4. Mandated standards by regulatory authorities

The first two are market-driven processes that emerge from the acceptance of a set of specifications from the market itself. These are in the literature referred to as de-facto standards. The differentiation between sponsored and unsponsored comes from whether the concerned entities are actively involved in the standard-setting process. The latter two are standard-setting processes that are directly steered by a regulatory agency; this can be a standards-writing organization like ISO or a governmental regulatory body. This formal process is called in the literature a de-jure standard.

Den Uijl (2015) states that the concept of platforms has become popular recently. In his dissertation, he argues that the trend of modular product architectures contributed to its popularity. Wheelwright and Clark (1992) coined the term 'platform products', these are products that can be modified easily into derivatives and provide an uncomplicated migration between generations. Den Uijl (2015) further

argues that the concept of platform products by Wheelwright and Clark (1992) has little overlap with the other discussed concepts (dominant design and standards). He defines platforms as systems that interact between the demand and supply networks. Since the concept of platforms is about supply and demand networks and concrete armour units are not relying on such systems, this concept will not further be elaborated on.

2.1.2. Overlap of the Different Facets

As described earlier, the different facets in the literature have a certain overlap, especially the concept of dominant design and (compatibility) standard. Various studies have made efforts to distinguish different concepts. Funk (2003) acknowledges that both concepts are about the acceptance of a design or a product/service. Srinivasan et al. (2006) adds that various scholars have used the terms 'dominant designs' and 'standards' interchangeably. Gallagher (2007) states that interchangeability of both concepts and therefore the confusion can arise from the fact that both concepts follow the same development trajectory. Where both begin with multiple competing designs/standards and eventually one wins the allegiance of the market.

Additionally, Funk (2003) and Srinivasan et al. (2006) states that a dominant design in a product category can consist of a number of standards. Where compatibility standards are the required technical specifications for the correct functioning of the product. Here the compatibility standard serves a functional purpose that is independent of market acceptance (Srinivasan et al., 2006). This differs from the concept of dominant design, where market acceptance eventually leads to dominance.

However, there are examples of products that are by scholars identified as a dominant design and standard in a product category at the same time (Den Uijl, 2015; Gallagher, 2007; Srinivasan et al., 2006). Examples are products like CD, DVD and floppy disks. In the currently known literature, there are more products that have an overlap between the different concepts(see Figure 2.1)

In this study, the concept of technological dominance will be assessed in relation to the concrete armour unit industry. On forehand, there could be concluded that concrete armour units, as the word implies, are merely made of concrete and therefore does not consist of any other components or subsystems where their shape and their configuration are important design aspects.

In Section 2.4 there will be shown that this industry is reacting to technological discontinuities and that some key innovations changed the industry entirely, where the competition had to adhere to the established dominant design. This is in line with the definitions of dominant design by Tushman and Anderson (1986) and J. Utterback (1994). Therefore in this thesis concrete armour units will be treated from a dominant design perspective with some elements of standardization, in Section 2.4 some examples of unsponsored market-driven standardization are given.

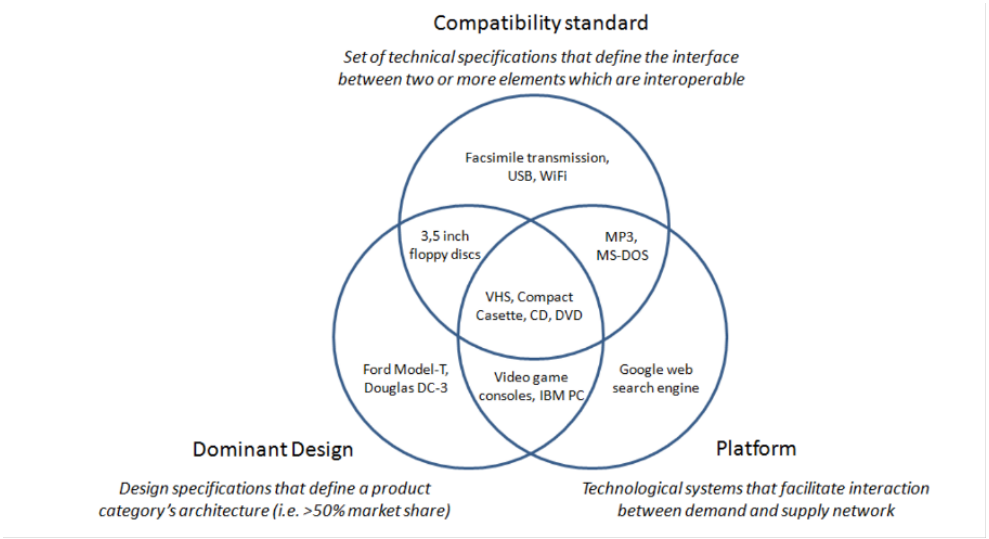

Figure 2.1: Overlap of the different facets of technological dominance (Den Uijl, 2015)

2.1.3. Section Summary

This section shed a light on the concept of technological dominance and its characteristics. Over the years scholars from various disciplines have studied this phenomenon found more examples of technological dominance in designs, standards and platforms. This led to fragmentation and overlap in the literature. Other scholars made effort to combine the various approaches into one framework and determine their influence on the dominance process. The subsection section will elaborate on the used framework in this study and why it is chosen.

2.2. Proposed Framework

As described earlier scholars made effort to distinguish important factors which influence the outcome of a technology battle (Lee et al., 1995; M. A. Schilling, 1998; Suarez, 2004). Van de Kaa et al. (2011) found that the existing literature and frameworks were fragmented and made effort to combine previous research in a complete overview. Four different literature streams were combined (evolutionary economics, network economics, institutional economics and technology management/standardization) by means of an extensive literature review where 127 publications were studied, resulting in 29 factors over five categories. The literature used multiple definitions and are used interchangeably (standards, platforms and dominant designs). Van de Kaa et al. (2011) merge these three definitions and defines them as 'formats'.

More recently, Den Uijl (2015) made a contribution to the literature by drawing up a new integrative framework of important factors for technological dominance. Den Uijl followed roughly the same process as Van de Kaa et al. (2011), wherein the extant literature is studied for important factors. Den Uijl's study resulted in 36 factors divided over 3 categories; firm, technology and market/industry. Additionally, a distinction is made between different orders of factors.

In order to guide experts in choosing and weighing relevant important factors regarding this industry a framework is chosen. The framework selected for this study is the one drawn up by Van de Kaa et al. (2011), this framework is more compact in terms of number of factors in comparison to the framework by Den Uijl (2015). Although the proposed framework is more compact, it has a large overlap with the more elaborated framework by Den Uijl. Since experts must select relevant factors in the first round and weigh those in the second round, a more compact framework is necessary to prevent confusion. In the next subsection each of the the factors identified by Van de Kaa et al. are further explained.

2.2.1. Characteristics of the Format Supporter (Internal Factors)

This category consist of all the internal factors regarding the firm involved in a technology is summed up. In this study, the format supporter is defined as the company that is developing and commercializing concrete armour units. In this thesis, the category *characteristics of the format supporter* will be defined as *internal factors* and consist of the following factors:

- *Financial strength*: the current and future financial status of a firm (e.g. liquidity) are of importance for achieving dominance (Willard and Cooper, 1985). Financial resources are needed when a new technology is being developed (Ehrhardt, 2004) or can be used for marketing (M. Schilling, 1999).
- *Brand reputation and credibility*: according to Van de Kaa et al. (2011) reputation plays a big part in adopting new technologies. A good reputation enables the firm to acquire new projects and helps to obtain new stakeholders supporting your technology (Foray, 1994).
- *Operational supremacy*: is defined by M. A. Schilling (2002) as when a firm has an operational advantage in comparison with the competition. For example: A firm uses its resources more efficiently than the competition does.
- *Learning orientation*: can be described as the ability to gain and implement knowledge from their operations and share this information within the firm (Duncan and Weiss, 1979). M. A. Schilling (1998) argues that when a firm lacks to learn, their technology is at risk to be locked out of the market.

2.2.2. Characteristics of the Format (Technology Factors)

This is the second category defined by Van de Kaa et al. (2011) and describes the superiority of the format compared to others in terms of technology related factors. The degree of superiority contributes

to the chance of becoming dominant. This category of factors consists of 4 factors:

- *Technological superiority*: a design is considered superior when its characteristics are beyond the capabilities of other similar designs (Schumpeter and Nichol, 1934). However, being technologically superior gives no guarantee of becoming dominant (David, 1985).
- *Compatibility*: is the ability to cooperate with other related objects/technologies ((de Vries, 1999). These objects could be backwards compatible (a new product, works with older versions products) or horizontal compatible (same product, but for example from a competitor are working together)
- *Complementary goods*: additional features or objects required for a successful implementation in the market (Teece, 1986).
- *Flexibility*: is the amount of time and funds needed for a modification of an existing technology to meet new requirements (Thomke, 1997). adaption of a technology could be necessary due to demands of the costumer or technological advancements.

2.2.3. Format Support Strategy (Strategy Factors)

The third category consists of factors that are related to a range of strategies companies could use that increases the chance to become dominant. Van de Kaa et al. (2011) states that there are 7 factors relevant regarding the strategy:

- *Pricing strategy*: the tactics to create market share by means of pricing. An example is a penetration pricing strategy that impedes the competition from entering the market (Farrell and Saloner, 1986).
- *Appropriability strategy*: The tactics to protect from copying or use by the competition (Lee et al., 1995). Protection could be done through patenting and registering trademarks.
- *Timing of entry*: the tactics in time to introduce a product in the market. Van de Kaa et al. (2011) show that an early entry does not automatically lead to a higher chance of becoming dominant.
- *Marketing communications*: strategic information management to clients to get greater market share.
- *Pre-emption of scarce assets*: : if an object or technology require scarce goods/resources and a company can obtain these goods/resources early in the dominance process, it creates an advantage with respect to the competition (Barney, 1991).
- *Distribution strategy*: the drive, level and tactics to improve the supply system. Employing a distribution strategy could speed up the acceptance of a new product (Willard and Cooper, 1985).
- *Commitment*: dedication of a firm to develop a technology. Lack of attention could result in a slower dominance process (Tegarden et al., 1999).

2.2.4. Other Stakeholders (External Factors)

This category refers to all external stakeholders involved in the technological dominance process, which lies outside the firm involved and consist of 8 factors:

- *Current installed base*: Farrell and Saloner (1986) defines the installed base as the quantity of technology implementations. The installed base has an influence on the acceptance of a product when the market is influenced by network externalities (Van de Kaa et al., 2011).
- *Previous installed base*: product that needs the installed base of a previous technology in order to become dominant.
- *Big fish*: is an external player that has a large influence to steer the outcome of the dominance process. This influence can be wielded by buying large quantity of products from a certain technology that it becomes dominant (Suarez and Utterback, 1995).

- *Regulator*: an authority that is demanding a specific technology. This could lead to achieve dominance. However, this cannot be influenced by the firm and is not an outcome that is result of the market (Axelrod et al., 1995).
- *Antitrust laws*: regulative authorities or the judiciary can forbid certain technologies to become dominant by making laws against it.
- *Suppliers*: companies that manufacture complementary goods and/or supply additional services for the format. These suppliers can help to increase the chances of achieving dominance (Besen and Farrell, 1994).
- *Effectiveness of the format development process*: this factor describes how efficient a format is developed. For example: by a single firm, a consortium or through standardization committees.
- *Network of stakeholders*: having a large network of stakeholders adopting and supporting a new format could help to achieve dominance. Additionally, Gomes-Casseres (1994) stresses that firms are more likely to become dominant with their technology when they have a diverse network of stakeholders.

2.2.5. Market Characteristics (Market Factors)

This category consists of factors that define the market. Firms are not able to influence the market where they in operate, but it will influence the outcome of the technology battle (Van de Kaa et al., 2011). A total of 6 factors are considered relevant within this category:

- *Bandwagon effect*: tendency to adopt certain formats, simply because others are doing so. This could strengthen the market position and increases the likelihood of a format becoming dominant.
- *Network externalities*: are defined as a change in the benefit that a user derives from a format when the number of other users consuming the same, changes (Katz and Shapiro, 1985).
- *Number of options available*: the market share is influenced by the number of competing technologies (Tripsas, 1997).
- *Uncertainty in the market*: When the market is uncertain companies are more risk-averse when choosing a format. This reduces the chance and slowdown the pace of achieving dominance.
- *Rate of change*: this factor is about the rate of how the market and technologies develop, a high rate of change decreases the likelihood for a technology to become dominant (Smit and Pistorius, 1998)
- *Switching costs*: cost of switching from one format to another. High switching costs result in a slower dominance process (Van de Kaa et al., 2011).

2.2.6. Section Summary

29 factors by the framework by Van de Kaa et al. (2011) were discussed in the previous section, 4 categories are in the sphere of influence of the firm and the last category are market-related factors that the firm can not control. All these factors were collected by an extensive literature study where 127 publications about technological dominance were studied. In the previous sections, the concept of technological dominance was treated with the accompanying important factors contributing to this phenomenon. The next section will elaborate on how technological dominance emerges.

2.3. The Process of Technological Dominance

In the previous sections, the various perspectives of technological dominance are discussed. It became clear that different approaches were applied to this phenomenon. Which led to fragmented literature and what is eventually brought together by the framework by Van de Kaa et al. (2011). Now when all the factors that can influence the outcome of a technology battle are identified the process of how a technology becomes dominant is being discussed in this section.

When a new technology emerges it faces competition in the market with other technologies, which serves the same purpose. Eventually, the market decides which technology is to be adopted as the

de-facto standard. The outcome of this competition is an important event for competing firms since the outcome defines the architecture of the entire product category (J. Utterback, 1994).

Foster and Pryor (1986) were one of the first scholars who created a model about the trajectory of the adoption of new technologies. This model is the classic well-known S-Curve and consists of three phases (see Figure 2.2). In the first phase, the technology is still in development but has entered the market. The market in this phase consists of niche markets and early adopters, therefore the size of the market is small and limited. In the second phase, the technology becomes more accepted and a dominant design emerges and wins the allegiance of the market. Due to a large number of new supporters, this phase is accompanied by rapid growth in market size. The last phase is where the technology reaches maturity and the market becomes saturated. As the market becomes saturated and technology is matured the involved firms are challenged to keep on innovating while maintaining the market position. This will continue till eventually a new technology emerges and become dominant, where the old technology will be obsolete at that point.

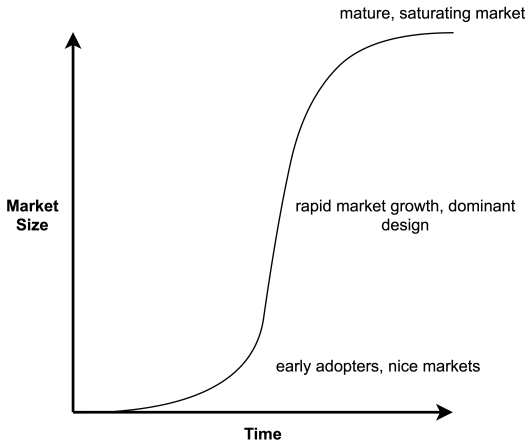

Figure 2.2: S-Curve by Foster and Pryor (1986)

The model of product and process innovation by J. M. Utterback and Abernathy (1975) extends the S-Curve of technology adoption by differentiating between product and process innovation (see Figure 2.3). In their paper, they argue that innovation changes over time in three phases. In the first phase (fluid phase) the innovation of the product is the most important, where conducting experiments can be a major part of the product innovation. At this point, the rate of process innovation is much smaller. When the rate of process innovation exceeds the rate of product innovation, the basis for the transitional phase is formed. In this phase, the attention shifts towards making the product more cost-efficient. In the transitional phase, it becomes clear which product is winning the allegiance of the market and therefore becomes dominant.

Suarez (2004) argues that the dominance process can be described in 5 key milestones (see Figure 2.4. Each of the milestones marks a new phase in the dominance battle. The first milestone (T0) marks the start of R&D by a pioneering firm or research group aiming to develop a new commercial product. Most often the pioneer firm will soon be followed by other organizations. These other organizations are often subject to different technological trajectors than the pioneering firm. The second milestone (Tp) is reached when the first working prototype of the new product is shown. This sends a message to all other firms involved that their prototype is on a technologically feasible trajectory and that soon a commercial product will enter the market. The launch of the first commercial product marks the third milestone (TL). Suarez states that typically the first product in the market is too expensive for the mass market and is therefore aimed at the early adopters or niche markets. This is in line with the models made by J. M. Utterback and Abernathy (1975) and Foster and Pryor (1986). Being the first product

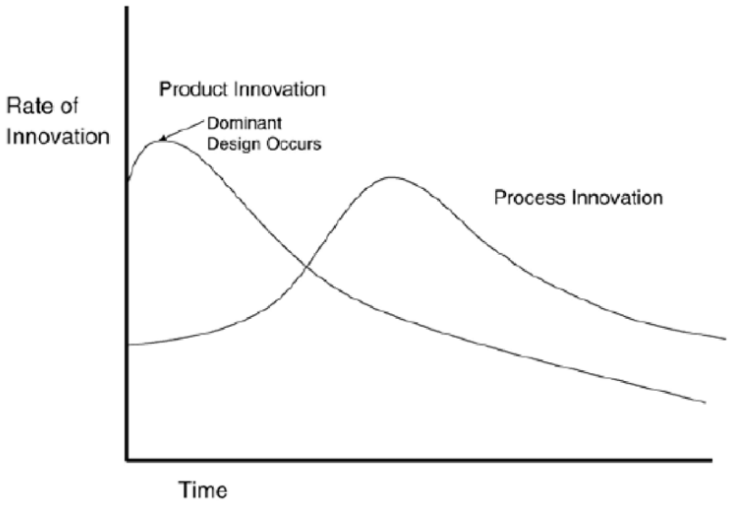

Figure 2.3: The model of product and process innovation by J. M. Utterback and Abernathy (1975)

to enter the market helps to become a 'forerunner'. The existence of a frontrunner marks the fourth milestone (TF) in the process of technological dominance. Suarez acknowledges that the front runner makes a chance to win the battle for technological battle, as its installed base is larger in comparison with the competition. However, if the competition is able to improve their designs fast enough and the market growth allows them to catch up. The last milestone (TD) is marked when a technological trajectory reaches dominance, according to Anderson and Tushman (1990) is that when 50% market share is reached.

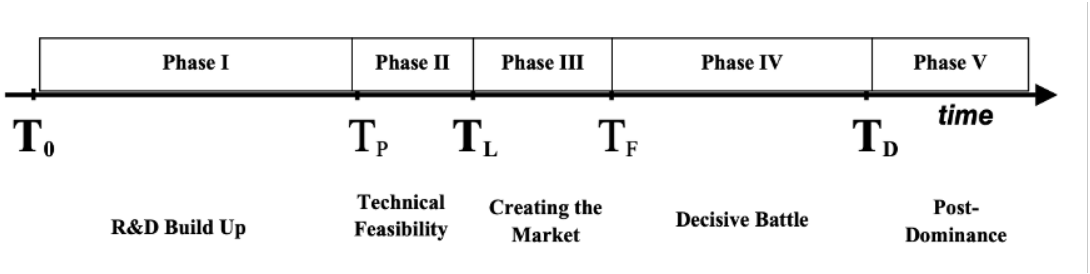

Figure 2.4: Five milestones by Suarez (2004)

In his dissertation, Den Uijl (2015) argues that a sixth phase can be added to the process of technological dominance of Suarez (see Figure 2.5. This sixth phase is between the 'decisive battle' and 'post dominance' (respectively the fourth and fifth phase).

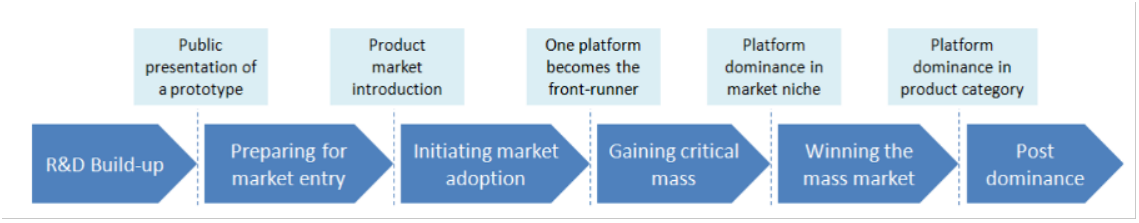

Figure 2.5: Six milestones by Den Uijl (2015)

2.3.1. Section Summary

Scholars identified that the nature of innovation changes over time (J. M. Utterback and Abernathy, 1975) and when new technologies enter the market an S-shaped trajectory is followed (Foster and

Pryor, 1986). Other scholars identified more milestones in the technological dominance process (Den Uijl, 2015; Suarez, 2004). In the subsequent section, a link is made between the previous sections about technological dominance and the researched topic of concrete armour units.

2.4. Dominant Design and Technology Battles in Relation to Concrete Armour Units

As described in Chapter 1 multiple battles within this industry could be identified. Until World War II, where breakwaters were designed with a gentle slope and were armoured with a relatively high number of units that derived stability mostly on their own weight (P. Bakker et al., 2003). Such armouring could be either quarry stone or a simple cube shape. The latter was used on most occasions where quarry stone was not available or economical. The cube is never patented and up to this day, cubes are still applied. In 1950 the Tetrapod was developed and patented, the first concrete armour unit with interlocking properties. Having these interlocking properties resulted in a more stable unit in comparison with cubes, with less concrete needed. At that time, units were placed in a two-layer configuration, this implies that blocks were stacked in two layers. This was done to ensure that the uncertainties regarding hydraulic and structural stability would not result in failure (CIRIA, 2007). Tetrapod was developed by the Laboratoire Dauphinois d'Hydraulique (the predecessor of Sogreah and later Artelia). The Rock Manual (CIRIA, 2007) argues that the economic advantage of Tetrapod instead of other bulky units made this unit a large success all over the world, despite the fact the unit was vulnerable to breakage.

In the years after the development of the Tetrapod, a large amount of other interlocking two-layer concrete armour units were developed. Where the stability was obtained with a combination of own weight and interlocking. Here it can be concluded that in that time the market moved to a two-layer design with interlocking units, in situations where quarry stone was not available or not economical. Between 1950-1980 the units became highly interlocking and more complex in terms of shape. For instance, the Dolos developed in 1963 in South Africa was a high interlocking unit with a slender shape, this gave a huge economical advantage since less concrete is needed. Despite this advantage, slender armour units in the top layer tend to rock, which means they are moving in their own position, this movement is causing the units to slam into each other with damage as result (Sogreah, 1985).

A turning point in the market was when a breakwater in Portugal (Baird et al., 1980) was built with Dolos. At that time, the idea was that (slender) units could be scaled to larger dimensions without any problems. What was neglected was that these units are not reinforced and their structural strength is at risk. When constructing the breakwater in Sines, Dolosses of 40 tonnes were used. During the construction, a storm with a lower design wave height caused the breakwater to collapse. After this incident Dolos is barely applied in any form of coastal infrastructure (Edge et al., 1982).

After this incident design formulae and safety standards were reconsidered and the market moved back to a more bulky design with still interlocking capabilities (CIRIA, 2007). A new 'era' began where the market moved to a one-layer design with little rocking and a more bulky design. In 1980, Sogreah (predecessor of Artelia) introduced the Accropode. This was the first randomly placed unit in a one-layer configuration and became the leading unit over the next twenty years (P. Bakker et al., 2003). Having only one layer gives a huge economical advantage, less concrete use and fewer units have to be cast and placed. Up to this day, Artelia has more than 200 projects done with Accropode in over 48 countries.

Again other companies followed with making similar units in a one-layer configuration, where both interlocking and own weight is key. Here the market moved again to an accepted standard in the industry, where this standard was the one-layer interlocking configuration. Scholars acknowledge the success of Accropode (P. Bakker et al., 2003; P. B. Bakker et al., 2004; CIRIA, 2007; Muttray et al., 2003 and it can be concluded that within the standard of one-layer interlocking units Accropode was for a long time the dominant one.

In 1994 the US Army Corps of Engineers (USACE) introduced the Core-Loc (Melby and Turk, 1995, which has a similar shape to the Accropode. The difference is in the legs, which are direct replication of the legs of the Dolos. The purpose was to replace damaged breakwaters built with Dolos with Core-Loc and therefore Core-Loc could easily be combined with existing Dolos breakwaters. In 2003 the Dutch contractor BAM/DMC developed Xbloc, a similar block in comparison with Accropode and Core-Loc. However, there are a few differences in terms of symmetry. Accropode and Core-Loc have 3 faces, where Xbloc does have 2 faces. This geometry enhances the ease of placebility and interlocking. As

a response to this innovation, Artelia developed a new iteration of the Accropode, which is called the Accropode II. At this time the market became more fragmented and where Accropode dominated the industry in the first 20 years it is now more evenly distributed (see Figure 1.1).

On the basis of this brief history of the development of various concrete armour units, there can be a few things concluded. The first thing that can be concluded is the presence of standardization in the industry. Over the last 80 years, the industry shifted from various standards. After World War II breakwaters started to be armoured with interlocking units in a two-layer configuration. After interlocking was discovered, more units were developed with even higher interlocking capabilities and more slender shapes. After the collapse of various breakwaters the market shifted to a new standard. New generation blocks were developed with more bulky shapes where the balance was between interlocking and own weight. This standard is widely accepted to date. Secondly, every time a new product was introduced the French company Artelia was the frontrunner. They were the first to develop and patented an interlocking unit and be able to commercially exploit this over the world. This gave the company a huge advantage, in terms of experience, knowledge and reputation, something where they still benefit from. Also their ability to exploit their knowledge and be able to develop new blocks, meeting the demands of the industry. Since they are a well-established name with large funds available, they are the main competitor of this industry.

2.4.1. Important Technical Factors

This topic of concrete armour units is never studied from a management perspective, the general literature of concrete armour units treats only topics like design, development and other technical aspects. Therefore, The literature gives only technological factors that drove certain units to success. Important technical factors are mentioned in three papers. The first paper by Reedijk et al. (2003) argues that the strong and weak points of concrete armour units are in respect to:

1. Structural integrity and hydraulic stability
2. Fabrication, storage, handling and placement of armour units (constructability)
3. Maintenance and repair of armour layers.

The Rock Manual (CIRIA, 2007), which is a widely accepted and used design manual for rock used in hydraulic engineering, adds that appearance can be as well a main (technical) criterion for the selection of an armour unit. Since appearance is considered as a subjective criterion and is not measurable, it is left out in this study. Muttray and Reedijk (2009) mentioned the same factors of Reedijk et al. (2003) which are important for the technical characteristics of an armour unit. In table 2.1 the relevant factors for technological superiority are shown with their definition.

Table 2.1: Characteristics for technological superiority of concrete armour units

Structural integrity	The ability to deal with internal stresses (e.g. the strength of an unit (Burcharth and Liu, 1993))
Hydraulic stability	The ability to withstand hydraulic wave loads. This can be obtained by own weight, interlocking or friction (CIRIA, 2007)
Constructability and placebility	The capabilities of an armour unit in terms of constructing (casting) and the ease of placing (CIRIA, 2007)
Maintainablilty	The ease of performing repairs on a breakwater structure with armour units

2.4.2. Section Summary

In this section, a brief history of the concrete armour unit industry is given. Based on this history a few conclusions can be made, the industry is sensitive to a good brand name. Which can be vanished by design faults or badly executed projects, like Dolos for instance. Additionally, technological aspects

of concrete armour units were discussed and how they define technological superiority. In the next section, the methodological approach of this master thesis will be discussed.

3

Methodology

This section will discuss the methodologies used to answer the main research question with the corresponding sub-questions. Data is collected through a literature study about important factors for technological dominance to answer the first sub-question. These factors will be consulted with experts in the industry, and the relevant factors are selected. For the second sub-question, a second round of interviews is conducted. In this round, the selected relevant factors are ranked by experts.

3.1. The Role of the Researcher

This study was performed to fulfill the master program Construction Management and Engineering and in cooperation with the Delft University of Technology and the Royal BAM Group in the Netherlands. The goal of this study is to identify important factors for technological dominance in the concrete armour unit industry. To ensure an unbiased outcome of this master thesis there is attempted to prevent any bias of the researcher by asking every expert the same questions and treating all the generated data equally. Any possible bias is addressed in section 5.4.

3.2. Data Collection

3.2.1. Literature Study

As mentioned in the previous chapter the theoretical foundation of this study is the concept of dominant design. Various scholars made effort to identify important factors that could lead to technological dominance. Recently, Van de Kaa et al. (2011) and Den Uijl (2015) combined the existing literature into a broad framework with respectively 29 and 36 factors that contribute to the outcome of a 'technology battle'. The doctoral work by Den Uijl resulted in a new integrative framework, that arose from a similar process of the framework by Van de Kaa. Where factors mentioned in the technological dominance literature are collected and categorized. The framework by Den Uijl (2015) is in terms of factors more elaborate but covers roughly the same factors. To prevent that the interviewee is overwhelmed with a list of factors, the integrative framework by Van de Kaa et al. (2011) is chosen for this study. Since there is less overlap between the factors in comparison with the framework by Den Uijl.

In this study, the used framework is the integrative framework of factors for interface format dominance by Van de Kaa et al. (2011)). The framework by Van de Kaa consists of five categories, characteristics of the format supporter, characteristics of the format, format support strategy, other stakeholders and environmental factors. The latter category lies outside the influence of the firm and is a constant factor that affects the entire industry. In this study, the market characteristics are left out because of the assumption that all the products in this industry are subject to the same market. Therefore, no strategy can be drawn to an individual product since they are operating in the same market. This reduces the number of factors to 23.

3.2.2. Interviews

Expert Criteria

Data is gathered in this thesis by conducting interviews with experts from the industry. Experts from different disciplines are being interviewed. To determine who is an expert a few criteria are drawn up, this is necessary to obtain reliable data from the interviews and from the BWM. Every expert has to comply with the criteria related to their experience. Additional criteria are set to the experts involved in the first interview round because a smaller group of interviewees will be in this round. Due to the smaller number inconsistencies can occur in the results. To ensure the validity of the first round highly experienced people from the industry are being interviewed. These experts have contributed to this industry by developing design formulae, conducting extensive research, having a managerial position in a company that holds patents of concrete armour units. In order to compose this group of experts, other experts are asked if they can point out key figures in this industry. If multiple experts have an agreement about which expert is a key figure, then his person will be interviewed in the first round. This approach is called 'social acclamation' (Shanteau et al., 2002). Below are the general criteria (table 3.1) and additional criteria (table 3.2) stated.

Table 3.1: General criteria for expert selection

General criteria
• Working at a company or institution that is involved in concrete armour units.
• Has a relevant function within this industry, this could be in research and development of concrete armour units, designing, management, producing, maintaining, construction or is academically involved.
• Has dealt with projects where concrete armour units were involved.
• At least 10-year experience in this industry, for the first round a minimum of 20 years of experience is required.
• Has knowledge about the market and has an understanding of various units used in the industry.

For the selection of key experts for the first round of interviews, more extensive requirements are being asked to ensure this expert is a 'key expert'. These criteria are shown below:

Table 3.2: Additional criteria for the first round

Additional criteria
• 20 years of experience in this industry
• Is a key figure in this industry, which means that he/she has done pioneering work in terms of research and development in this industry or has a leading function.

Round 1

The aim of the first round is to identify important factors for technological dominance in the concrete armour unit industry. It is key that the expert is able in this round to speak unhindered about his/her opinion. The interview will be semi-structured where the questions serve as guidance for the expert, to prevent the expert from only speaking about technological aspects. This can be expected since experts from this industry are mostly technically educated and reflect this industry from their background. To extract more information from the interviewee a high degree of probing will be performed. This will ensure that the interviewee tells his/her reasoning of the factors he/she find important.

Data collection by means of interviews consists of two parts, the first part is a semi-structured interview where the experts are being asked about their experiences in the industry and if they can identify important factors for technological dominance. If an expert mentions an important factor that can be

attributed to the list of factors by Van de Kaa et al. (2011), more probing will be done about that factor. The second part is more structured, here the total framework by Van de Kaa will be presented. This is done at the end of the interview to prevent that the interviewee is biased in the first part. All the factors from the list will be walked through and explained then the expert is asked to mark the factors he/she finds important and relevant for this industry. Since a concrete armour unit is a technological product it is possible that interviewees are marking the factor 'technological superiority'. When an expert is marking this factor, more probing will be done in order to find out which technological factors are contributing to technological superiority. If this is the case, the factor technological superiority will be replaced with the mentioned technological important factors.

Factor Selection

After the first round factors are being selected for further the next round. In this section, the criteria for the selection of factors are being discussed and how they are applied in the next round. The literature about concrete armour units is not providing non-technological factors for technological dominance, therefore the opinion of the experts is leading in this thesis. Since the methodological approach is to interview the leading key experts in this industry, every mentioned factor should be taken into account. This implies that every mentioned factor (implicitly or explicitly) by an expert is considered relevant.

As mentioned in (literature study section) the last category 'Market Characteristics' is not taken into account, since the market is simply there and cannot be changed from a company perspective. Therefore, these factors will only be selected when an expert in the first round explicitly mentioned one of these factors. The main focus is on the other four categories; characteristics of the format supporter, characteristics of the format, format support strategy and other stakeholders. Which are defined in this study as internal factors, technology factors, strategy factors and external factors.

If the total selected factors are exceeding the maximum amount suitable for the Best Worst Method (more than 9 criteria), the factors will be split per category with each their separate BWM. Hence, an extra level will be added to the hierarchy of this problem. This extra level is divided into multiple subsets, where each sub-set represents a category of the framework by Van de Kaa et al. (2011). This will make the ranking process more structured and helps the interviewee to make consistent choices.

Round 2

The aim of the second round is to elaborate further on the mentioned important factors according to the experts interviewed in the first round and give weight to each mentioned important factor.

In the second round, the factors mentioned by the experts in the first round and mentioned by the literature are presented to a broader group of experts (criteria can be found in section 3.2.2.1). The purpose of this round is to rank the selected factors from round 1 into the format prescribed by the Best Worst Method (explained in section 3.3.1). This round will be performed in a questionnaire format. Where experts are being asked to fill in a form in the BWM format.

3.3. Multi-Criteria Decision Making (MCDM)

To determine the importance of each factor the obtained data from the second round will be processed by an MCDM tool. This tool is able to assign weight to each factor that is being ranked in the second interview round. Over the years multiple MCDM tools are being developed. In this section various MCDM's will be discussed and explained why the Best Worst Method is selected for this thesis.

In order to assign weight and determine the importance of each factor, the factors will be treated as an MCDM problem. In an MCDM problem, the goal is to select the best alternative by means of evaluating alternatives with respect to a number of criteria. Here the criteria are drawn up by the decision-maker, where in most cases an alternative consists of multiple criteria. MCDM problems can be divided into two categories, where is differentiated between the solution space of the problem; continuous and discrete. Continuous problems are solved with multi-objective decision-making (MODM) methods. Here the criteria are in the form of objectives, where the number of items is theoretically unlimited. MODM's are appropriate for example in design problems. Discrete problems are solved with multi-attribute decision-making (MADM) methods. In contrast to MODM's the number of criteria is finite and the criteria are in the form of attributes. MADM methods are used for the selection and evaluation of alternatives. Since this study consist of a finite number of factors, provided by the literature and experts, a multi-attribute decision-making method will be used in order to evaluate and assign weight

to factors. Therefore in this thesis, the selection and ranking of factors will be processed and treated as a discrete MCDM problem.

In the past, multiple MCDM methods are proposed in order to help the decision-makers find the most desirable alternative, based on their preference and assigned weight of the finite number of criteria. The most common and popular multi-attribute decision-making methods are AHP (Analytic Hierarchy Process) by Saaty (1977) and ANP (Analytic Network Process) by Saaty (1996). Both MCDM's methods make use of the pairwise comparison method, this method is introduced by Thurstone (1927) under the name of the law of comparative judgment.

In theory, the pairwise comparison matrix ($A = (a_{ij})_{n\times n}$) should give consistent results if for each i and j, $a_{ik} \times a_{jk} = a_{ij}$. However, there are practical implications that makes obtaining consistency challenging. Forman and Selly (2001) argues that inconsistency can be caused, for example by clerical errors, lack of information and lack of concentration. Rezaei (2015) acknowledges that effort is made to overcome and correct occurring inconsistencies but proved to be unsuccessful. He adds that the main cause of the occurring inconsistencies is in the unstructured way pairwise comparisons methods like AHP are executed. In his paper, a new method is proposed that is able to overcome inconsistencies occurring in the previously mentioned methods. This method is called the Best Worst Method (BWM) and will be further explained in the next section.

3.3.1. Best Worst Method (BWM)

The Best Worst Method (BWM) is a recently developed multi-criteria decision-making method by Rezaei (2015), this method is able to solve discrete MCDM problems. The weight of each alternative is derived by a pairwise comparison with the best (most important) and the worst (least important) criteria with the other criteria. The best and the worst criteria are identified by the decision-maker and are pairwise compared with the other criteria (see figure 3.1). Comparing the best with the others and the worst with the others helps the decision-maker with consistent choices. With pairwise comparison, the decision-maker has to express both the direction and strength of the preference. To determine the direction of the preference is in most cases no problem for the decision-maker. However, determining the strength of the preference is more difficult for the decision-maker. Expressing the strength of the preference (which is quantified by a number) is according to Rezaei (2015) the main cause of occurring inconsistencies with pairwise comparisons.

For MADM with a discrete solution space, AHP is one of the most popular and used MCDM techniques in many different domains and environments (Gupta and Rohil, 2012). However, in his paper Rezaei (2015) shows that BWM outperforms AHP in various aspects, and makes it a more robust alternative. The first aspect where BWM outperforms AHP is the number of comparisons required. BWM needs $2n-3$ comparisons, where AHP needs $n(n-1)/2$ comparisons. This implies that when considering 9 criteria AHP needs 36 comparisons, where BWM only requires 15 comparisons. This makes the process for the decision-maker easier to understand and the decision-maker is less likely to lose concentration since fewer comparisons have to be made. Another aspect that makes BWM a preferred choice is that BWM proves to be more consistent compared to AHP. Where AHP (and other MCDM's) have a consistency ratio to check if the comparisons are reliable or not, the purpose of the consistency ratio in BWM is to check the level of reliability since the output of BWM is always consistent (Rezaei, 2015). Additionally, BWM uses only integers (1 to 9) where other MCDM's like AHP uses a combination of integers and fractional. This makes the BWM more convenient to use since only integers are needed the express the strength of the preference. In addition to the classic linear BWM by Rezaei (2015) a Bayesian BWM method will be employed. This MCDM tool is proposed by Mohammadi and Rezaei (2020) and employs Bayesian probabilistics in order to calculate weights and yields additional information, based on the same input as the classic linear BWM. The Bayesian BWM (BBWM) is able to calculate the weights of a group of decision-makers more precisely in comparison with the BWM, since the classic BWM is averaging out all the weights by the decision-makers and averages more are sensitive for outliers. The Bayesian BWM is able to assign a confidence level to each criterion by means of a ranking scheme, here it can be measured to which degree the group of decision-makers prefers one criterion over the others. The confidence level is expressed in the form of $A \xrightarrow{d} B$, where A is the preferred criterion over B with the confidence d. The classic linear BWM is considered as the main MCDM in this study, where the BBWM is used to yield more additional data on the basis of the same input. In the next section, the BWM and the BBWM process are being discussed.

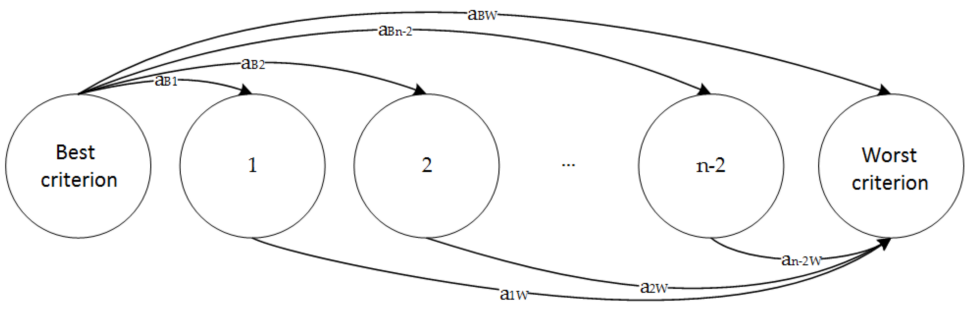

Figure 3.1: Pairwise comparison of BWM

BWM Process

The process of deriving the weight of the criteria consists of 5 steps (Rezaei, 2015). In this study, the first step is being executed in the literature study and the first round of interviews. The other 4 steps are being executed in the second round of interviews.

Step 1
Determine a set of decision criteria
In this step, the criteria for the MCDM problem are being identified in the form of $\{c_1, c_2, \ldots, c_n\}$. For this study, criteria are identified by the literature and by experts in the first round of interviews.

Step 2
Determine the best (most desirable, most important) and the worst (least desirable, least important) criteria
In this step, the decision-maker identifies the best and the worst criteria. No comparison is made in this step. In this study, this step marks the beginning of the second round of interviews. Here the experts are asked to identify the most and least important factors for obtaining dominance in the concrete armour unit industry.

Step 3
Determine the preference of the best criterion overall the other criteria using a number between 1 and 9. The resulting Best-to-Others vector would be:

$$A_b = (a_{B1}, a_{B2}, \ldots, a_{Bn})$$

Where a_{bj} indicates the preference of the best criterion B over criterion j. In this step, the experts are asked to quantify the preference of the best criterion over the other criteria.

Step 4
Determine the preference of the worst criterion overall the other criteria using a number between 1 and 9. The resulting Worst-to-Others vector would be:

$$A_w = (a_{1w}, a_{2w}, \ldots, a_{nw})^T$$

Where a_{jw} indicates the preference of the criterion j over the worst criterion W In this step, the experts are asked to quantify the preference of the worst criterion over the other criteria.

Step 5
Find the optimal weights $(W_1^*, W_2^*, \ldots, W_n^*)$
The optimal weight for the criteria is the one where for each pair of w_B/w_j and w_j/w_w, we have $w_B/w_j = a_{Bj}$ and $w_j/w_w = a_{jW}$. To satisfy these conditions for all j, a solution must be found where

the maximin absolute differences $|\frac{w_B}{w_j} - a_{Bj}|$ and $|\frac{w_j}{w_W} - a_{jW}|$ for all j is minimized. Which gives:

$$minmax_j\left\{\left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right|\right\} \tag{3.1}$$

Subject to

$$\sum_j w_j = 1 \tag{3.2}$$

$$w_j \geq 0, \text{ for all } j \tag{3.3}$$

3.1, 3.2 and 3.3 can be transferred to the following problem: min ζ

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \zeta, \text{ for all} \tag{3.4}$$

$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \zeta, \text{ for all} \tag{3.5}$$

By combining 3.2, 3.3, 3.4 and 3.5 the problem could be solved and $(W_1^*, W_2^*, ..., W_n^*)$ and ζ^* is obtained. With ζ^* the consistency ratio can be calculated according to table 3.3 and the following equation:

$$\text{Consistency Ratio} = \frac{\zeta^*}{\text{Consistency Index}} \tag{3.6}$$

Table 3.3: Consistency Index (CI) Table by Rezaei (2015)

A_{bw}	1	2	3	4	5	6	7	8	9
Consistency Index (CI)	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

The Bayesian BWM follows the same steps as the classic linear BWM but differentiates in the last step (step 5). The classic linear BWM yields values in the form of $w^* = \{w_1^*, w_2^*, ..., w_{n^*}\}$, where the Bayesian BWM yields a probabilistic distributed individually optimal weight $w^{1:K}$ and an overall optimal weight w^{agg}, based on the vectors $A_b^{1:K}$ and $A_w^{1:K}$. Where the decision-maker is defined by $k = 1, ..., K$. To estimate w^{agg} and $w^{1:K}$ Mohammadi and Rezaei (2020) propose the following joint distribution:

$$P(w^{agg}, w^{1:K} | A_b^{1:K}, A_w^{1:K}) \tag{3.7}$$

After the calculation of equation 3.7 the probability of every individual variable is computed by:

$$P(x) = \sum_y P(x, y) \tag{3.8}$$

Where x and y in equation 3.8 represents two arbitrary variables. If Bayes' rule is applied to joint distribution equation 3.7, the following equation is yielded:

$$P(w^{agg}, w^{1:K} | A_b^{1:K}, A_w^{1:K}) \propto P(A_b^{1:K}, A_w^{1:K} | w^{agg}, w^{1:K}) P(w^{agg}, w^{1:K}) \tag{3.9}$$

Equation 3.9 can be rewritten as:

$$P(w^{agg}) \prod_{k=1}^{K} P(A_w^k | w^k) P(A_b^k | w^k) P(w^k | w^{agg}) \tag{3.10}$$

To specify the distribution of every element in equation 3.10 the variables are modelled as a multinomial distribution:

$$A_b^k|w^k \sim \ multinomial(\frac{1}{w^k}), \forall k = 1, ..., K \tag{3.11}$$

$$A_w^k|w^k \sim \ multinomial(w^k), \forall k = 1, ..., K \tag{3.12}$$

Given w^{agg} the value of each w^k is expected to be close to each other, this means that every individual weight of w^k in equation 3.11 and 3.12 must be in proximity of w^{agg}. Subsequently, the needed Dirichlet distribution described by Mohammadi and Rezaei (2020) must be rewritten into:

$$w^k|w^{agg} \sim \ Dir(\gamma \times w^{agg}), \forall k = 1, ..., K \tag{3.13}$$

Equation 3.13 is in respect with the mean and concentration. Where w^{agg} represents the mean of the distribution and γ the concentration. The final weight w^{agg} are calculated by the use of an uninformative Dirichlet distribution where α is defined by Mohammadi and Rezaei (2020) as $\alpha = 1$:

$$w^{agg} \sim \ Dir(\alpha) \tag{3.14}$$

The Bayesian BWM model does not provide a closed-form solution, to solve this model a Markov-chain Monte Carlo (MCMC) implementation is used to compute the required distribution. In order to generate a random MCMC sample, a sampler by Plummer (2004) called “just another Gibbs sampler” (JAGS). All these calculations are executed in MATLAB.

3.3.2. Processing the BWM results

After the second interview round is completed and all the experts have filled in the BWM sheet. All the individual BWM must be processed. How the results are processed depends on the number of factors are being selected by the experts in the first round of interviews. If the number of factors (criteria) is less or equal to 8, the final weight of each factor is the average of all the individual weights of each factor. Further, the consistency ratio is being averaged out of all the results. If the number of criteria exceeds 8 criteria, the BWM is separated into four categories (sub-sets). This is described in section (3.2.2.3). The weight of each subset is the number of factors (criterion) divided by the total number of factors of all the sub-sets combined. Then the weight obtained for each criterion belong to each sub-set by the weight of the whole sub-set to get the ”global” weight of the criteria. Where the sum of all the global weights becomes 1.0. When the global weight is determined the rest of the processing is the same when having less than 8 factors.

4

Results

In this chapter, the results are being presented according to the methodology described in chapter 3. Starting with the results of the first round of interviews, where a select group of key experts reflect on the important factors of technological dominance in literature and to which extent they can be applied to the concrete armour unit industry. The factors marked as important by the experts are used for the second round. Where the marked factors will be weighed in a multi-criteria decision-making model called Best Worst Method.

4.1. Respondents Description

4.1.1. Expert Summary

In this section, the background of the interviewed experts are being described. For this study 14 experts were being interviewed divided over two rounds. Expert 1 to 4 were being interviewed in the first round and experts 1 to 3 provided input for the BWM in the second round. The rest of the interviewed experts from expert 5, were only interviewed for the second round of interviews.

Expert 1

The first interviewed expert who met the criteria drawn up in section 3.2.2.1, is the head of the hydraulic department of a large Dutch contractor and has a working experience of around 30 years in this sector. In his employment, he has broad experience with various units and he developed multiple concrete armour units, where he is one of the patent holders. Therefore this expert is considered a key figure since this expert made a pioneering contribution in this industry in terms of research and inventions.

Keywords: Round 1, Round 2, Inventor, Manager, Department head, Contractor

Expert 2

The second interviewed expert has over 30 years of experience in this industry. Head of marine structures at a renowned Dutch research institute, involved in lots of coastal projects. At this research institute, model tests are performed in order to test if the design meets the hydraulic requirements in terms of stability. Besides these activities, this expert is affiliated with the Delft University of Technology and gives guest lectures in breakwaters and shore protection.

Keywords: Round 1, Round 2, Academic, Researcher, Consultant, Research Institute

Expert 3

The third expert in this first round is currently active as an independent consultant in the field of coastal structures and gives lectures in dams and breakwaters. In his work, he is involved in lots of projects as an external expert to check whether the design is correct with concrete armour units. This expert conducted pioneering research in formulating empirical design formulae, in the field of overtopping and rock stability. The latter formula is nowadays widely applied in the design of breakwaters with concrete armour units. His total years of experience is around 40 years in this industry.

Keywords: Round 1, Round 2, Academic, Researcher, Independent consultant

Expert 4
The last interviewed expert in the first round is a commercial director of the largest supplier of concrete armour units. Prior to this function, he was active as a consultant at an engineering firm in the field of coastal engineering. In his experience, he has done a number of projects worldwide where concrete armour units were involved. In his current work, he is responsible for the commercial affairs of the concrete armour units. His total years of experience in this industry is around 35 years.

Keywords: Round 1, Manager, Commercial Director, Consultant

Expert 5
This expert is working for a large Dutch contractor and is responsible for the acquisition of new projects involving concrete armour units. He is on a daily basis in touch with potential clients and consultants involved in the construction of breakwaters and revetments. Additionally, this expert is also closely involved with the research and development of new units. The total years of experience the expert has in this industry is around 20 years.

Keywords: Round 2, Manager, Global Acquisition Manager, Contractor

Expert 6
Is working for almost 30 years as a professor and as a director of the hydraulic laboratory at a university. During his professional experience, he made several academic contributions to the research of physical modeling of breakwaters. This expert is also a patent holder of a concrete armour unit, which was developed in cooperation with the university and a local Spanish contractor.

Keywords: Round 2, Inventor, University

Expert 7
Is a full-time professor at the coastal and harbor engineering department of a university in Italy and made various academic contributions in the field of coastal engineering. This expert has a professional experience since 1982 and worked as a designer, consultant and project manager in coastal engineering projects, like harbors and breakwaters.

Keywords: Round 2, Academic, Consultant, University

Expert 8
Is head of the rock department of a large Dutch dredging company, this expert has over 30 years of professional experience in this industry. During his career he worked all over the world with various units and clients.

Keywords: Round 2, Manager, Department Head, Consultant, Dredger

Expert 9
This expert is active an consultant in the coastal engineering sector and has a professional experience of around 30 years. Currently, this expert is a senior engineer of coastal projects at an oil company. Previously, this expert was working as an assistant professor for 26 years at an Egyptian university.

Keywords: Round 2, Independent Consultant, Academic, Independent consultant

Expert 10
Has a professional experience of over 50 years in the design and testing of breakwaters, seawalls and other coastal structures. Currently, this expert is active as an independent consultant in this field. Previously, he was technical director at a British hydraulic laboratory and made various academic contributions to the concrete armour unit literature.

Keywords: Round 2, Independent Consultant, Academic, Independent consultant

Expert 11
Is the managing director of a consulting subdivision of a large Dutch contractor, which is responsible for the development, sales and implementation of concrete armour units. As a managing director, he is ultimate responsible for all the activities regarding concrete armour units. These activities include; R&D, business development, design and model testing. The total amount of years of experience is 25 years.

Keywords: Round 2, Manager, Directing Manager, Contractor

Expert 12
Is an international business development manager at a large Dutch contractor. This expert is responsible for the strategy regarding the acquisition of new projects with concrete armour units. He has a background in civil engineering and was previously responsible for international construction projects. The total number of years of relevant experience is 25 years.
Keywords: Round 2, Manager, Business Development Manager, Contractor

Expert 13
Is a researcher at the US Army Corps of Engineers for more than 30 years. During his professional career, he has developed multiple concrete armour units. Additionally, he is specialized in coastal structure research and has contributed to the coastal engineering literature by writing various papers touching these topics.
Keywords: Round 2, Inventor, Researcher, Governmental

Expert 14
Is an inventor of a concrete armour unit called Seabee. This unit is used over 40 sites around the world. This expert has a background in coastal engineering for over 50 years and has made a contribution to the existing literature on the topic of coastal engineering.
Keywords: Round 2, Inventor, Independent consultant

Expert 15
This expert is involved in the research, advice and modelling of coastal and hydraulic structures for more than 20 years and is affiliated with the Delft University of Technology. At the university, he is giving lectures and is contributing to the literature and commonly used manuals in this industry.
Keywords: Round 2, Academic, University

4.1.2. Expert Composition

In order to gather reliable data, experts from different backgrounds were interviewed and were asked to weigh the relevant factors in an MCDM model. The composition of the experts are being expressed in two ways, the current employer and the background of the expert.

The employers of the experts can be divided into 6 different categories; contractor, dredging company, consultant, independent consultant, government and university.

For the purpose of this study, a contractor is defined as a firm that is responsible for the construction of buildings and other structures. In this thesis, contractors active in the field of coastal engineering are considered relevant. Some contractors extend their activities by providing consulting services for the client, like placement guidance and breakwater design. Dredgers are similar to contractors, but their focus is more on building coastal infrastructure. Consultants are defined as companies that only provide services in relation to the design of coastal structures. These consultants are often choosing the type of armour unit for the client and are therefore an important group to interview. A couple of experts in this industry were self-employed consultants that can be hired to give advice to contractors or clients, previously they were working as an academic at university. The latter two categories are public entities in the form of governmental bodies and universities. The category governmental is defined as an entity involved in this industry that is affiliated with the government. A university is defined as an institute where educational and research activities are conducted.

The professional background of the experts can be described with 6 keywords; academic, independent consultant, consultant, inventor, manager, researcher. For the purpose of this study, an academic is defined as someone who is working at a university and conducting research in this branch. A (independent) consultant is involved in the design of breakwaters and revetments where concrete armour units are placed. The difference between an independent consultant and consultant is whether the expert is affiliated with a company or working for himself. An inventor is someone who is the patent holder of a concrete armour unit and is actively involved in the development of new units. The keyword manager is applied to everyone who has a managerial role within this branch, the could be from department head to managing director. A researcher is like an academic but not affiliated to an educational institute.

Based on the keywords of every expert, a composition is made of the background experts. Here can be seen that in terms of background the division between various functions and experience is equally divided (see Figure 4.1

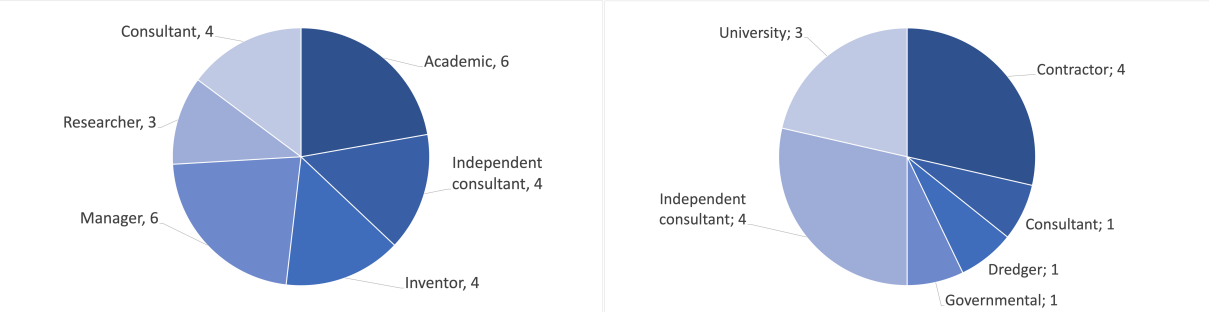

Figure 4.1: Expert (left) and employer (right) background

4.2. Round 1

The purpose of the interviews conducted in the first round is to determine what factors experts find important for obtaining technological dominance in the industry. As described in section 3.2.2 the interview consists of two parts, the first is open and semi-structured. Here the expert was questioned about his experience in this industry, to determine whether the interviewee was a key expert or not. Subsequently, the expert was allowed to speak without having knowledge of the framework about their experience in this industry, in order to determine if there could be important factors identified on forehand. The second part of the interview a list of factors was presented of the framework by Van de Kaa et al. (2011) in order to prevent that the expert was not overlooking factors. A full overview of the interview format can be found in Appendix A. The structure of this section is as follows; per expert is summarized why the person is considered an expert, what the answers to the questions were and what factors the expert find relevant with additional comments.

The methodological approach of the first round can be found in section 3.2.2.2. The structure of this interview can be found in Appendix A, the transcript of the interviews can be found in Appendix B, C,D,E. An overview of the selected factors in this round is shown in Appendix F.

4.2.1. Interview Expert 1

During the interview, it became clear that this expert has comprehensive experience in this industry. The expert has over 30 years of experience with constructing breakwaters and other coastal structures and has worked with almost every commonly used concrete armour unit. In the first half of the interview, the expert did not mention (implicitly) important factors regarding this industry. In the second part, the expert was more explanatory about which factors he found important. Comments on the selected factors can be found in Appendix F.

Relevant Factors

The first interviewed expert identified 8 relevant factors for this industry, in all of the four used categories (see table 4.1).

Table 4.1: Selected relevant factors Expert 1

Category	Factor
Characteristics of the format supporter	Financial strength Brand reputation and credibility Learning orientation
Characteristics of the format	Technological superiority
Format support strategy	Pricing strategy Appropriability strategy Marketing Communications
Other stakeholders	Network of stakeholders

Technological Superiority

As explained in the methodology 3.2.2.2, when an expert is marking 'technological superiority' more probing is done in order to determine if these factors can be divided into more sub-factors which are important for a technological superior concrete armour unit. Expert 1 is marking hydraulic stability as the most important in this category. Secondly, structural stability is almost equally important as hydraulic stability. At last, the expert is marking the constructability and the placebility as the final important technological factor. Hereby the expert states that there are blocks in the market that have around 11 placing restrictions.

4.2.2. Interview Expert 2

During the interview, it became clear that this expert has extensive experience with almost every commonly used concrete armour unit like Tetrapode, Cubes, Accropode, Accropode II, Xbloc, XblocPlus. This expert is involved in the testing of these units, mainly in the field of hydraulic stability and overtopping. Secondly, this expert is active in consulting clients and contractors about breakwaters.

On the question, if the expert could identify factors that lead to success in this industry that is non-technical related are reputation and image. The expert mentioned a couple of projects where damage occurred on the breakwaters, due to a faulty design or placement. The expert argued that this led to significant reputational damage for the company that is the licensor of the unit. Also, there are cases where the expert has encountered badly executed projects where the company kept the problems regarding the concrete armour units silent, in order to prevent reputational damage. The expert further states that the market of these units is highly conservative, clients are not very eager to 'try' new units. There are examples of countries that are using the same unit for half a century.

The expert was also questioned about what is lacking in this industry. The expert suggests that improvement in design formulae is needed, especially formulae about rocking. Where rocking is the small movement of the blocks against each other. This movement should be minimal since the blocks are damaging each other. The opinion of the expert is that rocking should be more researched and that the degree of rocking must be quantified. Secondly, the expert finds it disappointing that licensors of concrete armour units are not really willing to perform comparative studies. The decision for a certain type of block nowadays depends on subjective considerations. The expert would like to see that more factual considerations are made based on comparative studies.

Relevant Factors

The second expert identified 8 relevant factors regarding this industry.

Table 4.2: Selected relevant factors Expert 2

Category	Factor
Characteristics of the format supporter	Brand reputation and credibility Learning orientation
Characteristics of the format	Technological superiority
Format support strategy	Pricing strategy Appropriability strategy Marketing Communications Commitment
Other stakeholders	Effectiveness of the format development process

Technological Superiority

As shown in the table 4.2 the factor technological superiority is here marked as well, the expert was asked where this factor consists of. Firstly, the expert stated that hydraulic stability is the most important for a technological superior block. Secondly, factors like constructability/placebility are important as well. This expert found in a lesser degree the structural integrity important for a block since this depends on the hydraulic stability as well.

4.2.3. Interview Expert 3

This expert has done extensive research in the design and stability of one-layer system armour units, like Accropode, Accropode II and Xbloc. This research led to the development of a widely applied stability formula. Nowadays this expert is an independent consultant in the design of breakwaters, where the expert has an advising role for the client.

Expert 3 identified the success of Accropode to the fact that was developed to tackle problems that occurred by breakwaters build with Dolos (Sines, 1978). At that time, the idea was that units could be scaled without problems. However, due to the slender construction of the Dolos and the maximum tensile strength of unreinforced concrete, the units broke during construction. Due to this accident, the market was very hesitant to use units like Dolos. But Dolos was a very good interlocking block but in the two-layer configuration. Sogreah, the predecessor of Artelia, developed a unit that has the same interlocking capabilities and could be used in a single-layer configuration. Which reduces concrete use.

When the expert was asked if there are factors that are contributing to a successful product expert 3 implicitly mentioned the factor 'effectiveness of the format development process'. The expert gave an example of a newly developed block (Cubi-Pod), which is a cube. This cube is developed in cooperation with a university and a local contractor. Only a few projects are done with Cubi-Pod, expert 3 argues the reason for this could be when a non-competitive entity is affiliated with the development. Additionally, the expert states that having an engineering firm onboard with practical knowledge based on model tests is key to become commercially successful.

When the expert was asked about what this industry is potentially lacking and where future developments could be expected. Expert 3 firstly mentioned that in terms of design formulae and blocks to most development already had taken place. The expert would like to see developments in the toe structure of a breakwater.

Relevant Factors

Table 4.3: Selected relevant factors Expert 3

Category	Factor
Characteristics of the format supporter	Brand reputation and credibility Operational supremacy Learning orientation
Characteristics of the format	Technological superiority
Format support strategy	Pricing strategy Appropriability strategy Marketing Communications Distribution strategy Commitment
Other stakeholders	Big Fish Effectiveness of the format development process

Technological Superiority

When asked what technological superiority implies for concrete armour units, the expert mentioned two important aspects, hydraulic stability and placebility. The expert found both aspects equally important.

4.2.4. Interview Expert 4

During the interview, it became clear that this expert looks to the market from a commercial point of view. Expert 4 is a commercial director at the largest licensor of concrete armour units. The factors expert 4 selected are shown in table 4.4.

Expert 4 states that this market is highly conservative and that clients are very hesitant to try new innovations. A good reputation in terms of a good track record is key in this industry, it makes you credible towards clients. The expert adds that the client is also interested in the final cost of a project. The opinion of the expert is that the client should not only look at the cost of the license of the blocks for

the project, but the total cost of the technical assistance. The expert illustrates that when a patent of a block is expired (after 20 years) everybody is free to cast the shape without paying royalties. However, the name of a block (e.g. Xbloc and Accropode) is protected by a trademark. As a result of this (local) contractors are using the blocks with another name (e.g. Chinapod). Often these contractors have little to no experience with the design and placement of the blocks, with structural problems and more costs as result. The expert believes that a licensing company should offer technical assistance to ensure that the design and the placement of those blocks are being properly executed. When a licensing company has a good track record and therefore an extensive experience in designing and placement, clients want to have the founding company on board in their project. Even if the patent is expired, because the technological knowledge remains in the licensing company.

The expert mentions implicitly two relevant factors. First an appropriability strategy, where the focus is not to protect their product in terms of patents, because they are temporary, but protecting it by being the only one with adequate knowledge on how to implement it. Secondly, the expert states that their reputation is everything in a highly conservative market. Clients want to have established companies on board. Therefore one could argue that their appropriability strategy is linked to their brand reputation and credibility. If they do not have a good reputation for assisting clients well, they will not be able to protect their product after the patent is expired. Because clients will move to third parties which offer better assistance.

On the question where innovation is necessary the expert states that in terms of concrete use no further improvements are really needed. However, improvements could be made in terms of the ease of construction (placebility).

Relevant Factors

Table 4.4: Selected relevant factors Expert 4

Category	Factors
Characteristics of the format supporter	Brand reputation and credibility Learning orientation
Characteristics of the format	Flexibility
Format support strategy	Marketing Communications Appropriability strategy Commitment
Other stakeholders	Network of stakeholders

Technological Superiority

Expert 4 has not marked the factor ‘technological superiority’ therefore no additional probing will be done (see Appendix A).

4.3. Round 2

In the second round the Best Worst Method is applied, in section 3.2.2.4 the methodological approach of this round can be found. The factors selected by experts in the first round were further elaborated and weighed according to the Best Worst Method. In this round 14 experts were asked to rank the identified relevant factors from the first round. The selected 17 factors were divided into 4 categories since the BWM does not allow more than 9 factors simultaneously.

4.3.1. Standard Linear BWM Result

In the results, it can be seen that the factor ‘Brand reputation and credibility’ is considered the most important factor among experts (Table 4.5 and figure 3.1). Experts were pointing out the importance of building a sustainable reputation as a firm in order to become commercially successful. In the industry, there are clear examples of how reputation can affect the market share of a unit. Being the first, like Artelia with the Tetrapod and Accropode (see section 2.4), and being able to implement these units

correctly contributes to build a sustainable brand reputation. However, bad implementations due to a faulty design or other causes outside the influence of the patent holder (Jensen, 2014) could lead to a unit that is being neglected by the market, like Dolos. Among experts, there is an understanding that the number of (successful) placed units (or number of projects) is the basis of building a reputation.

The second and third most important factors according to the Best Worst Method are technological factors found in the literature about concrete armour units, these factors are respectively 'hydraulic stability' and 'structural integrity'. Among the experts, there is a consensus that both aspects are interrelated and it is important that a block should have both.

The factors that are considered least important and have the lowest assigned weight are financial strength, maintainability and flexibility. Various experts argue the importance of the financial position of the developing firm, evidently funds are needed for research and testing. However, the majority of the experts found that the importance of the financial strength is lower in comparison with other factors. The experts' reason is that only larger companies with enough funds and a broader experience are viable in this industry. These companies are in general firms with a construction background, this could be either a contractor or a consultant and is active in coastal engineering. The importance of maintainability has shifted over the years, in section 2.4 is described how the industry moved from a two-layer design to a one-layer design. Units in a two-layer configuration often required more maintenance, due to the less strict placing conditions units are able to rock. In a one-layer configuration, units are placed in a fixed grid where placing conditions are tighter. In case of failure, a two-layer configuration is more redundant in terms of units than a one-layer configuration. Therefore, in a one-layer configuration units are designed with a larger safety margin and are designed without damage. This results in that maintainability being less of an issue nowadays. Flexibility is the next lowest weighed factor, the majority of the experts state that the industry does not demand a unit that can be easily adapted to meet new requirements.

Table 4.5: Results standard BWM

Factor	Average weight
Financial Strength	0.026
Brand Reputation and Credibility	0.111
Operational Supremacy	0.050
Learning Orientation	0.049
Structural Integrity	0.079
Hydraulic Stability	0.095
Constructablility and Placebility	0.061
Maintainability	0.031
Flexibility	0.028
Pricing Strategy	0.064
Appropriability Strategy	0.058
Marketing Communications	0.074
Distribution Strategy	0.040
Commitment	0.058
Big Fish	0.062
Effectiveness of the Format Development Process	0.038

Consistency

The classic linear Best Worst Method gives an insight into how consistent the decision-maker expresses his preference. This is done by calculating the ζ^*, the lower this value the more consistent the expert was. In table G.1 a full overview of all the consistency values is shown, where can be seen that the total average ζ^* was 0.088. In the right column, the average consistency is shown of each individual expert, the minimum value is 0.034 and the maximum 0.151. At the lower row, the average consistency per category is shown. Based on these values it is noticeable that there is a learning curve among the experts, the first three ζ^*'s are decreasing in consecutive order. The last ζ^* of the *external factors* is higher than the other, this could be attributed to the fact that experts were losing concentration at the end of the interview.

Table 4.6: ζ^* values of the linear Best Worst Method

Consistency ratio (ζ^*)					
Expert number	**Internal factors**	**Technology factors**	**Strategy factors**	**External factors**	**Average**
1	0.095	0.085	0.083	0.255	0.130
2	0.039	0.085	0.047	0.089	0.065
3	0.098	0.087	0.061	0.123	0.092
5	0.112	0.000	0.116	0.111	0.085
6	0.191	0.129	0.092	0.193	0.151
7	0.106	0.073	0.000	0.173	0.088
8	0.072	0.085	0.000	0.000	0.039
9	0.069	0.049	0.000	0.173	0.073
10	0.189	0.080	0.077	0.100	0.112
11	0.085	0.052	0.000	0.000	0.034
12	0.139	0.119	0.054	0.111	0.106
13	0.081	0.102	0.034	0.160	0.094
14	0.092	0.089	0.000	0.100	0.070
15	0.141	0.095	0.000	0.155	0.098
Average	0.108	0.081	0.040	0.125	**0.088**

4.3.2. Results Bayesian BWM

As described in the methodology (section 3.3.1) the classic BWM approach could be applied to groups of decision-makers (DM) by taking the arithmetic mean of all the weights. The Bayesian BWM is able to extract more information out of the data, such as the credal ranking. By applying the Bayesian approach to the BWM data a confidence level is added to each ranking. The credal ranking is only applied to every category separately since the expert made pairwise comparisons within each category. Secondly, a credal ranking graph consisting of 17 factors is not legible.

The first category is about the internal factors about the firm or is categorized as 'Characteristics of the format supporter' by Van de Kaa et al. (2011). Four factors were marked as relevant in the first round and weighed in the second round, the credal ranking of the category is shown in figure 4.2. It is clearly visible that brand reputation and credibility is the most important factor in this category and there is consensus among the experts (confidence of 100% over all the other factors). This is in line with the results of the classic BWM approach described in section 4.3.1. Almost all the factors share the same confidence level of 100% except Learning orientation, here confidence is 69% towards Operational supremacy. This implies that the experts are more divided whether learning orientation is more favourable/important than Operational supremacy. This lower confidence could be attributed to the fact that in this branch there is an overlap between Learning orientation and Operational supremacy. The definition of Operational supremacy is about the efficiency of how resources are managed. Material resources are not relevant from the patent holder perspective since units are being cast by the contractor on location. The only resources the patent holder has to manage are human resources and intellectual resources. The ability to properly manage your intellectual resources and gain knowledge based on experiences is also in the definition of Learning orientation.

The second category is about the important technical characteristics of concrete armour units. In figure 4.3. is shown that hydraulic stability is the most important factor, all the confidence levels connected to this factor are around 100%. As described in section 4.3.1 Hydraulic stability and Structural integrity are strongly related to each other and experts are not totally confident about which one is more important, which can be seen back in the slightly lower confidence. Additionally, there can be concluded that experts have a consensus about the two lowest-ranked factors, Maintainability and flexibility, only their mutual preferability has lower confidence (67%). An explanation could be the fact that in this study both factors are ranked as strongly unimportant and that experts found it difficult to determine which one is the least important.

The next category is about important factors regarding the strategy the patent holder's company should employ in order to be commercially successful. In figure 4.4 can be seen that commitment is

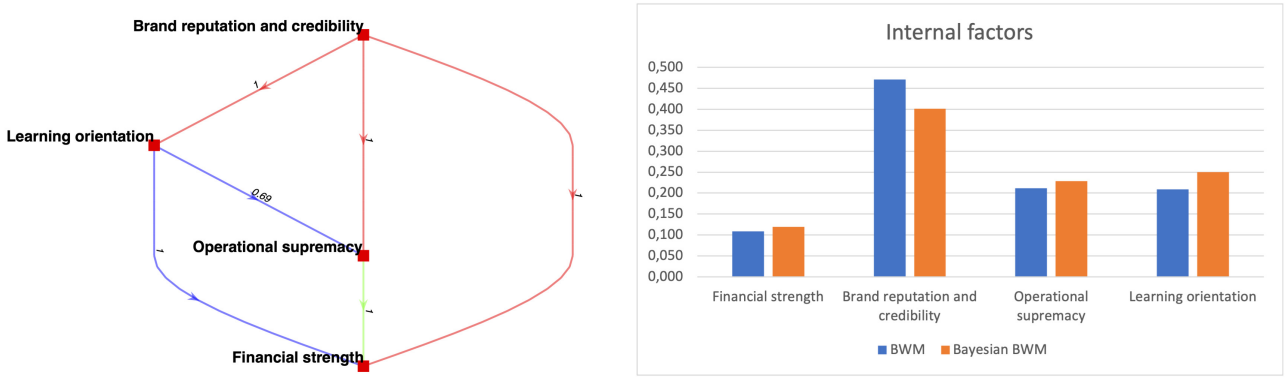

Figure 4.2: Credal ranking and weights of the internal factors

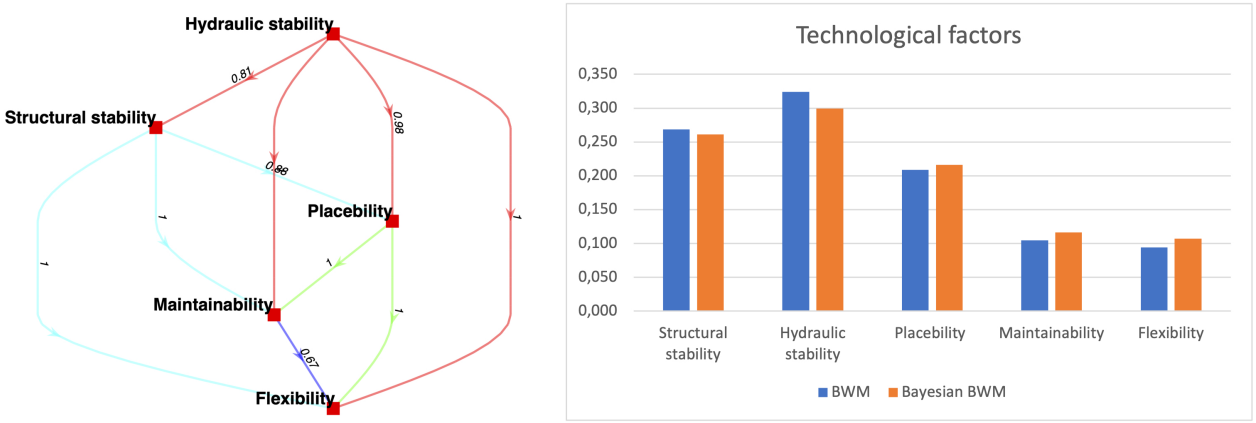

Figure 4.3: Credal ranking and weights of the technical factors

considered most important within the category. Close to Commitment is Marketing Communications ranked with 57% confidence, this lower degree of confidence is attributed to the fact that experts ranked these as equally important. The remainder of the factors is ranked lower but not with a large margin. Therefore, based on the results in figure 4.4 one could say that experts are not unanimous about which strategy must be applied in order to be successful as a patent holder.

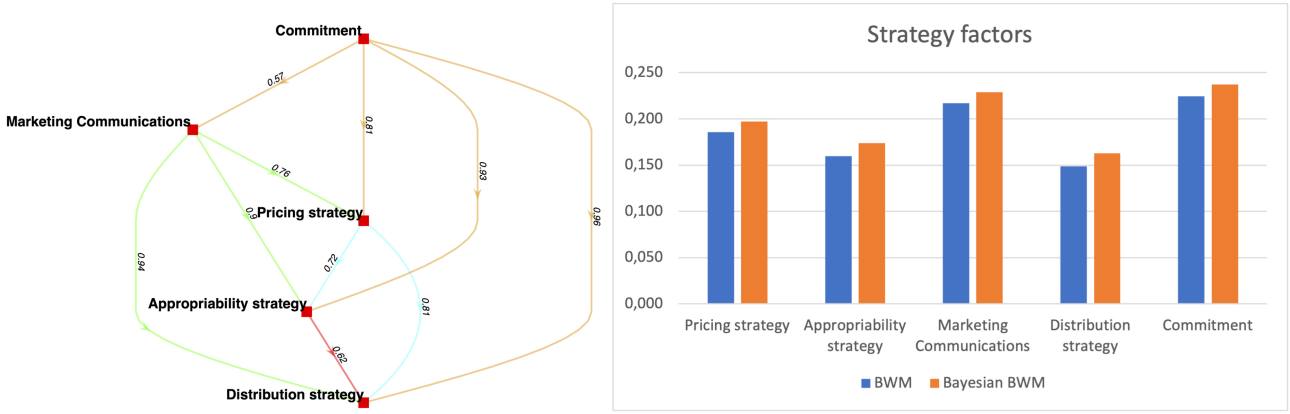

Figure 4.4: Credal ranking and weights of the strategy factors

The last category consists of 3 factors that are outside of the patent holder's company. The effectiveness of the format development process is considered least important by the experts and has in relationship with the other factors a confidence of respectively 100 and 96 percent (see Figure 4.5). Experts point out that having a large network of stakeholders, which can be consisting of a big fish, could be very advantageous in this branch. Such players could be research institutes, contractors and consultancy firms, when these players are aligned in favour of your concrete armour unit could lead to potential commercial success.

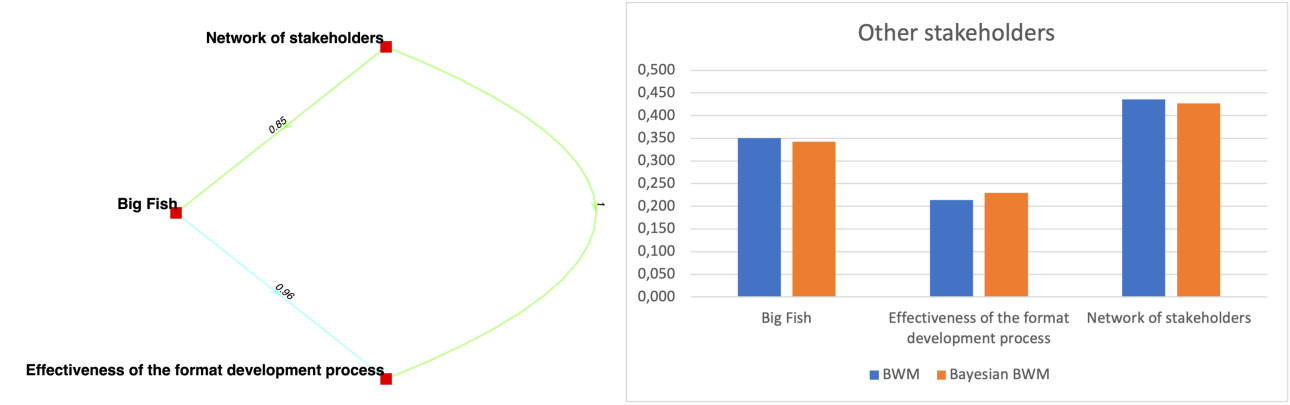

Figure 4.5: Credal ranking and weights of the external factors

4.4. Comparison Between Classic BWM and Baysian BWM

This section will elaborate on the comparison of the global calculated weight of the BWM and the Bayesian BWM, respectively in Section 3.3.1 the classic BWM and the Bayesian BWM are explained. The global weight is obtained by multiplying each criterion with the number of criteria of each category divided over the total number of criteria. The Bayesian BWM uses the same input as the classic BWM but the weights are not calculated per category, this implies that 17 criteria are weighted at once. In figure 4.6 all the weights are shown of both BWM's (in Appendix G a enlarged version of figure 4.6 is shown).

Further, it could be seen that the majority of factors follow the same ranking as the global BWM weight. However, some factors are ranked different in the Bayesian BWM model (see table 4.7). Some of these factors that deviate from the global BWM weight have some outliers in the individual data, which implicates that the selected group of experts have strongly opposed preferences (see Appendix G). This is in line with the findings of Mohammadi and Rezaei, 2020 that concludes that using a classic BWM approach to multiple decision-makers is highly sensitive for outliers, since the arithmetic mean is being calculated. The probabilistic approach by the Bayesian BWM results in aggregated calculated

Table 4.7: Ranking table BWM versus Bayesian BWM

Factor	Average weight	BBWM	Rank BWM	Rank BBWM
Brand Reputation and Credibility	0.111	0.097	1	2
Hydraulic Stability	0.095	0.099	2	1
Structural Integrity	0.079	0.086	3	3
Network of Stakeholders	0.077	0.068	4	5
Marketing Communications	0.074	0.064	5	7
Pricing Strategy	0.064	0.055	6	10
Big Fish	0.062	0.055	7	9
Constructablility and Placebility	0.061	0.071	8	4
Commitment	0.058	0.066	9	6
Appropriability Strategy	0.058	0.047	10	12
Operational Supremacy	0.050	0.053	11	11
Learning Orientation	0.049	0.059	12	8
Distribution Strategy	0.040	0.044	13	13
Effectiveness of the Format Development Process	0.038	0.038	14	14
Maintainability	0.031	0.038	15	15
Flexibility	0.028	0.033	16	16
Financial Strength	0.026	0.027	17	17

weights that are less sensitive to outliers and therefore deliver a more robust result. Secondary, the Bayesian BWM provides a credal ranking with the expressed confidence (see figure 4.2-4.5).

Based on the results, the Bayesian BWM can be expanded to more than 8 factors by combining the input of multiple BWM's. This method yields a reliable result that is less sensitive for outliers than the arithmetic mean of the classic BWM. However, having a larger number of factors makes the credal ranking not legible. Additionally, having the credal ranking makes no sense in the global ranking since the preference is expressed per category.

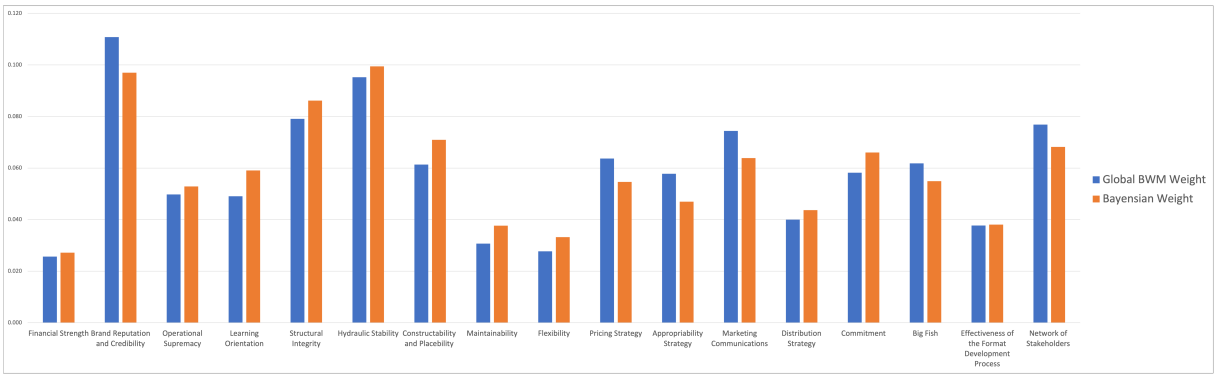

Figure 4.6: Results BWM versus Bayesian BWM

5 Discussion

In this chapter the results are being reflected to the literature and how technological dominance is present in the concrete armour unit industry. Subsequently, the results are discussed and the theoretical and practical contributions are discussed. Lastly, the limitations of this study are being treated.

5.1. Literature Reflection

Suarez (2004) poses in his paper five milestones in the process of technological dominance (see figure 2.4), where various factors contribute to specific milestones. One of these factors is brand reputation and credibility, Suarez states that this factor is of importance in the R&D buildup phase and in the phase where a dominant design emerges. During the R&D buildup phase, the firm gathers technological resources in order to develop a new commercial product. Suarez argues that in this phase the reputation plays a big role in acquiring those resources. Subsequently, reputation plays again a big role when the 'decisive battle' milestone. In this phase, various competitors develop similar technologies and are competing in the market until one product wins the allegiance.

Based on this study, an additional milestone that could be added to brand reputation and credibility. In this branch, patent-holding firms are benefiting from their reputation after the 'decisive battle' has taken place. A positive example is the large market share and the number of new projects regarding Accropode (Artelia, 2020). Even though this armour unit is over 40 years old the patent-holder firm Artelia acquires as many new projects with Accropode as it acquires with its successor Accropode II. Here, in combination with a good brand reputation an (increasing) installed base is obtained. An example of negative influence can be found in the history of the unit Dolos (see section 2.4), this unit was widely applied all over the world and was considered technological superior at the time. Dolos outperformed other units on hydraulic stability and concrete use. However, due to the slenderness of the unit a breakwater collapsed (Baird et al., 1980) and the whole industry moved to another design and locked out the Dolos.

Additionally, Klepper and Simons (2000) described the phenomenon of dominant birthright. This implies that firms with prior experience and reputation in similar technologies could obtain dominance more easily than new entrants in this branche. In the armour unit industry, companies have often prior experience in the field of coastal engineering and use this knowledge and their network to develop (new) units. Based on the interviews and the existing literature it could be argued that the phenomenon of dominant birthright is present in this branch.

Therefore, it can be concluded that various phenomena described by scholars in the field of technological dominance are present in the branch of concrete armour units. Such as technological lockout and birthright dominance.

5.2. Discussion on the Results

The results shown in figure 4.6 and in table 4.5 are stating that the factor 'brand reputation and credibility' are considered most important and secondly 'hydraulic stability'. However, the linear BWM application is sensitive to outliers since the arithmetic mean is calculated of all the individual BWM inputs. It

can be argued whether 'brand reputation and credibility' or 'hydraulic stability' is the most important factor, since the results cannot be generalized for the whole population of experts in this industry. The Bayesian BWM is considered more accurate and yields 'hydraulic stability' as most important on the basis of the same input. Since the classic linear BWM is considered as the main BWM in this study, the results yielded by this method will be regarded as leading. In section 5.4, more light is shed on the fact whether these results can be generalized and on how the possible presence of bias is treated.

5.2.1. How Can Actors Benefit from the Results?

As discussed in the Sections 4.2 and 4.3 brand reputation and technological characteristics of armour units are very important in this industry. Almost every expert ranks brand reputation and credibility as the most important factor for technological dominance in this branch. Experts point out that building a good (product) reputation is vital for obtaining commercial success. Subsequently, experts consider technological factors also as very important for a successful product. When all the weights of the factors that define 'technological superiority' are added up it represents a high combined weight. This implies that in this industry technological facets of a product are of great importance, in particular hydraulic stability, structural integrity, constructability and placebility.

If actors want to take advantage on the basis of these results, they should take into account that reputation is key in this branch. Having a strong brand reputation helps in the acquisition of future projects, contractors and consultants know the brand and its capabilities. A good reputation can be obtained by developing a product with good technological properties, like the aforementioned technological characteristics. But companies should also focus more on providing client-friendly services instead of focusing only on technological improvements. Additionally, future developments by the firm can benefit as well from the reputation built by previous units. Firms with an extensive track record are benefitting from a good reputation. Providing services around the implementation of an armour unit like model testing and placing guidance helps to improve reputation if executed properly. Lastly, a good reputation will play a big role in the sales of units when the patent is expired. Some units where the patent is expired are still widely applied because the product (and its founding company) have a strong track record and a large installed base, see figure 6.1 (Artelia, 2020).

The technological superiority of concrete armour units is also very important in this industry. Experts pinpoint that hydraulic stability is the main technological benchmark of how an armour unit performs under extreme wave conditions. Structural integrity, closely related to hydraulic stability, is also a measure of how good an armour can withstand forces under extreme wave conditions. Experts state that these two factors are the main technical characteristics that are leading in this industry. However, they also argue that these two factors are the most developed aspects over the years and no real innovations relating to those are expected to happen. This could be attributed to the failure of units in the past, that the focus of innovation was drawn to hydraulic and structural stability (Baird et al., 1980; Jensen, 2014). The technological focus is nowadays more on constructability and placebility, where some experts believe that the next innovation is in this category.

In this branch, it is advantageous to maintain a large network of stakeholders that are supporting the product. In the development phase partnerships with research institutes help to make the product more credible for future clients, by validating the performance of the product by means of model testing. Some players in this network could also be a large player that influences the market (big fish) such as a government body like Rijkswaterstaat. If a company in the concrete armour units industry is able to align these stakeholders in favor of their product, it could result in technological dominance.

5.3. Contributions

In this section the theoretical and the practical contributions of this master thesis are being described. This section reflects on the relevance of this study, described in section 1.2.

5.3.1. Theoretical Contribution

This master thesis contributed to the technological dominance literature by validating its occurrence in the concrete armour units industry, this is obtained by means of a literature study and interviewing experts. Where firm-level factors and environmental factors were identified in this branch.

Additionally, the classic Best Worst Method and the Bayesian Best Worst Method were employed to assign weights on the relevant factors. The Bayesian Best Worst Method proved to be a reliable

alternative for group decision-makers and is suitable for aggregating separate BWM inputs into a global weight. Moreover, the Best Worst Method proved to be easy to understand for all the interviewed experts and no data had to be discarded because of excessive inconsistency.

5.3.2. Practical Contribution

This study additionally fulfils a practical purpose, as described in chapter 1 this branch is mainly studied from a technological perspective. Actors in this branch could benefit from the insight provided by this study on how technological dominance (i.e. more commercial success) can be obtained . Actors should not only focus on the technological facets of their units but also put effort into building a strong brand reputation. With this knowledge, actors can develop new strategies where more attention to soft factors are present (see section 5.2.1).

5.4. Limitations

During this master thesis, various methodological choices were made that result in (possible) limitations. In this section those limitations are being addressed.

Firstly, in this study is deliberately chosen not the include the 'market characteristics' by Van de Kaa et al. (2011) (see chapter 2). The reasoning for not including this category is that the market is there and can not be changed, therefore no strategy can be drawn based on this category since all actors are operating in the same market. Secondly, having lesser factors to choose from will increase the relevance of other factors and the expert could be less overwhelmed. A secondary methodological complication is the generalization of the results. In this study 14 experts were asked to rank relevant factors according to the Best Worst Method. The final average weights of the BWM model are presented in this thesis and represent the average expert's opinion. However, for the purpose of this study, the results are generalized in order to try to give an insight into the preferences regarding this branch. It is debatable of this generalization of the group experts is relevant for the total population of experts. In this research, the goals was to interview experts who have a leading role in this industry in order to mitigate irrelevant results.

For conducting this study, the methodological approach to interview experts brings additional limitations, such as expert composition, subjectivity and lack of concentration. In the first round, 4 key experts were interviewed who have 20 years of experience and made a pioneering contribution to the industry, such as inventors, key managers and important researchers. During the interview, the experts were asked to identify which factors are important for technological dominance (commercial success) in this branch. In the second half of the interview the framework by Van de Kaa et al. (2011) was shown and experts were asked to mark which factors were relevant in the concrete armour unit industry. Every marked factor by an expert was carried into the next round. A possible limitation could be that the expert was overwhelmed by the number of factors and could not memorize all the factors and not accurately select the relevant factors. In this round is attempted to interview the key experts, according to additional criteria. However, these criteria are not objectively measured. There could be a chance that these experts are not at 'the top of the bill' regarding this industry and therefore not providing the desired results.

The purpose of the second round was to rank factors selected in the first round by 4 key experts. The ranking was done according to the Best Worst Method. In this round, various experts found that some factors were missing in the list of factors. Due to methodological reasons and relevancy these factors could not be added to the BWM model. Another is limitation is that 17 factors were weighted and the expert could lose concentration. Also, some experts found it difficult to reflect on their experience in relation to some factors.

An additional limitation that is encountered during this thesis is the composition of the experts. During the process of approaching experts for interviews, a broad composition was desired where experts from various positions and disciplines are being interviewed. However, in this industry the client (e.g. customer) from the perspective of the patent-holding company is not always the same. On some occasions, the commission party of a project (in general governmental bodies) have a clear idea of which brand of concrete armour they would like to implement on their coastal infrastructure. However on most occasions, the commission party has no strong preference about which unit they would like and let the decision over to the consultants (designers) or contractors. Consultants and contractors are companies that are executing such projects on a regular basis, all over the world. Commission

parties were much more difficult to approach since a lot of projects are done all over the world and not clear which person is responsible for the decision of a certain unit. Also, commission parties are not doing such projects on a regular basis, a service life of 50 years for a breakwater is not uncommon. Therefore commissioning party is left out of this study, the focus was on the experts who are into these projects on a regular basis and have close relationships with commissioning parties. Lastly, this study is also prone to a certain bias in various facets. The researcher could be biased in his questioning and the explanation of factors during both interview rounds. Also, the interviewed experts could have a bias towards this industry based on their personal experience. Effort is made to reduce this bias to interview experts from various disciplines such as, inventors, (independent) consultants, managers and academics (see figure 4.1).

6 Conclusion

In this chapter, based on the results of this study the research questions proposed in section 1.3 are being answered. Furthermore, the additional findings of this study are being presented and recommendations for further research are made.

6.1. Research Questions

The main purpose of this master thesis was to give an insight into how factors for technological dominance affect the branch of concrete armour units. In order to answer the research questions a literature study was performed, where the literature about technological dominance and armour units are explored. In the literature study, the concept of technological dominance is explained and how it is evolved over time. Subsequently, a framework is chosen where the important factors for technological dominance found in the literature are summed up. Also, the literature about armour units is elaborated on where the main focus was on the characteristics of this industry and if patterns of technological dominance could be identified. Thereafter, when the factors were identified, a group of 4 key experts were interviewed to determine which factors are relevant in this industry. After the first round, the second round of interviews a ranking process is employed to weigh all the selected factors according to the Best Worst Method.

6.1.1. Sub-Question 1

In order to answer the main research question, 2 sub-questions were drawn up that are answered preliminary. The first sub-question is formulated as follows:

> *Which factors for technological dominance are relevant for the outcome of the technology battle between the key products in the concrete armour unit market in the opinion of the experts?*

As described in chapter 1 and shown in figure 1.2, the key products in this industry are nowadays; Accropode, Accropode II, Core-Loc, Cubi-Pod, Xbloc and XblocPlus. All of them are placed in a single layer configuration and are all placed randomly except XblocPlus, which is placed in a uniform brick pattern.

The basis for answering the first sub-question is in the literature study and the first round of interviews. The input for this interview were the factors from the framework established by Van de Kaa et al. (2011) and were presented to a group of experts who made a large contribution to this industry. Each expert was asked to reflect on the concrete armour unit industry based on their experience and select relevant important factors for technological dominance, the results of this round are found in table 6.1 and a full overview of the relevant selected factors can be found in Appendix F. The results obtained by the first sub-question is used as input for the second round of interviews.

In the first round, experts identified 14 factors of the framework by Van de Kaa that they considered relevant in this branch. The factor ‘technological superiority’ was selected by 3 out of 4 experts as relevant. According to the methodological approach of this thesis additional probing was done to determine

what technical aspects contribute to a technological superior unit. 4 factors were found, namely 'structural integrity', 'hydraulic stability', 'constructability and placebility' and 'maintainability'. Those factors are in line with what is found in the literature about important technical aspects of concrete armour units. Following the methodology of this study, the factor 'technological superiority' is replaced by the 4 found relevant technical aspects.

Table 6.1: Selected factors by experts in the first round

Category	Factor
Characteristics of the format supporter	Financial strength Brand reputation and credibility Operational supremacy Learning orientation
Characteristics of the format	Structural integrity → *Technological superiority* Hydraulic stability → *Technological superiority* Constructability and Placebility → *Technological superiority* Maintainability → *Technological superiority* Flexibility
Format support strategy	Pricing strategy Appropriability strategy Marketing Communications Distribution strategy Commitment
Other stakeholders	Big Fish Effectiveness of the format development process Network of stakeholders

6.1.2. Sub-Question 2

The second sub-question is about the weight assigned by the Best Worst Method and is formulated as follows:

> *What is the importance of each of the relevant factors for technological dominance in the technological battle between the key products in the concrete armour unit market in accordance with the Best Worst Model?*

The second sub-question is answered by applying the input found in sub-question 1 into the Best Worst Method multi-criteria decision-making tool for assigning weights to each factor. A total of 17 factors were found in the literature and by the interviews. Since BWM supports only up to 8 factors simultaneously, separate BWM's were made per category. These categories are defined as Internal Factors, Technological Factors, Strategy Factors and External Factors. Later these separate local BWM's weights are combined in global total weight. For the second round, a group of 14 experts from all over the world were asked to fill in the BWM form. The composition of these experts can be found in figure 4.1 and composed of; inventors, managers, (independent) consultants and academics. Early on in this study, it became clear that this industry is highly conservative and relies on reputation. Experts in the first round were pointing out that in order to be commercial successful as a company your reputation is key. Experts state that building a good reputation can contribute to the adoption rate of new armour units or can increase the commercial lifespan of an armour unit, because of the strong accompanied brand name. For instance, an expert quoted "I would choose one block over the other another one, because of the image of the company". Another expert who invented blocks states that their prior reputation helped to implement their new unit more easily.

Based on the results (shown in table 6.2), it can be seen that again reputation is a very important factor in this industry and proved the right of the experts of the first round. Additionally, the technological factor of hydraulic stability proved even as important as brand reputation and credibility. Based on the

credal ranking, less consensus is about which strategy the patent-holding company should employ in order to be successful (see figure 4.4).

Experts argue that having a good reputation ensures the patent-holding company of business and the acquisition of new projects. Being involved as a patent-holding company in a large number of projects helps to build knowledge about their armour unit. Companies who have built an extensive knowledge base about implementing concrete armour unit profits of this know-how after the patent is expired. Clients will still come back to the original company, since they have the most experience, even if an armour unit is no longer patented.

In the interviews conducted in the first round, there was consensus among the experts on 3 factors by the framework by Van de Kaa et al. (2011). These 3 factors were 'brand reputation and credibility', 'learning orientation' and 'marketing communications'. As described above, experts got really into detail by the factor 'brand reputation and credibility'. This is in line with the results yielded by the BWM, where 'brand reputation and credibility' is the most important ranked factor. There can be concluded that these 3 factors, when using consensus as a measure of importance, are considered most important.

In section 5.2.1 it is discussed how actors can benefit from these results yielded by the BWM, here it is elaborated on the fact that it can be advantageous for a company who is developing concrete armour units to invest in a brand reputation and other soft factors. Up till now, the focus was mainly on the hard (technological) factors about the technical properties of armour units, which can be seen in the number of technical related publications. Firms must invest in more soft related factors, like reputation and network of stakeholders, in order to draw an advantageous strategy for the future.

Table 6.2: Ranked linear BWM results

Rank	Factor	Average weight
1	Brand Reputation and Credibility	0.111
2	Hydraulic Stability	0.095
3	Structural Integrity	0.079
4	Network of Stakeholders	0.077
5	Marketing Communications	0.074
6	Pricing Strategy	0.064
7	Big Fish	0.062
8	Constructablility and Placebility	0.061
9	Commitment	0.058
10	Appropriability Strategy	0.058
11	Operational Supremacy	0.050
12	Learning Orientation	0.049
13	Distribution Strategy	0.040
14	Effectiveness of the Format Development Process	0.038
15	Maintainability	0.031
16	Flexibility	0.028
17	Financial Strength	0.026

6.1.3. Main Research Question

The main research question for this master thesis is formulated as follows:

> *How do factors for technological dominance affect the technology battle between the key products in the market of concrete armour units?*

The main research question is partly answered by the sub-questions. A combination of soft and hard factors is dictating technological dominance in this branch. Where technological characteristics define the technological superiority of a unit, is the reputation the driving force behind the acquisition of projects and the adoption of (new) armour units. However, the question remains what the influence is of each relevant factor on each phase of the dominance process, a light has been shed on this lightly. But should be investigated more elaborately.

Additionally, it can be seen that not always the most technically superior unit is the one that wins the allegiance of the market. For instance, Accropode has a steady flow of new projects (see figure

6.1) and has built an extensive track record of over 200 projects in 48 countries ("The ACCROPODE™ unit", n.d.). However, newer units like Xbloc can save up to 10% in terms of concrete use which lead to a cost reduction and smaller CO_2 footprint (P. B. Bakker et al., 2004). Still, clients rely on the services of the founding company Artelia for the placement of Accropode. Even though the unit has become public domain since 2000, and everybody is free to cast without paying royalties.

6.2. Additional Findings

Outside the main research scope, some additional findings were observed during this study. In this section two of these additional findings are addressed. The first finding is about that some concrete armour units have followed an S-curve like trajectory. The second finding is the ability of concrete armour unit to coexist in this market.

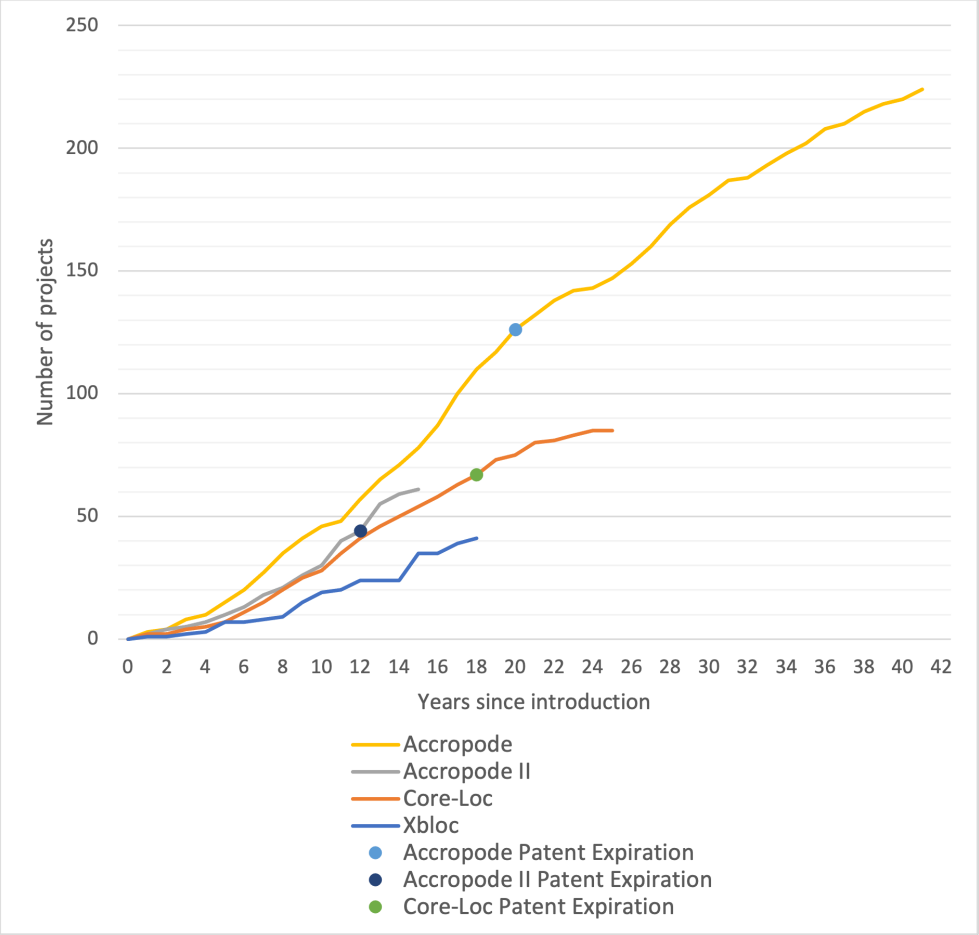

Figure 6.1: Cumulative number of projects since year of introduction

6.2.1. S-Curve Like Trajectory?

As described in section 2.3 the technological dominance process and the adoption of new technologies could follow an S-curve like trajectory. Where first the adoption rate is slow due to high competition in the market. When a technology wins the allegiance of the market the adoption rate is increasing and the mass market is created. Eventually, the market becomes saturated and/or the product becomes obsolete and the adoption rate/market share is decreasing. The theorem of technology adoption is inseparable from the concept of technological dominance, therefore it was included in chapter 2 but it was not the main scope of this thesis.

During the interviews, various experts were pointing out the patents of some key products used in this branch were expired. Accropode was patented in 1980 and Accropode II was patented in 1999, this

means that the patent is expired respectively in 2000 and in 2019. Core-Loc was introduced in 1995 and the patent expired in 2015 (Melby and Turk, 1995). The Xbloc was introduced in 2003, therefore the patent expires in 2023. This means that the majority of the defined key products are not patented anymore and are free to use for third parties.

The two leading patent-holding firms in this business are the Artelia Group and the Royal BAM Group, both companies publish every year their track record (Artelia, 2020; Royal BAM Group, 2021). Every year they show how many new projects they acquired and with which unit the project will be. Artelia, who is the longest in this business have a track record dating back to 1980. On the basis of the available track records, a graph is made with the cumulative number of projects. The cumulatively sold units would be more ideal, but companies are reluctant to give this data since it is regarded as sensitive. However, this gives a general idea of what the adoption rate is of the key products.

In graph 6.1 the cumulative number of projects since the year of introduction is shown. Please note that the Accropode II is introduced in begin 2000, but the first project is dating back to 2007. Therefore, the line is slightly shifted. The same applies for Core-Loc, the first project dates back from 1997.

Based on the graph it can be concluded that Accropode remained a steady flow of new projects, even though the patent is expired for more than 20 years. It can be noted that the line is less steep than it was at the time the patent was valid, but still Accropode benefits of its strong brand reputation built over the years. Accropode II and Core-Loc are both more flattening out after the patent is expired and are now following a more S-curve like trajectory. Xbloc is not following a really S-curve like trajectory up to this time and has a smaller growth in comparison with other units. This could be attributed to the fact that at the time Xbloc entered the market and was the new kid on the block without any track record, more units were competing against each other. In the next section will be more elaborated if concrete armour units can coexist in the market. In Japan, the Tetrapod is still widely applied. This

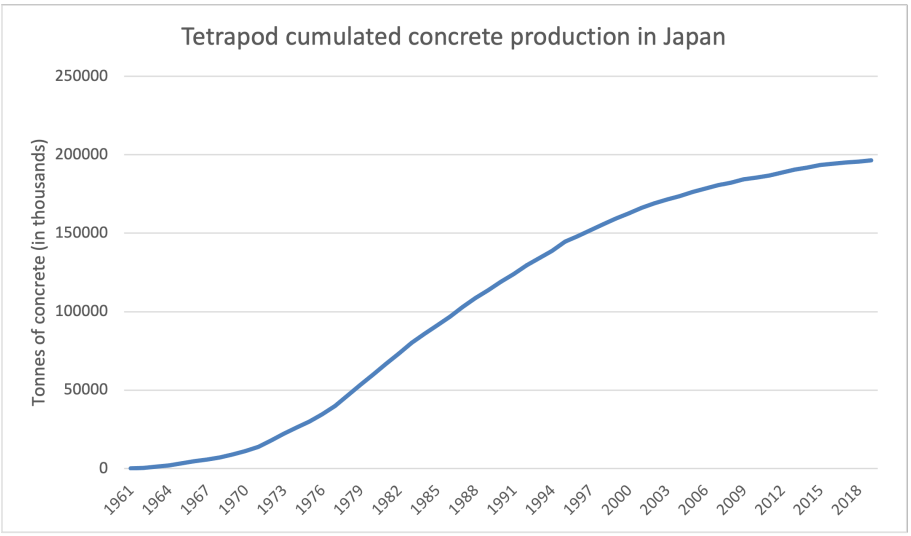

Figure 6.2: Cumulative Tetrapod concrete production in Japan

unit was among the first developed concrete armour unit (see section 2.4). In the 1970s the Japanese company Fudo Tetra bought the rights and started commercializing the Tetrapod in Japan. The data of how many tonnes of concrete Fudo Tetra are sold in Tetrapods is public, in figure 6.2 it can be seen that this unit followed a clear S-curve like trajectory over 60 years.

6.2.2. The Coexistence of Concrete Armour Units in the Market

Experts were additionally pointing out the market of concrete armour units growing. The main contribution of this growth is attributed to climate change. Due to the changing climate, more heavy storms and wave conditions are expected. This means that a large amount of coastal infrastructure must be adapted for the future (Kumar et al., 2020). Concrete armour units play a big role in protecting breakwaters and revetments for high wave loads. Based on the same data of the previous section a graph

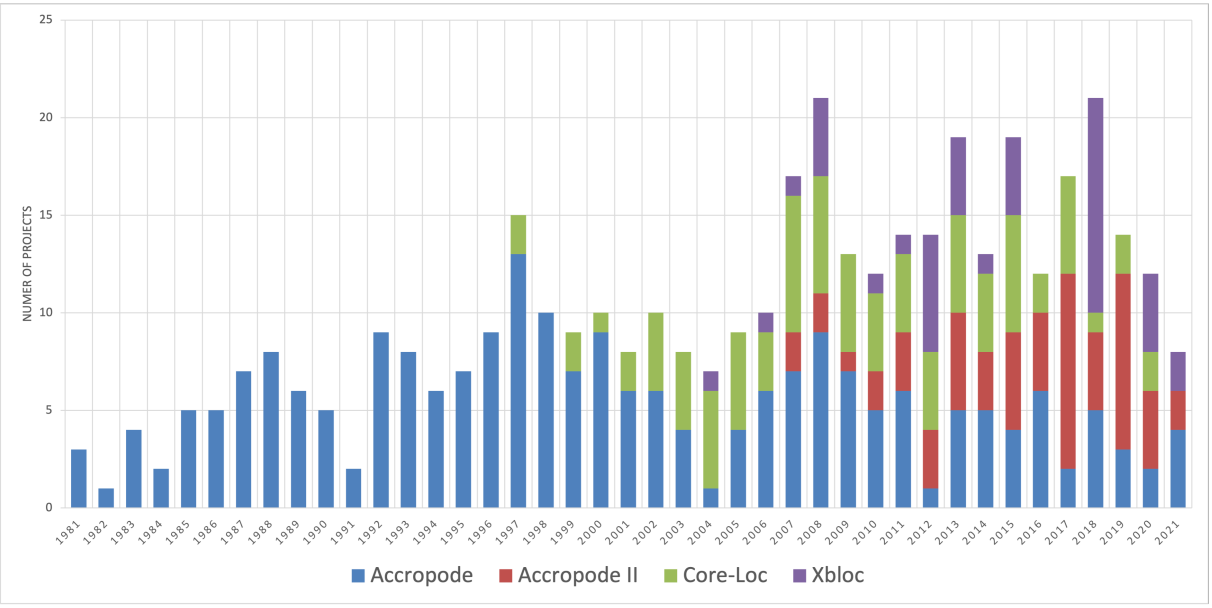

Figure 6.3: Number of projects per key product per year (please note that the data of 2020 and 2021 are not complete)

is made which shows the number of acquired projects per unit per year (see graph 6.3). Here it can be seen that after the 2000's more units came into the market and that the market rose alongside it. Which sometimes led to the cannibalization of units of the same patent-holding company. However, for companies like the Royal BAM Group that are this business for 20 years, there are opportunities to build a successful brand name in this expanding market.

6.3. Future Research

Based on the limitations described in section 5.4 and due to time constraints during this study, some recommendations for future research are made. Since this is the first study about technological dominance a lot of knowledge can be gained in this branch. These recommendations include the additional research of the market characteristics, the importance of the relevant factors per phase in the dominance process, more client-orientated research, and the relation of a business to business market in the field of technological dominance.

As described in section 3.2.1 the category 'market characteristics' by the framework by Van de Kaa et al. (2011) cannot be influenced by the firm, these aspects of the market just exist. This implies that firms present in this market cannot draw a strategy based on the market characteristics of a certain industry. Due to these implications, the methodological choice was to not include this category in this master thesis. However, this does not mean that these factors are irrelevant for this industry. Future research about the market characteristics could be beneficial for a better understanding of this branch and help actors to respond to the market. Having this knowledge will presumable not directly influence the firm's strategy, but will result in a secondary effect that actors know how the market behaves. This study can be executed with the same methodological approach and the same composition of experts of this study, where weights can be assigned to the factors in the category 'market characteristics'.

Secondly, this research does not include the importance per phase. Various scholars identified the importance of factors during the dominance process (Den Uijl, 2015; Suarez, 2004). They argue that the importance of certain factors for technological dominance shifts during the lifespan of a product. In order to obtain a more complete overview of the influence of factors for technological dominance in this

industry, future research in this field is necessary. This insight can be obtained by performing a BWM study where the same group (e.g. same composition of experts) is asked to rank the importance of each of the relevant factors per phase. This will yield the weights of each of the categories and adds more value to the results of this study.

Furthermore, as described in section 5.4, this study is limited by the difficulty of approaching clients. This is due to the fact the client in this branch is not always the commissioning party. In order to obtain a better knowledge of the market a more elaborated client-orientated research should be carried out.

In the first round, experts did not mark 'current installed base' and 'previous installed base' in the framework by Van de Kaa et al. (2011) as relevant factors for technological dominance for this branch. However, during this study literature and experts were implicitly suggesting that in order to obtain a strong brand reputation and become credible in this branch an extensive track record must be built. Farrell and Saloner (1986) argue that an installed base can be described as the number of users who adopt a specific technology. These 'number of users' could be translated to the number of projects acquired or the number of units placed. Future research is necessary to fully study the influence of an installed base on 'brand reputation and credibility' and to this branch in general. More extensive interviews with more probing in the direction of these factors are needed to obtain a better understanding about the importance of these factors in the dominance process.

Lastly, the literature about the concept of technological dominance is mainly studied from a business to consumer perspective (Srinivasan et al., 2006). To gain a better understanding and validating the concept of technological dominance in a business to business environment, more research covering business to business examples is necessary. To obtain a better understanding of technological dominance in the business to business environment more qualitative research is required.

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A

Interview Round 1 Setup

A.1. Set-up

In this interview round four key figures in the industry are being interviewed. Key figures can be identified as people who are involved in this industry for a long time and contributed to the research and development of concrete armour units. The purpose of this round is to discover which factors key figures in this industry find important for the successful implementation of concrete amour units.

The interview can be divided into two parts, the purpose of the first part is to let the expert speak about his/her experience in the industry and determine what factors are contributing to a successful implementation. For the second part, the framework by Van de Kaa et al. (2011) is presented, the purpose here is to discover additional factors which are overlooked by the expert in the interview. The framework gives the interviewee a structured overview of important factors supported by the technological dominance literature.

A.2. Background

In this research, experts in the industry will be interviewed about the important factors for obtaining market dominance in the concrete armour unit industry. These units are concrete interlocking blocks that are applied on coastal infrastructures such as revetments and breakwaters. The factors mentioned by the literature and the experts will be weighed in a multi-criteria decision tool called Best Worst Method. The outcome will be which factor the industry considers most important

A.3. Script

The approach for this round is to have a semi-structured interview with an expert about important factors that lead to a successful implementation of concrete armour units. The way the questions are structured has as purpose to help the expert to think about important factors. First, the expert is asked about his/her own experience and if the expert can identify important factors based on his own experience. After the questions about important factors in this industry the framework by Van de Kaa et al. (2011) is presented. The expert in question is asked to mark important factors from the list, that are relevant and can be applied to this industry. If the expert marks the factor 'technological superiority', the interviewer will probe the interviewee to give a more elaborate answer on what technological property is important for a concrete armour unit. In Italics the script and the guideline of the interviewer is written down.

A.4. Interview

A.4.1. Introduction

In this research important factors for a successful implementation in the concrete armour unit industry are being identified by means of interviews and a literature study. The interview consist of 2 rounds, the first round key figures in the industry will be interviewed and asked about their experiences and if important factors can be identified. After the first round a selection of relevant factors is made. In the second round a broader group of people who are involved in this industry is asked to rank the selected

factors from the previous round. The results of the second round are used as input for a multi-criteria decision model called Best Worst Method in order to assign weight to each factor.

A.4.2. Questions

Question 1 to 4 are introduction questions, try to get an idea what the experience is of the expert.

1. Have your read the consent form and do you give permission that this interview is being recorded?
2. Could you describe the company's activities where you are employed?
   Try to identify keywords like; dredging, contractor, consultancy firm, research institute, R&D of concrete armour units
3. What is your function there?
   Try to identify keywords like; inventor, academic, consultant, management, designer

Use question 4 and 5 as an introduction to question 6. If the interviewee is automatically starting about various units, let the expert speak and probe/clarify in the direction of what kind of experience the interview had with certain units and if he/she could identify important factors

4. Could you describe your current activities, regarding concrete armour units?
   Link this question with the next question. If the interviewee is beginning to speak about his/her experience.
5. Do you consider yourself an expert in this industry? And why?
   If the interviewee does not mention their number of years' experience ask for it.

Questions 6 to 9 are more in depth about the experience of the expert in relation to possible identified important factors

6. What is your experience with concrete armour units, and with which units was that experience (Tetrapod, Accropode, Accropode II, Xbloc, Core loc, XblocPlus or Cubipod)?
   Probe into the direction of positive and negative experiences with each unit, try to clarify if there are company/technical factors involved that influence the positive or negative experience.
7. In the past, armour units like Tetrapod and Accropode proved to be very successful in terms numbers of units placed. What caused that success, and what factors contributed to that success in your opinion?

If the interviewee mentioned factors that could be identified as important factors in the previous two questions, try to clarify those by summarizing these factors and let the interviewee confirm those If the interviewee is starting about innovation, use question 11 as a probe question to discover what the industry needs in terms of new innovations, this could be linked to question 10 as well (e.g. ' What is lacking in this industry and what innovation is needed to overcome this?') Question 8 has as purpose to trigger the interviewee to think about non-technical factors. Since in this industry people approach this matter mostly from technical point of view.

8. Are there non-technical factors contributing to a successful implementation?

Question 9 has as purpose to trigger the interviewee to consider this from the other way around, if there factors that strongly influence a negative outcome on the implementation

9. Can there be factors identified which have a negative impact on the implementation of a concrete armour unit?
   Use a variant of question 10 as clarifying question, 'is this what the industry is lacking in general?

10 and 11 are probing questions if the interviewee is not mention it himself.

10. What is this industry lacking?
11. What kind of innovation could you expect in this industry?

Summarize and clarify all the factors that are mentioned by the interviewee and continue with the framework.

12. In order to prevent that factors are overlooked I present you a list of factors (see table A.1) that could according to the literature contribute to a successful implementation of a product.
First walk all the factors through, with explanation of each factor. Ask than if the interviewee understands all the factors, clarify and link the mentioned factors previously by the interviewee that were summarized before question 12.

Table A.1: Used framework by Van de Kaa et al. (2011)

Factors for technological dominance	
Characteristics of the format supporter	Financial strength Brand reputation and credibility Operational supremacy Learning orientation
Characteristics of the format	Technological superiority Compatibility Complementary goods Flexibility
Format support strategy	Pricing strategy Appropriability strategy Timing of entry Marketing communications Pre-emption of scarce assets Distribution strategy Commitment
Other stakeholders	Current installed base Previous installed base Big Fish Regulator Antitrust laws Suppliers Effectiveness of the format development process Network of stakeholders

13. *Optional, ask when technological superiority is marked)*
The factor technological superiority is a broad term. Which technological characteristics of concrete armour units are relevant in your opinion?

14. Are there factors that are not mentioned in the list and/or interview but you still want to add?

End of the interview and recording

B

Transcript Expert 1

Speaker 1: Wat zijn uw activiteiten waar u werkzaam bent?

Speaker 2: Ik werk bij [...] op het interne ontwerpbureau.

Speaker 1: En wat is uw functie daar?

Speaker 2: Hoofd op de afdeling Water

Speaker 1: Dan gaan we door naar de volgende vraag

Speaker 1: Waarom beschouwt u zich een expert in deze industrie?

Speaker 2: Ik heb 32 jaar werkervaring en dus al vanaf het begin af aan beziggeweest met golfbrekers, mijn eerste golfbreker was eentje met TP.

Speaker 1: Dat was ook de eerste echte golfbrekerelement.

Speaker 2: Ja.

Speaker 1: En u heeft met alle gangbare blokken ervaring? (ACC, ACCII, CL, TP, XB, XPB)

Speaker 2: Ja ik heb ACC ervaring, TP ervaring. Reviews gedaan van ACC II en CL ontwerpen.

Speaker 1: Oké en met CP, heeft u daar weleens iets mee gedaan?

Speaker 2: Niks mee gedaan. Wel natuurlijk de ontwikkelingen nauw gevolgd. Bijvoorbeeld ook het Hanstholm project.

Speaker 1: Was dat het eerste project?

Speaker 2: Nee het eerste project in noord west, Europa, dus eerste project buiten Spanje en dat in plaats van XB was het CP geworden, daarom waren we natuurlijk erg geïnteresseerd van hoe dat ontwerp eruit zag.

Speaker 1: Okee, dit was het eerste deel. Nu gaan we factoren uit de literatuur langs om te bepalen welke van belang zijn.

Factor Selection

speaker 1: Technological Superiority is nogal een breed begrip, waar hangt deze superiotiteit vanaf als je het bekijkt vanuit het persepectief van concrete armour units? Waar hangt dat van af?

Speaker 2: Ten eerste de hydraulische stabiliteit.

Speaker 1: En hoe moet bouwbaar zijn.

Speaker 1: En met name in hoeverre ze neer te leggen zijn.

Speaker 1: Dus en eigenlijk al die andere dingen die je dus in de literatuur dus wel vaak voorbij zien komen, dus bijvoorbeeld die packing density en schade, maar bijvoorbeeld ook de de interne krachten, zodat die bijvoorbeeld niet als je maar vallen wat die niet gelijk een stuk.

Speaker 2: Ja, dat,

Speaker 1: Ja.

Speaker 2: Ja je hebt ook met structural integrity te maken.

Speaker 1: Maar hij heeft met elkaar te maken?

Speaker 2: Ja want een hydraulisch stabiel blok is meestal ook structural stabiel.

Speaker 1: En die andere was?

Speaker 2: Bouwbaarheid, placebility

Speaker 1: Zijn er voorbeelden van blokken die dat niet waren?

Speaker 2: Veel discussie is er rond TP. Bij elk blok heb je het wel. Maar TP in het speciaal. Is een dubbellaags blok. En niemand weet goed hoe je die lagen moet leggen.

Speaker 1: Ja.

Speaker 2: Niemand wist het

Speaker 1: Kwam dat puur omdat het overgedimensioneerd werd?

Speaker 2: Of niet, dus je kan ze in allerlei manieren neerleggen, maar niemand weet wat naar de goede manier is.

Speaker 1: Ah vandaar

Speaker 2: Een van de redenen om nieuwe blokken te ontwikkelen was de moeilijkheid van plaatsen van de bestaande blokken. Die hadden rond de 11 plaatsings regels

Speaker 1: Dat is echt veel, ja, dus dan dan praat je zeg maar over de hoek en as en hoe het staat?

Speaker 2: Ze mogen niet twee blokken naast elkaar leggen. Met hetzelfde oriëntatie mogen meer, minder dan 30 procent blokken, mogen met het aambeeld op het talud staan soort zaken, ja, dat is wel erg onhandig.

Speaker 1: Goed dan de 7e vraag, ik heb een lijst gepresenteerd en een aantal dingen gevraagd. Maar mist er iets?

Speaker 2: Je ziet dat het hebben van een goed netwerk erg belangrijk is. Zo zijn er voorbeelden van blokken die goed waren. Maar puur doordat een bedrijf geen goed netwerk had zijn die geen succes geworden.

Speaker 2: Het tegenwoordig wat minder natuurlijk, maar vroeger waren de engelse consultants wereldwijd marktleider en dus die bepaalde wat gekozen werd.

Speaker 1: Dus als je zeg maar naar de technische aspecten kijkt, is het gewoon goed blok,

Speaker 2: Ja inderdaad.

Speaker 1: Nu heb ik nog een vraag. Waarin zou deze industrie nog echt moeten innoveren?

Speaker 2: Waar nog veel te halen is dus ecologie. Ecologie en vormgeving. Toen wij begonnen waren we puur industrieel bezig. Je moet er iets beschermen tegen, golfen en dan beton erop, terwijl dit alles wat je in zee legt is, gewoon een is woonruimte voor zee leven. Dus dat wordt steeds belangrijker.

Speaker 1: Nee, maar dat was, dat was dan de tijd niet, dus het is de ontwikkeling zou dus veel meer in het in het esthetische vlak, en duurzame vlak.

Speaker 2: En multifunctioneel, het is meer dan alleen de talud beschermen

Speaker 1: Maar denkt u dat het product vanuit technisch oogpunt gezien een beetje uitontwikkeld is. Als je kijkt naar beton gebruik en stabiliteit?

Speaker 2: Nee dat denk ik niet. Ik denk dat er nog wel nieuwe ideeen komen

Speaker 1: Wil je nog iets toevoegen verder?

Speaker 2: Nee

End Recording

C

Transcript Expert 2

Question 2-3

Speaker 1: Dus maar bij deze, maar volgens mij werkt het allebei. Dus dat is dus dat is fijn. Nou, dan gaan we naar de eerste vraag dat is eigenlijk heel basaal maar kunt u omschrijven wat wat voor bedrijf u werkzaam bent en wat voor activiteiten daarbij zitten?

Speaker 2: Ik ben bij twee plekken werkzaam: Deltares en de TU Delft. Bij Deltares ben ik afdelingshoofd van de groep Coastal Structures and Waves. En daarin testen wij onder meer golfbrekers maar ook dijken en ook bepalen wij ook hydraulische randvoorwaarden voor allerlei waterbouwkundig constructies en daar ben ik afdelingshoofd van een groep van 25 en op de TU werk ik parttime als hoogleraar Coastal Structures.

Speaker 1: Oké nou, helaas u nooit in de collegebanken gehad.

Speaker 2: Nee, ik ga. Ik geef niet één cursus, maar ik geef alleen gastcolleges zeg maar. Dus als je breakwaters of bed en bank protection had gevolgd, dan had je me wel een paar keer voorbij zien komen.

Speaker 1: Ja, ik heb alleen waterbouwkunde gehad.

Speaker 2: Ja, weet ik niet, wie dat heeft gegeven, want Henk Jan Verhagen misschien.

Question 4-5

Speaker 1: Oke goed is, ja, eigenlijk bij kennisinstituut Deltares en natuurlijk bij de universiteit. Bij de ene bent u afdelingshoofd om het zo noemen, denk ik, bij de andere, met verbonden aan TU Delft, bij de afdeling coastal structures. Kunt u omschrijven, welke activiteiten u, waar u mee bezig bent als het gaat om de golfbreker elementen. Waar houdt u zich, zoals nu mee bezig?

Speaker 2: Met name over de stabiliteit blijven liggen of niet, en ook over hoeveel van golfverslag gaat daarover de golfbrekers heen? Dat zijn de twee voornaamste, maar dat kan natuurlijk af en toe ook andere onderwerpen voorbij, zoals uitspoeling van onderlagen. Wat gebeurt er als er eenmaal schade aan de toplaag is? Of is de teen constructie wel sterk genoeg? Dus alle allerlei aspecten die te maken hebben met het ontwerp van golfbrekers.

Speaker 1: En hoeveel jaar ervaring heeft u in deze industrie?

Speaker 2: In 1991, dus dat is 30.

Speaker 1: Oké, dus een beetje van dezelfde periode als (..), als ik het zo hoor.

Speaker 2: Ja, ik denk dat hier iets langer is dan ik, denk ik.

Speaker 1: Ehm, ja, dus met uw huidige werkzaamheden kunnen we wel concluderen dat u een expert in deze industrie bent. Kunt u omschrijven wat voor ervaring u heeft met met de verschillende golfbreker elementen. Dus we hebben Tetrapod, Accropode, Accropode II, Core-Loc, Xbloc, XblocPlus en Cubi-Pod.

Question 6

Speaker 1: Kunt u wat vertellen met welke producten uw ervaring heeft dan wat een beetje uw ervaring en daarmee was? Ja.

Speaker 2: Ehm ja, ik zou bijna zeggen welk, met welke nog niet. Maar de kubussen we hebben ze allemaal wel getest. Kubussen, Tetrapod, Accropode, Core-Loc, Xbloc en XblocPlus ligt nu in één van onze faciliteiten.

Speaker 1: Ligt XblocPlus er met 3D proeven?

Speaker 2: Nee, met we doen voor de afsluitdijk testen.

Speaker 1: Oh ja, dat heb ik gelezen.

Speaker 2: En ja, we testen, dat is één zn als ontwerp is gemaakt dan of die voldoet of niet, maar ook optimaliseren of nog beter, kan ehm zelf doe ik ook nog expert, opinies als er dingen misgaan bij tijdens de bouw. Dus soms ga ik naar

een werk toe en dan vertel ik had er in mijn ogen mis is gegaan tijdens de bouw. Ehm en het ontwikkelen van ontwerp, formule voor allerlei ehm armour lagen. Nou is dat wel heel vaak bestaande uit steen dus is geen betonnen elementen, maar kubussen in een enkele laag bijvoorbeeld heb ik vrij veel aan gedaan om te ontwikkelen van dat soort simpele methodes, relatief simpele methodes voor golfbreker elementen.

Speaker 1: Oké, en heeft u eigenlijk ook een positieve en negatieve ervaringen met bepaalde producten? Sommige mensen hebben dat nogal sterk in deze industrie, heb ik gemerkt.

Speaker 2: Nou ja, je bent natuurlijk wel betrokken bij projecten waar dingen misgaan dan zie je wat ik mis gaan. Maar heel vaak kun je ook zeggen dat voor die betreffende de locatie niet het optimale element is gekozen, ook voor de betreffende aannemer, dat iets te ingewikkeld is. En dan zie je dus een soms wel dat het verkeerde keuzes worden gemaakt. Hè, je doet bijvoorbeeld een ontwerp en een kies je, een blok zoals de Accropode, en dan blijkt die aannemer dat niet goed aan te kunnen leggen, hetzij door ervaring, hetzij door andere redenen, buiten de aannemer om. En dan denk je van: ja, achteraf gezien had beter een andere aan armour unit gekozen kunnen worden. En er zijn natuurlijk ook in de tijd is er een voortgaande ontwikkeling. Er zijn ook blokken die inmiddels nauwelijks meer worden gebruikt, omdat het eigenlijk te duur is. Dus de Tetrapod en de Accropode. Die zijn zo langzamerhand wel uit de markt gedrukt door de door de units die een laag liggen. Alleen de kubus in een dubbele laag, dat komt nog wel regelmatig voor, maar de andere dubbele lagen, die worden, die zijn er eigenlijk zijn niet meer zo relevant. Uiteindelijk zijn ze. Ze zijn nog wel relevant, omdat natuurlijk constructies liggen die soms aangepast moeten worden. En dan heb je bijvoorbeeld een Tetrapod te maken, want die ligt er al en als die dan bijvoorbeeld versterkt moet worden, dan heb je de vraag of of je dat dan met met een andere laag. Ander element moet gaan doen of dat je gewoon nieuwe Tetrapods bijlegt dus je hebt te maken met bestaande constructies vaak. Maar voor de nieuwe constructies zijn dat soort blokken al wel uit de markt gedrukt, zeg maar.

Speaker 1: Ja, dus dat ja, dat is ook wel te zien. Als je de ja, dat track record van van de grote bedrijven daarnaast legt dan zie je dat dat dat eigenlijk de units waar eigenlijk geen patent meer op rust, dat die langzaam uit de markt verdwijnen.

Speaker 2: Ja, behalve de kubus, dus daar zit geen patent op en die komt er wel heel veel voor.

Speaker 1: Ja en wat is daar de reden voor dat die eigenlijk dan toch nog zo veel voorkomen?

Speaker 2: Naar de andere units die gaan al kijk je hebt afdekt lagen. Die halen hun sterkte uit gewicht en uit interlocking.

Speaker 1: Ja.

Speaker 2: En de kubus is dus meer op gewicht, terwijl bijvoorbeeld andere units als de Xbloc en de Accropode meer uit interlocking is. Maar om die interlocking te krijgen hebben ze wel bepaalde ingewikkeldere vormen, en die zijn voor sommige aannemers wat moeilijker te maken en ook moeilijker te plaatsen. Dus de eisen die gesteld worden aan het plaatsen van die interlocking units die zijn veel strenger dan wanneer het om blokken gaat, die kubussen bijvoorbeeld, die het voornamelijk uit van het gewicht moeten hebben en dat is de, dat geeft gelijk de twee grote lijnen weer tussen de verschillende units en zonder specifiek een bepaalde unit te benoemen. Dan heb je dus de in units daar zijn dus een serie van met met een een nodige problemen en maar ook voordelen: minder beton gebruik.

Speaker 1: Dolos is daar een klassiek voorbeeld toch van?

Speaker 2: Bijvoorbeeld ja, maar dat is een dubbele laag.

Speaker 1: Oh ja dat is waar.

Speaker 2: Ja maar ook de andere. Die breken. Als je, als je ze niet goed maakt, dan kunnen ze breken. En dat zie je dus in bepaalde werken, ook met

name in warme landen, waar de aannemer niet al te veel ervaring heeft met hoe je die blokken moet maken. Je kan altijd beton in een bepaalde mal gieten maar dat wil niet zeggen dat ze sterk genoeg zijn. Je moet het een goed nat houden en zo, en anders krijg je allemaal scheurvorming en dan breken en gewone stukjes af, en daar kun je die blokken niet meer gebruiken of je legt ze er wel in, maar dan kan de golfbreker element als nog kapot gaan.

Speaker 1: Ja.

Speaker 2: Dus dat is het nadeel van de interlocking terwijl de degene die het op gewicht doen. Die hebben we wel wat meer beton, maar die zijn ook wat makkelijker, makkelijker te plaatsen. Er komt niet zo nauw, want die hebben die interlocking niet nodig.

Speaker 1: En speelt misschien ook mee. Dat systeem, dat lijkt of een een kubus, lijkt meer op steen en het is misschien ook wel optisch wat fijn om naar te kijken dan kustlijn vol met ingewikkelde interlocking blokken om te zien. Speelt dan denkt u nog mee of niet?

Speaker 2: Nee, dat denk ik niet, want ik denk niet dat er veel mensen zijn die zeggen dat een kubus golfbreker mooier is dan een Accropode golfbreker of zo en ik denk dat dat beide kanten op gaat. Van ik vind de Accropode zo mooi.

Speaker 1: Nee.

Speaker 2: Maar dat kan wel zijn. Je hebt wel tradities in bepaalde landen, hè, je hebt een bepaalde landen waar ze gewend zijn om Tetrapods en Accropodes neer te leggen. En ja, dat, dat blijven ze dan bij. Dat, dat kan wel meespelen.

Speaker 1: Okee, dat hoor je meer. Dat men in bepaalde landen bij dezelfde blokken blijft.

Speaker 2: Oh ja, Oman is ook zon land waar je allerlei vormen ziet en waar er eerste na heel vaak dat als er eenmaal een unit is gekozen, dan zie je de hele tijd dat de volgende groep golfbrekers die daarna worden gebouwd, ook met de unit zijn. Zijn stappen niet zo gauw af op iets wat ze niet kennen. En dat is wel. Dat dus wel iets wat in dit vakgebied veel voorkomt hè dus een traditionele, markt, waarbij een heleboel mensen niet iets nieuws durven en niet de eerste willen zijn. Als een andere het heeft gedaan en een aantal keren dan is het een ander verhaal, maar niemand wil de eerste zijn of zelfs in een bepaald land de eerste zijn.

Question 7

Speaker 1: Ja, dat, dat is iets wat ik eigenlijk, maar vooronderzoek ook wel een beetje heb begrepen dat. Het is een hele conservatieve markt. En zelfs als er dus geen patent meer op rust, dan kiest men vaak toch nog soms voor die route. Ja, oké, nou, dan komen we eigenlijk naar de volgende vraag. In het verleden zijn de Tetrapod en de Accropode, dat waren en dat zijn, hele succesvolle product, om het maar even zo te noemen, om, als je kijkt naar de aantallen waarin ze zijn geplaatst. Wat is in uw in uw ogen de reden dat deze zo succesvol zijn geweest? Wat heeft daaraan bijgedragen?

Speaker 2: Gebruik van minder beton heeft daaraan bijgedragen, dus dat betekent ook die interlocking. Maar ja, er. zijn ook dingen misgegaan en met de Accropode bijvoorbeeld een hele, een beroemde golfbreker de eerste, een echtgrote, die echt kapot ging, was in in Portugal Sines en daar werd dus.

Speaker 1: Was dat niet Dolos in Sines?

Speaker 2: Sorry ja, het was de Dolos.

Speaker 2: Maar ja, dan zie je dus dat de kennis toch niet goed genoeg is, want wat men deed is in feite steeds extrapoleren, steeds groter en groter. En toen raakte men de sterkte van het element zelf uit het uit het zicht dat het voor kleine elementen is dat niet zon punt, hè, de sterkte van het beton en zo. Maar als het slank is, dan kun je dat niet uit de oneindig groter maken. En dat is toen wel gebeurd en toen gingen ze kapot. En toen heeft zo'n zo'n unit heeft een hele slechte naam gekregen, na nadat, nadat die golfbreker dus kapot is gegaan, en toen dacht iedereen wel drie keer na voordat die de Dolos gingen toepassen.

Speaker 1: Want die is, denk ik na, bijna niet meer toegepast of wel?

Speaker 2: Weinig. Ja, het is niet helemaal zo, want er zijn natuurlijk ook bedrijven die dan met fiber zouden worden, allerlei soorten, ach, wapening zegmaar maar aanbrengen, waardoor je dan toch weer iemand kan overtuigen van hij is toch sterk genoeg.

Speaker 1: In Japan kun je ze nog krijgen met wapening bij.

Speaker 2: Ja, ja, maar het is niet allemaal met met staal wapening het. Er zijn ook wat geavanceerdere wapening materialen met echte wapening ja, dat niet echt slim.

Speaker 1: Nee, dat lijkt mij ook een beetje moeilijk.

Speaker 2: In de zoute omgeving.

Speaker 1: Ja, dat gaat hard roesten en betonrot.

Speaker 2: Nee, maar ze zijn van kunststof

Speaker 1: Dus eigenlijk die factoren die u noemt inderdaad een slechte naam van een ander product, en die droeg dus bij aan dat dat dat bijvoorbeeld Accropode, daarmee ook succesvol was.

Speaker 2: De Accropode daarna was daardoor ook succesvol. Ja.

Speaker 1: Dus daarvoor nog niet?

Speaker 2: Ik weet niet of die er al was op dat moment.

Speaker 1: Uit mn hoofd is Accropode gepatenteerd in 1980 en Sines is 78.

Speaker 2: Het is wel rond die tijd, maar precies hoe ze toen in de markt zaten al, dat weet ik niet. Maar goed, je hoeft ook niet. Als de Dolos kapot gaat, hoef je ook niet naar de Accropode. Je kan ook naar de Tetrapod teruggaan natuurlijk.

Speaker 1: Maar dat is een dubbel laags. Maar Accropode was natuurlijk de eerste die in een enkel laagse configuratie geplaatst kon worden.

Speaker 2: Ja, hoewel die. Ja, ja, dat is waar.

Speaker 1: En het succes van Tetrapod? Ze zijn uiteindelijk, door hetzelfde bedrijf ontwikkelt Sogreah uit aan mn hoofd heeft, heeft, zeg maar de manier hoe dat bedrijf dat deed nog aan bijgedragen van ja, dat die twee producten eigenlijk best wel succesvol zijn geworden?

Speaker 2: Ja, dat denk ik wel, want ze gingen behalve het ontwikkelen van zo'n unit hebben ze ook laboratorium faciliteiten waarmee ze konden aantonen hoe goed iets was en het was nogal commercieel ze zorgde en dat is natuurlijk gegroeid ook naar in de Accropode tijd is dat vrij extreem geworden dat ze bij allebei de service erbij verzorgde en de inspectie tijdens de bouw daarbij deden. Ehm en ja, dat, dat helpt wel, hè, dat daarmee kun je het ook. Kun je ook je naam, zeg maar beschermen door tijdens de bouw te kijken of het allemaal wel goed goed gebeurt. En ja, interlocking moet verzorgd worden en dat is natuurlijk onder water niet vanzelfsprekend. Dus inspecties tijdens de bouw en duikers die gaan kijken onder water, dat is service, die zij dan gaan verlenen.

Speaker 1: Al vrij in het begin, denk ik.

Speaker 2: Ja, en het feit dat die gepatenteerd was, heeft in Nederland geleid. Tot dan willen we ze niet gaan gebruiken. Tetrapod was ook gepatenteerde en toen heeft in Nederland die ze toen een ander blok ontwikkeld omdat ze geen patent wilde betalen. En daar kwamen daar kwam Akmon uit.

Speaker 1: Dat is toch een soort gedraaid aambeeld op elkaar toch?

Speaker 2: Ja, zo kun je het ook omschrijven, hij is niet vaak toegepast, maar er zit daar ook geen commercieel bedrijf dan achter die zo'n blok dan in

de markt zet en daar reclame voor maakt. En eh ja, daar zijn veel klanten toch wel gevoelig voor, hè, want die willen niet, die willen ook de service die er bij is, hebben. En is de theoretisch. Als je een een kubus hebt, die die het bijvoorbeeld beter doet dan een interlocking unit, ja, en er is niemand die dat vertelt. Toen kwam allemaal mensen over de vloer die zeggen: mijn interlocking unit is beter en er is niemand die over de vloer komt van met de kubus kan het ook. Ook dan is men toch geneigd om de interlocking unit te nemen, even los van of dat een terecht is, want het kan natuurlijk compleet terecht zijn, maar dat hoeft niet altijd.

Speaker 1: Nee, nee, want dan zijn natuurlijk ook andere factoren daarin mee spelen zoals de hydraulische stabiliteit.

Speaker 2: Ja, inderdaad. Want er zijn natuurlijk ook op interlocking golfbrekers die zijn kapotgegaan die hebben gefaald en er is altijd wel een reden bij: heeft heel vaak met interlocking te maken.

Speaker 1: Want die even voor mijn begrip, die daar is natuurlijk een rocking noemen ze dat in het engels die kunnen ook een beetje heen en weer gaan en daardoor kunnen ze elkaar een stuk stoten. Dat is toch een beetje de achtergrond, waarom die dan stuk kunnen gaan.

Speaker 2: Ja, dat is waar, maar ze kunnen ook al tijdens het maken van het blok zelf niet sterk genoeg zijn. Dus het blok zelf kan je niet sterk genoeg zijn. De ze kunnen bewegen als in het talud zeggen liggen, dan kunnen ze ook kapotgaan zeg maar om dat, ook al zijn ze sterk genoeg, ehm. Het kan ook zijn dat die units niet genoeg inhaken op de onderlaag daaronder, zodat er een heel zwaar talud ligt, wat allemaal op de teen constructie drukt. Dan glijdt het hele zaakje af. Dat ook nog een optie ehm en die interlocking, ja, die ze moeten ook goed neergelegd zijn, eh en onder water is. Gaat dat niet altijd goed. Eén van de voorbeelden die ik ken, is dat men aan het baggeren was tijdens het plaatsen van de units ja, dan kun je wel duikers naar beneden sturen, maar die zien helemaal niks. Als er ergens als de in de buurt gebaggerd wordt en dan, ja, dan kan er ook wat van alles misgaan met die interlocking. Dat is dus meer, een procesmatig probleem we hadden van tevoren niet over nagedacht is, maar wel leidt wel tot falen van zon constructie.

Speaker 1: Oké is wel leuk om te weten. Dus een teen is heel belangrijk voor zo'n interlocking constructie als het op een talud ligt.

Speaker 2: Ook de onderlaag want je wilt die kracht het liefst van de van de toplaag zo snel mogelijk afvoeren naar de onderlaag alles wat hij niet afgevoerd naar de onderlagen dat komt op de teen. En ja, als je niet uitkijkt heb je het hele gewicht, zeg maar op de teen, en dan heb je een enorm zware teen nodig. Dus je wil eigenlijk dat dat dat gewicht door wrijving met de onderlagen al zo veel mogelijk op de onderlaag wordt afgedragen dat het niet allemaal op de tenen aankomt.

Question 9

Speaker 1: Oké, ja, dat, dat klinkt heel logisch. We hadden we hadden het net al een beetje over van ja, zeg, maar dat er ook factoren zijn die ook van niet technische aard zijn, die toch bijdragen aan aan een succesvol product. U noemde, denk ik, net hoe geloofwaardig een bedrijf is, wat wat bijvoorbeeld hun manier van marketing is, hoe commercieel zou zijn en services die erbij verleend kan worden. Maar, zijn er nog meer factoren dat u denkt van nou die kunnen weleens belangrijk zijn?

Speaker 2: Ja, de reputatieschade reputatieschade als er dingen kapotgaan die die speelt ook een rol. Hè als ze jouw, buurman, haven, de in de buurt, een interlocking unit heeft gekozen en die is kapotgegaan of dat het aan het ontwerpt ligt of aan aan de unit dat maakt even niet uit het feit dat er iets kapot is gegaan. Dat is toch een drempel om dat dan nog een keer te te doen?

Speaker 1: Dus eigenlijk het meest killing voor deze industrie is dus eigenlijk een project waar gewoon iets met jouw product misgaat want dat is eigenlijk de slechtste reclame

Speaker 2: Ja, dat is zo.

Speaker 2: Maar het is niet altijd killing want de Accropode eindelijk kan ik wel serie golfbrekers noemen die kapot zijn gegaan. Enorm. Toch zitten

ze nog goed in de markt, hè, want het ligt ook niet altijd aan de unit hè, het is, het kan ook gewoon aan het proces liggen. Of voor diepe treffende locatie had je beter een andere unit kunnen kiezen.

Speaker 1: Maar dat ligt om toch uiteindelijk er dan bij of de de fabrikant daar in gebreken is gebleven en niet de manier waarop het ontworpen of aangelegd is.

Speaker 2: Het gebeurt allemaal. Ik heb fouten in het ontwerp gezien. Ik heb fouten van de aannemer zelf gezien. Eh en eh gewoon management wise dat gewoon voor die locatie het interlocking en geen geschikte element is. En het voorbeeld wat ik net noemde van die dredging hij heeft niks met de met de unit te maken. Maar ja, ga daar als aannemer ik maar zeggen van: ja, ik kan niet door, want er is iemand aan dredging dan had ik even niet geen rekening mee gehouden en die druk is te groot. Dat gaat gewoon door. En ja, dat gaat wel eens mis.

Speaker 1: Maar toch, toch is zo'n bedrijf als die de Accropode maakt daar dan toch bovenop gekomen. Want u nu noemt dan meerdere projecten, dus dus wat wel, wat doen ze dan wel goed? Dat er dus een geloofwaardigheid dan daarmee niet in het geding komt.

Speaker 2: Zijn eerste wordt het niet aan de grote klok gehangen, want niemand heeft daar niet alleen zij, maar ook degene die het bout- en ook degene voor wie je gebouwd wordt, uiteindelijk klant. Die hebben we geen belang bij voor slechte reclame van mijn golfbreker is kapotgegaan dus het is niemand die dat aan de grote klok hangt, dus dat helpt enorm om die die imago imagoschade te beperken.

Speaker 1: Oké, er is wel een beetje, dat heb ik al een beetje, maar ook bij andere mensen die ik hier over gesproken gemerkt. Dat is wel een soort tamtam als het gaat om wie het projectje daar heeft, een project hier en wat wat daar gebeurt of wat er gebeurt, wat er misgaat is maar dat. Dat blijft wel dus enigszins op zijn plek dus.

Speaker 2: Toch wel ja, want ik denk dat er ook wel gevallen zijn die helemaal niet via de tamtam gaan.

Speaker 1: Nee, dat ook, oké. Nou, dat is leuk. Leuk om te horen dat ik vind dat trouwens heel interessant om deze industrie, je zou denken aan deze markt, je zou denken: nou ja, betonnen blokken, dan kun je heel plat over denken, maar dat er zoveel naar innovatie, dingen allemaal ook gewoon dingen spelen over projecten, dat er toch een hele grote wereld is, een veel belang, en dat is leuk. Leuk, omdat daar gaande weg zo achter te komen.

Speaker 2: Ja, in de traditie, wat ik al zei het, het is traditioneel dus je ziet in bepaalde landen zie je een voorkeur voor een bepaalde unit. Dus als je in Spanje komt, dan zie je of de kubus of de Cubi-Pod tegenwoordig, maar je zal er weinig Accropodes of Xblocs zien. En er zijn bepaalde landen waar dat helemaal niet speelt. Wij waren gewoon naar gekeken wordt van kom maar op, doe maar een voorstel en dan kiezen we wel.

Speaker 1: Ja, dat is ja, ik heb ook trackrecord van Accropode en Xbloc, CLI en BAM heb ik wel goed bestudeerd waar waar nou een beetje wat ligt, maar inderdaad, wat wat trouwens wel opgevallen toen is dat schiet me trouwens nu te binnen. Dat Accropode was in de regio. Azië had een bepaalde populariteit en dat is rond het jaar 2000. Is dat gestagneerd en ze hebben eigenlijk, ja, ze hebben nu een Hong Kong, dacht ik, nu een project, maar dat is eigenlijk daarna eigenlijk tussen tussen nu en 2000 hebben ze eigenlijk geen projecten meer in in zuid, oost azië voornamelijk gehad. Dat viel me toen nog op. Toen weet u misschien, maar dat zou kunnen liggen?

Speaker 2: De zuidoost azië, maar dan moet je even iets specifieker zijn over.

Speaker 1: Landen als Japan, de Chinese kust, Indonesië.

Speaker 2: Maar de Chinese, daar is een duidelijke reden voor. Die maken ze gewoon na in de noemen ze geen Accropode.

Speaker 1: De Chinapod?

Speaker 2: Dat zijn heel veel blokken nagemaakt daar dus kilometers lang. Alleen die, die betalen geen royalties die en die noemen het gewoon anders. Dus in China, dat is een heel ander verhaal. Mmm ja, in Japan, Japan is natuurlijk ook op heel veel plekken, een steile kust, is men wat meer gewend, daardoor ook om caissons aan te leggen. Dus helemaal geen rubble mound, constructies dus daar is de afweging meer een rubble mound of caisson, en dan heb je geen blokken meer. Ehm even kijken, Australië, daar is natuurlijk het één en ander wel gebeurd, ook met Accropode. Die zijn trouwens in Indonesië gemaakt.

Speaker 1: Oké.

Speaker 2: En verscheept. Maar ja, je zou gelijk kunnen hebben dat dat mag ik moet zeggen, ja.

Speaker 1: Te kijken of ik het nog ja, maar dat zijn wel interessante dingen om te zien, want inderdaad, ik heb de Japanse markt, ik een beetje bestudeert, maar dat, dat lijkt mij een hele gesloten markt, die hebben we in de jaren 70. Tetrapod trademark een soort overgedragen binnen Japan en die en die die leggen die dingen daar nog bij de vleet aan.

Speaker 2: Ja, zelfs die Akmon is daar nog gebruikt.

Speaker 1: Is dat zo?

Speaker 2: Ja.

Question 10-11

Speaker 1: Ja, die hebben een soort fascinatie voor kunstmatige kustlijn heb ik het idee. Goed, nou, laten we doorgaan. Nou eigenlijk wel een paar korte vraagjes en dan ga ik u een een lijst presenteren met wat andere factoren, maar daar zijn nog niet. Eigenlijk nog twee korte vragen. We hebben natuurlijk over de, over deze branche of markt gehad. Ja, wat. Wat zouden nog kunnen verbeterd worden? Wat is deze markt? Ja, wat? Waar blijven ze op achter? Is? Is bijvoorbeeld nog meer innovatie nodig. Waar moet het heen, om het zo te zeggen?

Speaker 2: Ehm, ja, en dat is wel vrij ingewikkeld. Kijk die als je kijkt waar ze aan kapot gaan en dat is nog wel heel vaak op basis van ervaring. Die rocking waar je het net over had om nou echt goede methodes waarmee je kan bepalen of rocking op gaat treden of niet. Die zijn daar eigenlijk niet. Dus het wordt heel vaak gezegd van: laten we maar aannemen dat het maar minder dan één procent van de mag rocken en dan gaat het waarschijnlijk wel goed. Maar ja, één procent van wat, één procent van hoeveel? Units dat wordt er meestal niet gedefinieerd in dat, dus, dat is niet erg duidelijk. Maar hij gaat vaak kapot door rocking en de relatie, met de rocking en wat is nou de grootte, van de blokken die ik nodig hebt, zodat ik daar geen last van heb? Die is nog niet. Ja, dat is, dat is wel heel empirisch. Dat is niet gebaseerd op testen of op kennis. Dat is één en wat we bijvoorbeeld, als ik een parallel maken. Met dijken heb je allerlei elementen, afdekken elementen en op een gegeven moment doe je dan vergelijkend warenonderzoek en dan kijk je gewoon: welke, is het sterkste en welke is minder sterk. En dan wordt diegene of en dat maakt niet altijd heel veel uit, maar de de top drie , zal ik maar zeggen, die wordt dan nog gebruikt en die andere worden allemaal niet meer gebruikt, omdat ie gewoon minder of minder sterk zijn, mmm en dat wil, dat leidt meestal toe dat degenen die afvallen die gaan hun product verbeteren, inhoudelijk verbeteren om wel weer bij de top te horen. En dat heb je hier in deze branche nog nauwelijks. Er is weinig vergelijkend onderzoek waardoor de afweging ga ik het ene unit gebruiken of het andere? Ja, niet op basis van feitelijke gegevens gebeurt, maar op allerlei dingen waar we het net over hadden. Van welke service komt, bij welke?

Speaker 1: Maar dat is op gevoel?

Speaker 2: Ja, want niemand die gaat, niemand kan zeggen van is de Xbloc wel beter dan de Cubi-Pod. Of andersom ja Cubi-Pod zal zeggen waarom die van hun beter is en de Xbloc zal zeggen waarom die van hun beter is. Maar ze hebben nooit naast elkaar gelegen, in een goot bijvoorbeeld. Hè gekeken van welke doet het nou het beste onder dezelfde omstandigheden?

Speaker 1: Daar willen fabrikanten niet aan een producten naast elkaar worden gelegd?

Speaker 2: Tot nu toe niet, nee, we hebben wel

eens geprobeerd om dat te vragen door jullie mee, maar ja, dat was was men heel huiverig voor.

Speaker 1: Nou ja, want ik vind dat wel bijzonder als je de onderzochte literatuur bekijkt binnen deze inderdaad, deze technische specificaties, dan tref je eigenlijk voornamelijk Nederlandse werk aan. Dus ook de Xbloc komt daar nog wel eens naar voren. En eigenlijk, om de Franse concurrent even te noemen. Die zijn er vele malen groter en veel meer succes gehad in het verleden, maar daar vind je eigenlijk nauwelijks publicaties van.

Speaker 2: Ja, ik vind het ook Xbloc niet echt heel erg veel, maar je hebt gelijk de Accropode als je ziet hoe lang die er al is en hoe weinig daarover naar buiten wordt gebracht. Dat is heel erg beperkt. Men altijd een leidinggevende positie in de markt en vond de innovatie ook niet echt echt nodig. Sterker nog, ze beweren dat toen de Xbloc kwam, dat ze een soortgelijke unit al op de plank hadden liggen, maar nooit naar buiten hebben gebracht om dat dat niet nodig was. En toen kwam de Xbloc en toen hadden ze opeens een blok die al eerder was gepatenteerd die wel heel erg op leek, zeg maar.

Speaker 1: De Accropode II.

Speaker 2: Ja, maar dat is wel een illustratie van. Er was geen noodzaak tot innovatie totdat de Xbloc tot ja, totdat de Xbloc kwamen. Toen moesten ze opeens wel iets verbeteren, namelijk minder beton. Er is natuurlijk. Hij was natuurlijk ook wel het belang van. Ze hadden geen belang om om te optimaliseren want als je afgerekend wordt op kubieke meters beton, waarom zou je dan een unit in maakt zetten met minder minder beton, dan krijg je ook minder royalties binnen.

Speaker 1: Ja, dat is, want die is heel begrijpelijk die keus, ja, dan hebben we nu wel eigenlijk best wel twee recente ontwikkelingen. De Cubi-Pod en XblocPlus, dat. Dat is van de laatste drie jaar aan mn hoofd, vier jaar dus. Hieruit concluderend zouden moeten leiden dat er weer meer in innovatie in de pijplijn zitten.

Speaker 2: Ja en XblocPlus is wel, vind ik, wel een beetje een ander verhaal dan andere, want die is nu regelmatig patroon. Geplaatst is als op de afsluitdijk en die. Dat geeft natuurlijk allerlei eisen aan en dat moet ook maar kunnen, want heel veel golfbrekers die hebben een kromming erin zitten, of ja, die hebben een kop. Wat ga je dan op de kop doen? En als je regelmatig wilt plaatsen, dan is ook je je plaatsings nauwkeurigheid dat gaat, het komt allemaal stuk nauwer je kan niet er tien centimeter naast zitten bij een regelmatig patroon, want dan raak je patroon kwijt. Dus dat was wel een ander verhaal. De, afgezien van de blok anders is, is het hele constructie methode, de eisen die worden gesteld, daar worden gesteld, die zijn over het algemeen hoger, een ingewikkelder.

Speaker 1: Oké.

Speaker 2: Dus niet overal zomaar toepasbaar dus je kan ook zeggen van ja, dat hoeft niet dezelfde markt te zijn als jij en een in een golf klimaat zo'n waar continu deining staat en of gewoon behoorlijk wat golven zijn, dan valt dat niet mee om zo'n de afsluitdijk achterige unit in een regelmatig patroon neer te leggen.

Speaker 1: Dus eigenlijk voornamelijk voor de kleine gewicht of de kleine inhoud. Kubieke meters, dat block

Speaker 2: Ja of ja, nou goed, de afsluitdijk is niet, is niet zo erg klein. Qua lengte is sowieso niet klein, maar qua afmetingen valt het wel mee ehm, maar dat speelt wel mee.

Speaker 2: Maar goed, dat is het punt. Dat is een regelmatig unit en al die andere zijn toch wat onregelmatig. Dus de Cubi-Pod en de traditionele Xbloc en de Core-Loc en de Accropode, die ja, die blijven bij heel veel golfbrekers dan toch mekaar beconcurreren terwijl op sommige plekken kun je dan wel met XblocPlus als een alternatief bieden. Daar kan esthetica wel een rol spelen, want er regelmatig kan men wel mooi vinden, dan onregelmatig. Regelmatig ja, en iemand die esthetica meeneemt die kan dat een voordeel vinden.

Speaker 1: Wel waar ik eigenlijk wel benieuwd hoe dat dat, dat heeft u niet heel vaak genoemd, maar de nou ja, goed, bepaalde partijen profileren zich juist als besparende keuze ten opzichte van een

andere als het gaat om het beton, gebruikt om zeg maar, dezelfde prestaties te behalen of zelfs beter. En in uw, in hoeverre is dat in uw ogen een doorslaggevend punt of belangrijk.

Speaker 2: Nou ik het, het is, het is niet onbelangrijk, maar het is zeker niet. Ik zou daar de keus niet op baseren, want ik heb ook golfbreker meegemaakt. Die werd gebouwd gewoon en die aannemer had daar zo veel moeite mee om om die units te maken en en te zorgen dat die interlocking goed was, dat ze toch overgegaan zijn op kubussen en dat is meer beton. Maar uiteindelijk heeft dat tot een besparing voor het aannemen geleid. Ja.

Speaker 1: Linksom of rechtsom.

Speaker 2: Ja, het was dus meer beton, maar het is voor het aannemer was het goedkoper. Die heeft ook een korting gegeven aan zijn klant. Als die, als die het ontwerp mocht wijzigen van Accropode naar kubus. Ja, dan dan is het wel duidelijk dat het voor hun goedkoper is om die kubus schokbreker aan te leggen.

Speaker 1: Ja.

Speaker 2: Inderdaad, dan heb je wel meer beton.

Factor Selection

Question 13-14

Speaker 1: Ja, daarom, dus in principe is het prima. Mmm nou, dan heb ik eigenlijk nog twee korte vragen, maar eigenlijk die ene die is al genoemd. Ik stop dan even delen van mn scherm, ehm, dat gaat over. U heeft de technische superioriteit nogal lekker extreem woord gekozen. Dat is natuurlijk een beetje een kapstok begrip en dat is denk ik, in deze industrie ook wel goed. Om even daar ook onderscheid te maken van wat voor technische karakters aspecten zou u nou belangrijk vinden we volgens mij al stabiliteit genoemd ehm, maar wat wat? Wat voor factoren? Zou u daar nog meer belangrijke vinden die, zeg maar, met de technische aard te maken hebben?

Speaker 2: Stabiliteit, maar ook constructability, van hoe moeilijk is om eh om om het te maken, want er zijn ook al. Kijk, dus is niet zo moeilijk om een nieuwe unit te bedenken, maar negen van de tien kun je zo neerschieten van, daar wordt nooit wat en dat zijn meestal hele vreemde vormen die die moeilijk het te gieten zijn en moeilijk aan te brengen zijn. Wat zij? Ja, stabiliteit, ja, sterkte van de unit zelf, hè, of dat ze niet breken. En dat is, denk ik, ik weet niet of je dat daar onder vindt vallen. Kijk, je hebt stabiliteit bij onder een bepaalde golf. Is die stabiel of niet? Dat is één. Gaat ie bewegen of niet, dus betekent dat maar ja, de de unit zelf.

Speaker 1: Interne structurele integriteit?

Speaker 2: Ja, breekt er geen stuk, geen poot je af of wat dan ook. Ja, dat is net zo belangrijk, want ja, als er iets afbreekt dan is het gewicht de minder en dan blijft er niet stabiel.

Speaker 1: Nee, dat duidelijk.

Speaker 2: En de laatste mmm, ja, de flexibiliteit kijk. Als je een, als je nou naar de XblocPlus kijkt, dan ben ik nog niet overtuigd van hoe je dat in de ronding moet aanbrengen. Dus ja, de flexibiliteit voor waar je wel en niet toe kan passen. Ik weet niet waar die je onder moet.

Speaker 1: Zou je dit niet aan het engelse woord 'placebility' kunnen verbinden?

Speaker 2: Ja. Want het is niet zo aantrekkelijk voor een aannemer om op de trunk van een constructie iets neer te leggen en op de roundhead het dan heel ander unit. Dan moet je met twee bedrijven gaan dealen dus dat was niet fijn.

Speaker 1: Nee, dat dat dat, dat begrijp ik inderdaad nou. Volgens mij hebben we alles besproken, in ieder geval ieder geval wat ik wilde vragen of wilde weten. Eigenlijk nog een kort vraagje niet zozeer wat deze met deze in dit met dit doen heeft. Maar goed, ik neem aan dat u in contact blijven als het gaat om de resultaten hiervan.

End Recording

D

Transcript Expert 3

Question 2 and 3

00:00:22 Spreker 1

Als eerst een korte vraag. Kunt u uw activiteiten beschrijven? Wat doet u bij wat voor bedrijf werkt u en wat is uw functie daar?

00:00:34 Spreker 2

Ik heb vroeger 6 jaar bij de voorloper van Deltares gewerkt, dus ik heb onderzoek gedaan, met name naar havendammen/golfbrekers, dus ook naar betonnen blokken.

00:00:51 Spreker 2

Ik heb 10 jaar bij een ingenieursbureau gewerkt, Maar het was altijd half advisering. Half onderzoeken dus veel toch wel in onderzoeksprojecten en 14 jaar geleden ben ik voor mezelf begonnen als een eenmans bv.

00:01:04 Spreker 2

Een onderzoek op gebied van stormen en dijken en ook van havendammen. Ik ben 7 jaar geleden voor één dag in de week hoogleraar geworden in Delft bij IHE.

00:01:28 Spreker 2

Als we naar de betonnen elementen gaan en met name de een laags systemen. Dan is Accropode was de eerste begin jaren 80 en Ik had toen net mijn proefschrift zo'n beetje afgerond en dat ging over stabiliteit van breuksteen bij golfafval, waar ook mijn formule is uit voortgekomen.

00:01:49 Spreker 2

En toen dacht ik van ja, Ik heb het nu voor breuksteen gedaan. Daarna heb ik gekeken naar kubussen, Tetrapods en daarna kwamen de Accropods op de markt en Ik heb dat rapport zijn. EN toen heb ik de Fransen gevraagd van, zal ik dat voor jullie ook systematisch onderzoeken in dezelfde geest als kubussen en Tetrapod? En dat vonden ze goed en daardoor kregen ze een onafhankelijk, ja onafhankelijke proefresultaten en daar waar het wel blij mee, dus Ik heb in 1985.

00:02:20 Spreker 2

Of was het 87, in ieder geval ik heb halverwege de jaren 80 de Accropods onderzocht

00:02:28 Spreker 2

Dus systematisch, dus niet voor een project.

00:02:29 Spreker 1

Dus echt structureel. Uw werk is uiteindelijk ook in de Rock Manual terechtgekomen.

00:02:37 Spreker 2

Ja, Je kunt altijd kiezen of je de Hudson formule gebruikt waar de helling van het talud nog in zit of dat je stabiliteit getal gebruikt.

00:02:48 Spreker 2

Ik ben met die hele steile dingen die op interlocking liggen, ben ik er wel voor om een stabiliteits getal te gebruiken en niet een invloed van de helling nog. Ik denk dat als je steiler komt te staan zijn ze misschien wel stabieler

00:03:01 Spreker 2

Omdat ze een beetje zakken en daardoor meer contact met elkaar hebben en gewoon stabieler worden.

00:03:09 Spreker 2

Er is wat anders aan de hand met breuksteen en daar is het heel logisch dat die liggen op gewicht dat als je talud flauwer maakt dat de stabiliteit toeneemt.

00:03:16 Spreker 1

Ja, dat dat klinkt vrij logisch inderdaad.

00:03:20 Spreker 2

Dat klinkt logisch, maar bij die deze elementen die in elkaar haken die echt op interlocking liggen en niet op gewicht. Kan het wel eens net andersom zijn.

00:03:28 Spreker 1

Dat is leuk om te horen dat het zo In de praktijk dan toch nog kan variëren.

Question 4

00:03:35 Spreker 1

We zijn al eigenlijk een beetje bij de volgende vraag: van wat zijn uw ja huidige activiteiten als het gaat om die betonnen blokken?

00:03:44 Spreker 2

Ik adviseer in ontwerp van nieuwe golfbrekers. Ik ontwerp er zelf ook wel eens eentje en afgelopen 3 maanden heb ik er twee ontworpen zelfs.

00:03:56 Spreker 2

Ook meteen ben ik nog bezig en die andere, die wordt nu bij DMC beproefd. Beiden worden betonnen blokken, dus jouw keus van. Hoe kom ik nou wel betonnen blok is, die is hier ook gespeeld.

00:04:11 Spreker 2

Voor de rest ben ik wel vaak betrokken bij dat andere mensen het wel ontwerpen en dat ik betrokken ben bij het model onderzoek, dat doe ik ook veel, dus dat dat daar mijn review wordt gevraagd.

00:04:25 Spreker 2

Nou, vaak gaat er een golfbreker ook wel stuk en het kan zijn omdat die verkeerd gebouwd is of gewoon de golven te hoog waren.

00:04:34 Spreker 2

Dus dan ga je onderzoek van wat is hier aan de hand. En dan met name naar jouw onderwerp toe, van hoe kom je tot de keuze van blokken? Dan moet je op het ontwerp aspect gaan zitten en niet wat er later eens een keer kan gebeuren.

00:04:49 Spreker 2

Een blok kan altijd heel veel schade laat zien en andere niet. Dan zal daar een voorkeur voor ontstaan. Maar dat is niet zo.

00:05:00 Spreker 1

Oké, dus dat is niet zo.

00:05:09 Spreker 2

De achtergrond van deze blokken over ze zijn ontwikkeld. We hadden eerst de Tetrapod, zijn de kubussen en de Dolossen, hè? Ik weet het ook niet allemaal kent dat zijn allemaal twee lagen systeem.

00:05:13 Spreker 1

Nou, Ik heb ik ken ze allemaal.

00:05:16 Spreker 2

Nou, dat zijn twee lagen systemen en met name de Tetrapods zijn met name Dolossen, hè? Die hadden meer haakweerstand en daarom verschrikkelijk stabiel.

00:05:28 Spreker 2

En in de jaren 60 hebben en begin jaren 70. Toen hadden kleine havens dus ook golfbrekers in relatief ondiep water.

00:05:36 Spreker 2

Maar dat was ook de tijd dat de mammoettankers kwamen en die hadden veel grotere diepgang dus moesten er ook havens komen die veel grotere diepgang hadden. En golfbrekers moesten daarom ook op 30, 40 m waterdiepte gelegd worden.

00:05:50 Spreker 2

Met grotere golven en soms echt heel veel grotere golven, soms wel meer dan 10 m. En we schaalden de elementen gewoon op, dat was normaal. Normaliter was dat 10 15 t en dat ging in 1 keer 50 60 tons elementen.

00:06:03 Spreker 2

Ja een betonelement is een kunstmatige steen. Het is niet een balk of kolommen die vol met wapening zit.

00:06:14 Spreker 1

En, hij was heel smal In het midden die Dolos.

00:06:18 Spreker 2

Ja in vergelijking tot andere elementen, niet in vergelijking met een balk of kolom

00:06:23 Spreker 2

Dat zijn grote dingen zijn en als je die zou moeten wapenen dan moet er heel veel wapening in.

00:06:30 Spreker 2

En de tweede als ze breken, dan breken ze door klappen en daar is gewoon wapening niet zo goed tegen bestand. Dan krijg je toch scheuren in beton, dan zou je voorspanning in moeten stoppen. En dan praat je over elementen die vier keer zo duur worden dan beton elementen.

00:06:43 Spreker 1

Ja, je hebt, denk ik, een hoge dekkingsgraad nodig omdat je Natuurlijk in zout water condities zit.

00:06:47 Spreker 2

Ja, dat speelt allemaal, beton is eigenlijk een kunstmatige steen. Ja, en stenen kun je ook niet van 50 t krijgen.

00:06:54 Spreker 2

Ja, ze zijn er wel, maar meestal niet van 50 ton want de breken ze, zelfde is met de betonnen elementen, de treksterkte, die wordt niet hoger.

00:07:01 Spreker 1

Nee nee.

00:07:02 Spreker 2

Dat is ook wat er in de eind jaren 70 en begin jaren 80 is gebeurd met 3 hele grote golfbrekers.

00:07:08 Spreker 2

Die zijn tijdens de bouw volledig weggevaagd, daar vonden we dat het breken van de elementen wat je in een model onderzoekt natuurlijk niet ziet, de oorzaak.

00:07:15 Spreker 1

Nee die schaalbaarheid natuurlijk.

00:07:24 Spreker 2

Toen heeft men men bedacht van, wat moeten we nou doen? En eentje daarvan was de ontwikkeling van

Accropode, Die in het midden sterk is en de haakweerstand uit. Ja, uit kleine dingen, kleine uitsteeksels haalt die aan het eind zitten, dus mocht er iets aan een Accropode breken, dan verlies je 10% van zijn gewicht. Breekt er een stuk af behoudt hij toch zijn interlocking. Extra voordeel was het werd op een in een laag gelegd, dus je bespaarde wel 40% beton. Dat waren dingen die die een 1 laag systemen wel favoriet maakte.

Question 6-7

00:08:05 Spreker 1

Ja, want Dat is één van mijn volgende vragen. Accropod en Tetrapod zijn vroeger heel succesvol geweest. Als je kijkt naar hoeveel projecten en welke aantallen die zijn aangelegd. Wat zou daar in uw optiek de reden voor kunnen zijn? Dat die producten zo succesvol waren?

00:08:27 Spreker 2

Nou, je moet onderscheid maken tussen de een laag systeem In de twee laag systeem

00:08:32 Spreker 2

Twee laag systemen worden nog wel toegepast. De twee laag systemen daar was de ontwikkeling van de vorm, was om hier haakweerstand te krijgen en Ik denk, de ultieme vorm daarvan is de Dolos met een dubbel anker en die haken echt goed in elkaar.

00:08:48 Spreker 2

Het grote nadeel was dat ze kunnen breken als ze groot worden. De Accropode die hief dat op, die was gewoon sterk In het midden en had haakweerstand.

00:08:59 Spreker 2

Interlocking was er heel veel, maar als ze braken. Dan was het maar een klein stukje en de interlocking bleef bestaan. Dus daarna werd de Accropode een heel succesvol element.

00:09:10 Spreker 1

Ja, en dat komt ook een beetje door de tijd van de introductie, toch? Want dat incident met dolos was, Dat is een Sines gebeurt een 78 uit mijn hoofd.

00:09:20 Spreker 2

Ja 78 volgens mij.

00:09:23 Spreker 1

En 1980 was natuurlijk de introductie van Accropode.

00:09:28 Spreker 2

Ja de Accropode is ontwikkeld vanwege deze grote schades ja, Azeu en Tripoli, dat waren ook twee, in de noordkust van Afrika. Dat waren ook twee hele grote golfbrekers van 50-60 ton Tetrapods. En daar heb je eigenlijk hetzelfde mee, die breken ook op eigen gewicht.

00:09:48 Spreker 1

Maar als je een dubbellaags systeem heb liggen, dan heb je ook meer units liggen.

00:09:58 Spreker 2

Ja dat is zo, maar je kan zo makkelijker leggen, want ze moeten random gelegd worden wel in een grit in een patroon die twee lagen hebt. Dan op de eerste laag leg je de tweede laag heb je een heel mooi systeem, maar op zich werkte dat wel goed.

00:10:09 Spreker 2

Het grote nadeel was dat ze kunnen breken en dat werd door de Accropode opgeheven en daarnaast waren er twee voordelen. Tenminste, ik zag twee voordelen, Dat was.

00:10:21 Spreker 2

Ze waren sterk en als ze breken, dan is het maar een klein stukje weg en behoudt zijn interlocking gaan houden. Dus dat ze bezwijken niet in één keer en het andere was.

00:10:32 Spreker 2

Ze waren heel erg stabiel en betekent dat je dat een hele hoge golfhoogte kon testen voordat er iets gebeurde.

00:10:39 Spreker 2

Maar als er iets gebeurde, ja, dan had je zo'n grote golfhoogte, dan werd die golfbreker weggevaagd dus eigenlijk het begin van schade en vernieling.

00:10:48 Spreker 2

Dus falen staat heel dicht bij elkaar. Op zich is dat gevaarlijk, want het is een 'brittle failure', dus je wilt graag hebben dat je wat waarschuwing hebt voordat het gaat falen.

00:11:02 Spreker 2

Wat je ook ziet bij de anderen, betonnen elementen bij lagere golfhoogte beetje schade, en bij hogere golfhoogte heb je meer.

00:11:10 Spreker 2

En, maar goed, Je kunt dat omdat het bij zo'n hele hoge golfhoogte was, maar waarbij de Tetrapods zen al die dingen allang bezweken waren, kun je zeggen, ik voer een veiligheidsfactor in. Ja, We hebben een veiligheidsfactor ingevoerd, ongeveer van 1,5 op de diameter, dus Het is wel een factor 3 op gewicht en ik zei van nou, Als je hem daar ook ontwerpt, dan ontwerp je ook geen schade.

00:11:33 Spreker 2

Maar mocht je 1 keer een overload krijgen, of je hebt je ontwerp golfhoogte gewoon te verkeerd ingeschat als dat 10 of 20% meer is dan verwacht je nog steeds geen schade. Er is geen ander golfbrekerelement die dat heeft.

00:11:48 Spreker 2

De schade neemt echt exponentieel toe Als je Tetrapods of kubussen of Dolossen hebt. Het voordeel dat ze hier ontwerpt echt ook geen schade, ook Als je de golfhoogte niet helemaal precies weet. Nog steeds ontwerp je geen schade.

00:12:02 Spreker 2

Dus ze gebruikten minder beton dan een twee laags systeem en ze waren heel stabiel en je verwacht geen schade.

00:12:08 Spreker 2

Nou, dat waren de elementen die voor een laagssysteem heel mooi waren.

00:12:12 Spreker 2

Ja daar is de Accropode heel succesvol in geweest.

00:12:15 Spreker 1

Ja, zij waren denk ik ook de eerste in een eenlaagssysteem. Of heb ik dat mis?

00:12:19 Spreker 2

Ja, zij waren de eerste.

00:12:22 Spreker 1

En was Tetrapod eigenlijk ook de eerste interlocking golfbreker element of spant dat er misschien om?

00:12:31 Spreker 2

Dat weet ik niet, die is van 58 geloof ik.

00:12:36 Spreker 2

Dolos in 62 ofzo. Die is net even na. Er zijn heel veel elementen ontwikkelen wanneer ze precies ontwikkeld zijn, dat weet ik niet precies.

00:12:43 Spreker 1

Ja, Er zijn echt hele hoop ook hè? Alle bijzondere vormen maar natuurlijk was er maar weinig echt succesvol geweest.

00:12:50 Spreker 1

In het geval dat je ze veel ziet.

00:12:52 Spreker 2

Ze waren wel succesvol als de golfhoogte, maar beperkt daardoor het gewicht beperkt bleef.

00:12:59 Spreker 2

Heel veel golfbrekers, die wel voldoen met Dolos of Tetrapods en vanuit de Nederlandse waterbouw is de kubus favoriet omdat die sterk was.

00:13:12 Spreker 2

Dus die brak veel minder snel dan die andere elementen.

00:13:16 Spreker 1

Ja kubus is denk ik makkelijk te plaatsen ook.

00:13:18 Spreker 2

Ja, nou, dat zeg je nou?

00:13:22 Spreker 2

Het is niet altijd zo.

00:13:24 Spreker 2

Een kubus wil je random plaatsen zodat je twee lagen hebt en dat de blokken tussen elkaar in liggen. Maar als je niet oppast een kubus heeft een groot vlak en dan vlak wil altijd een ander vlak glijden.

00:13:37 Spreker 1

Oké ja.

00:13:38 Spreker 2

Hoewel je ze probeert random te leggen, zie je toch dat ze gaan glijden en tegen elkaar gaan liggen, dus je moet een heel goed grit hebben, zodanig dat ze echt random komen te liggen.

00:13:49 Spreker 2

Dus Het is niet heel eenvoudig om kubussen goed te plaatsen. Moet je heel goed over nadenken.

00:13:56 Spreker 1

Oké, Dat is wel weer leuk om dat te horen. Hoe dat dan kan. Ik kijk ook weleens op Google maps naar golfbrekers en dan zie je dat kubussen ook vaak in een soort tegelpatroon liggen. Dus niet echt random Dus dat zie je soms nog wel eens dat het niet goed ligt.

00:14:13 Spreker 2

Je kunt er ook ongeveer zo plaatsen, want Antifer kubus, die lijkt er natuurlijk ook op. Die is bijna nog meer favoriet dan kubus. Hij is een beetje taps en heeft groeven.

00:14:24 Spreker 2

En daar kun je nog kiezen van ik zet de basis naar beneden of ga ik ze echt random neerleggen. Ik weet of je weleens naar Zeebrugge hebt gekeken?

00:14:34 Spreker 1

Nou, dat zou wel kunnen, maar ik weet het niet zeker.

00:14:39 Spreker 2

Nou die hebben onderkend dat de kubussen nog wel willen zakken en naar elkaar toe willen glijden.

00:14:47 Spreker 2

En die hebben gezegd van nou, weet je wat? We maken een steil talud en we leggen ze met de basis verticaal naar boven tegen elkaar.

00:14:56 Spreker 2

Dus er zat helemaal geen ruimte tussen en is ook niet random. En wat ze dan In de lengte gedaan hebben is de porositeit maken, dus daar zat de 30% porositeit. Dan is de basis gewoon op elkaar gelegd.

00:15:04 Spreker 1

Oh ja, ik zie inderdaad.

00:15:09 Spreker 2

En de porositeit in de lengte en daardoor krijg je een soort regelmatig patroon, terwijl er wel porositeit is.

00:15:14 Spreker 1

O ja, want Dat is Natuurlijk ook belangrijk aan die constructie met poreus te Laten zijn.

00:15:20 Spreker 2

Ja, Je moet porositeit hebben, maar eigenlijk wil je niet hebben dat die dingen zakken en dat hebben we op deze manier voorkomen. Dit is een semi random plaatsing en dat heeft heel goed gewerkt.

00:15:32 Spreker 1

Oke, dus dat is wel weer iets nieuws.

Question 8

00:15:35 Spreker 1

Goed, nu heb ik eigenlijk nog een vraag. U zei net over Accropode dat was erg goed in interlocking, en daardoor ook stabiel. In een eenlaags configuratie.

00:15:46 Spreker 1

Maar er zijn bijvoorbeeld ook dat u in uw ervaring heb gezien dat bijvoorbeeld niet technische dingen bijdroegen aan een aan een succesvol product? In de zin van hoe een bedrijf zijn onderzoek inricht of hoe een bedrijf gewoon simpelweg de marketing doet. Kunt u daar iets over zeggen?

00:16:03 Spreker 2

Ja, Ik denk dat we eerst een stapje verder moeten, want de Accropode is een echte nieuwe uitvinding. En die heeft een aantal jaren alleen bestaan met een patent en toen kwam er Xbloc, de Cubi-Pod, de Accropode 2 en de XblocPlus

00:16:24 Spreker 2

Dus Ik denk dat dat nog voornaamste zijn, waarbij de XblocPlus die op de Afsluitdijk gaat liggen, toch wel de nieuwste variant weer is.

00:16:32 Spreker 2

En die wordt regelmatig geplaatst. Cubi-Pod is eentje, die is een uniform blok. Hij is uniform van vorm, die anderen zijn dat niet.

00:16:44 Spreker 2

Nou, daar zitten weer wat verschillen in, dus we hebben nu meer keuze in blokken. Dus als je zegt. Ik ga nu een golfbreker ontwerpen en welk blok zal ik erop leggen.

00:16:52 Spreker 2

Dan heb je een grotere keus. Maar de eerste keus die je moet maken is of je gaat voor een laag systeem of twee lagen systeem. Waar je principe is dat heel vaak een laags systeem Omdat het heel veel beton bespaart.

00:17:03 Spreker 2

En je maakt een golfbreker die eigenlijk geen schade mag hebben.

00:17:08 Spreker 2

Er zijn wel redenen waarom het niet kan. Bijvoorbeeld in Chili hebben we een golfbreker ontworpen. Waar je een dagelijkse golfhoogte hebt staan van 2 m.

00:17:17 Spreker 2

Elke dag altijd wel 2 m en Je moet voor 8 m ontwerpen dus je hebt blokken van 30- 40 t.

00:17:26 Spreker 2

En op 20 tot 25 meter waterdiepte. Als je overal altijd elke dag 2 m golfhoogte hebt staan.

00:17:33 Spreker 2

Dan kun jij een blok in een laag niet plaatsen.

00:17:37 Spreker 2

Met een excavator is niet groot genoeg. Je doet het met een draadkraan en met die 2 m golfhoogte krijg je ze nooit op zijn plek.

00:17:44 Spreker 2

Wil je daar gaan bouwen, is het technisch gezien onmogelijk om met een draadkraan daar een een laags systeem te bouwen, dus we moeten naar een twee laags systeem. Maar dat zijn uitzonderingen

00:17:55 Spreker 2

Ik zou zeggen van in principe ga je wel voor een een laags systeem en dan kom je voor de vraag van ja.

00:18:00 Spreker 2

Wat neem ik nou? De oude Accropode, of Accropode twee of de Xbloc die vergelijkbaar is.

00:18:07 Spreker 2

Of doe je de Cubi-Pod of XblocPlus, dat zijn dan de vragen.

00:18:12 Spreker 1

Ja ja.

00:18:13 Spreker 2

En, daar speelt het bedrijf een rol in.

00:18:20 Spreker 2

Sogreah, heeft de Accropode ontwikkeld en daar is later apart bedrijf uit voortgekomen die het patent heeft en de begeleiding uitvoert en alleen zich met de blokken bemoeit.

00:18:32 Spreker 2

Dus dat is niet meer het ingenieursbureau, maar die houdt zich alleen maar bezig met de blokken. Dat bedrijf heeft CLI.

00:18:38 Spreker 2

Ik ken dat bedrijf en dat hangt natuurlijk ook van de mensen af. Dat bedrijf is vrij agressief.

00:18:46 Spreker 2

Ze zijn heel succesvol geweest met de eerste Accropodes, maar later, toen de concurrenten waren, zijn ze redelijk agressief geworden.

00:18:54 Spreker 2

Ik hou daar zelf niet zo van, zeker niet Als je een monopolie hebt en nog steeds hebben ze misschien wel 70% van de mark in handen dan mag je ook wel eens hun concurrenten toelaten en daar zijn ze helemaal niet van gediend. Dat is een houding die mij een beetje tegenstaat en misschien andere ook hoor.

00:19:14 Spreker 1

Is het niet het Franse chauvinisme wat daar een beetje door komt?

00:19:17 Spreker 2

Ja ja komt wel een beetje door. Ja ja, dan heb je DMC die de Xbox en de XblocPlus heeft ontwikkeld die die zijn er altijd vrij open in geweest.

00:19:27 Spreker 2

Die hebben geprobeerd blok te maken wat zeker zo goed is en wat misschien op een aantal punten voordelen heeft, zoals iets minder beton per vierkante meter en zo.

00:19:41 Spreker 2

Dus Ik denk dat DMC het goed doet qua begeleiding, alles weet wat het blok kan doen. Ook heel veel onderzoek. Alles wat maar mogelijk is onderzoeken ze. Die is wel is wel positief, denk ik en heeft ook een redelijke markt ontwikkeld met hun Xbloc.

00:19:58 Spreker 2

En dan heb je de Cubi-Pod, die is bij een universiteit ontwikkeld.

00:20:03 Spreker 1

Ja in Spanje toch?

00:20:04 Spreker 2

Ja, in Spanje de Universiteit van Valencia.

00:20:11 Spreker 2

En dan zie je toch wel dat een universiteit is die het doet en niet een bedrijf die het veel meer dingen denkt. Er zit wel een bedrijf bij 1 grote aannemer. Dus dat is in universiteit met een aannemer en wat er eigenlijk daar anders is, is de praktische inbreng van een ingenieursbureau die daar echt goed kijk op heeft . Zoals een DMC en CLI en dus ook de de formules die ze gebruiken om te ontwerpen die die wijken af van bijvoorbeeld van de Accropod en de Xbloc.

00:20:42 Spreker 2

Ze hebben hun eigen weg, een Spaanse weg, een beetje gekozen, dus Het is een beetje Spaans blok met meer universiteit gehalte.

00:20:50 Spreker 2

En daardoor zitten er ook hier en daar wel wat foutjes. Het blok zelf is wel een leuk blok omdat het uniform is, dus je plaatst het veel makkelijker dan die andere dingen (Accropode en de Xbloc)

00:21:02 Spreker 2

Daar moet je echt goed naar kijken, zeker de Accropode. Daar zijn hele grote restricties aan wat betreft de plaatsing.

00:21:10 Spreker 2

Moet vaak een duiker bij dan, dat kan niet altijd.

00:21:14 Spreker 2

XblocPlus, die komt ook bij DMC vandaan. Die proberen ze te promoten, hebben een beetje ervaring met een golfbreker in Polen en natuurlijk de Afsluitdijk, maar daar kan boven water gebouwd worden dus is altijd makkelijker.

00:21:26 Spreker 1

Ja dat is wel snel plaatsen bovenwater.

00:21:30 Spreker 2

Je ziet wat je doet. Ze zeggen dat het ook kan met een steil talud en onder water gaat ook vrij gemakkelijk, want er is maar een manier om het te plaatsen. Je moet tussen het andere blok zetten.

00:21:41 Spreker 1

Ja, een soort Lego steentjes.

00:21:43 Spreker 2

Ja, dus ja, als die ernaast er tussen zit dan zit die goed.

00:21:46 Spreker 1

Ja ja.

00:21:54 Spreker 1

Dus ja, Dat is wel In het is ook iets nieuws, want u beschreef net inderdaad wat agressieve marketing of te agressieve manier van bedrijfsvoering van de Fransen, maar zij hebben eigenlijk als je naar de afgelopen 20 jaar kijkt eigenlijk niks nieuws ontwikkeld. Alleen die Accroberm.

00:22:13 Spreker 2

Ja afgelopen 20 jaar niet veel.

00:22:17 Spreker 2

Accropode II ontwikkeld? Die werd tegelijk ontwikkeld met de Xbloc. Ze lijken een beetje op elkaar. Ik geloof dat ze onafhankelijk van elkaar zijn ontwikkeld. Maar de

Fransen zeggen dat de Accropode II eerder was ontwikkeld. Alleen die hebben ze even in de la Laten liggen, Omdat ze toen ook het patent van de Core-Loc kregen voor Europa. Ze hadden al twee blokken. Dus ze wilden niet nog een derde naast leggen.

00:22:41 Spreker 2

En in diezelfde tijd werd de Xbloc ontwikkeld. Toen dachten ze verrek dat lijkt wel heel veel op.

00:22:46 Spreker 1

Ja, Als je de historie er een beetje onder achter onderzoekt, er zit inderdaad maar een jaar tussen wanneer ze allebei het eerste project hadden en dat het allemaal publiek werd dat ze dat product hadden dat is wel ironisch om te zien.

00:22:54 Spreker 2

Ja dat is het verhaal wat ik van de Fransen heb. Na de Accropode II hebben ze niet veel meer ontwikkeld. Ze hebben nu wel een teen blok ontwikkeld.

00:23:03 Spreker 1

Ja Accroberm.

00:23:05 Spreker 2

Ja die.

00:23:08 Spreker 2

Maar wat ze zakelijk wel hebben gedaan is, behalve dat ze het patent habben, waarvan trouwens volgens mij vooral allebei de Accropodes het patent alweer verlopen is.

00:23:19 Spreker 2

Nu zeggen ze van. Nou, We kunnen je de mallen toeleveren. We kunnen je laten zien hoe je dingen moet bouwen, maar ze hebben een tweede tak en dan gaan ze naar de opdrachtgever toe en zeggen; jij bouwt een golfbreker met Accropodes.

00:23:35 Spreker 2

Wil je ook de zekerheid hebben dat hij goed gebouwd wordt, dus wil je een certificaat hebben naar afloop en dan gaan wij gewoon controleren wat die wat die aannemer heeft gedaan en dat het goed is, dan krijg je een certificaat. Dat is niet goed is dan moet de aannemer aan de slag.

00:23:49 Spreker 2

En daar zijn ze vaak van twee kanten bij een project betrokken. Ze gaan aannemen vertellen wat hij moet doen. En later gaan ze voor de opdrachtgever controleren of die aannemer het wel goed gedaan heeft.

00:24:00 Spreker 1

Ja, Dat is een goede manier om aan het werk te blijven, lijkt mij.

00:24:04 Spreker 2

Ja, Dat is niet altijd even ethisch.

00:24:07 Spreker 1

Nee, want Dat is wel een beetje. De slager keurt zijn eigen vlees

00:24:14 Spreker 2

Ja. Hier kunnen we hebben dat aannemers de houding hebben van oké, zij weten, dus wij doen precies wat jij zegt. Dan maken we een goede golfbreker en wordt ook vaak wel goede golfbreker.

00:24:24 Spreker 2

Maar Er zijn ook wel eens aannemen zeggen, ja, allemaal leuk en aardig. Maar we plaatsen die blokken beetje op onze eigen manier en dan is het ook wel een beetje afwijkt van wat CLI wil, dan worden ze afgekeurd en dan krijg je grote problemen tussen de aannemer en opdrachtgever en tussen de aannemer en CLI.

00:24:41 Spreker 2

Dus aan de ene kant is het misschien voor de opdrachtgever goed om zo'n certificaat te hebben.

00:24:48 Spreker 2

Want in mijn ogen zou dan niet CLI moeten zijn.

00:24:52 Spreker 1

Ja, nou, Dat is ook een beetje waar die meneer (…) op inspeelt

00:25:04 Spreker 1

Ja (…), ja.

00:25:07 Spreker 2

Ja hij komt wel uit die hoek, maar die is nu volledig zelfstandig, maar die duikt daar wel een beetje op.

00:25:16 Spreker 2

Ja, Hij heeft wel verstand van hoe die dingen verplaatst moeten worden. Het is geen civil engineer, Het is een duiker die zoveel van die dingen gezien heeft dat hij wel ziet onder water ziet of die dingen goed geplaatst zijn. Daar is die expert in.

00:25:29 Spreker 1

Ja, Dat is waar.

00:25:30 Spreker 1

Interessante niche om weer in te duiken.

00:25:32 Spreker 2

Ook zeker zeker. Ja, Hij is wat dat betreft werk genoeg.

00:25:37 Spreker 1

Nou, wat een mooi verhaal.

00:25:39 Spreker 2

Ja.

00:25:40 Spreker 1

We gaan even door.

Question 9

00:25:44 Spreker 1

Nou ja, goed, we hadden het er net al een beetje over, maar zijn er ook dingen wat een negatieve invloed kan hebben als het gaat om je jouw succesvolheid van zo'n blok? Is dat bijvoorbeeld je reputatie? De industrie en literatuur grijpt vaak dat incident bij Portugal aan als een soort van kantelpunt in ontwerpfilosofie bijvoorbeeld.

00:26:14 Spreker 2

Ja, Dat is ook zo. We hebben gekeken naar de sterkte van dit soort elementen. Dat is daar absoluut uit voortgekomen, Omdat is er heel veel onderzoek geweest om te kijken hoe we die dingen zoals Tetrapod en Dolossen sterker konden maken, maar duidelijk is, dat de oplossing veel meer in de richting gaat naar die een laags systemen die van zichzelf veel sterker zijn.

00:26:38 Spreker 2

Dus ja Tetrapod en Dolos weten van, maak ze niet te groot, dan heb je problemen.

00:26:43 Spreker 2

Want dat geldt voor die een laags systeem, dan kan je ze wel redelijk groot maken maar aan de kant. Je hoeft niet zo groot te maken, want ze zijn stabieler, dus dat is ook een voordeel. Tetrapod ontwerp voor een golfhoogte van 8 m of een Accropode die is al zal kleiner. Dus die zal ook minder snel breken.

00:27:01 Spreker 2

Dat zijn allemaal voordelen voor het een lagen systeem, maar goed ook daar wil je hebben dat ze niet bezwijken.

00:27:09 Spreker 2

En elk project waarbij dat wel gebeurd is vinden ze dat vervelend en dat is ook zo.

00:27:16 Spreker 2

En soms zijn er verschillende oorzaken. Er was een project. Ik denk dat CLI daar niet eens bij geweest is.

00:27:23 Spreker 2

Dat was een heel klein dammetje die een aannemer daar zo gemaakt heeft en de golfhoogte onderschatte met een factor twee.

00:27:28 Spreker 1

Oei.

00:27:30 Spreker 2

Ja, die ging ook kapot.

00:27:32 Spreker 1

Ja daar gaat geen veiligheidsfactor meer tegenop.

00:27:35 Spreker 2

Nee precies, Aan de ene kant zie je dat de Accropode daar volledig is bezweken en uiteindelijk als je er goed naar kijkt, zie je. Ja, Dat was ook wel logisch, maar dat ligt niet aan Accropode.

00:27:45 Spreker 2

Ja, Ik heb een ander geval waarbij een Accropode golfbreker werd gebouwd en Dat was In de Caribische Zee en die werd dus gebouwd met prachtig mooi weer Zonder een enkele golf en dan de eerste de beste orkaan een beetje In de buurt en Het was echt niet ontwerp golf en een keer zakte die dingen in elkaar en zag je een behoorlijk groot gat rondom de kruin. Hij bezweek niet maar zakte allemaal naar beneden.

00:28:12 Spreker 1

Ja als ze natuurlijk tegen helling liggen, ja niet gek.

00:28:15 Spreker 2

Ja, ze liggen op een helling. Aan de ene kant kun je het een beetje verwachten, maar dit was wel extreem veel. Zoveel dat ze ook zeggen, je hebt ze niet goed geplaatst, dus hebben we al de blokken eraf gehaald en ze hebben hem keurig op met CLI erbij opnieuw geplaatst. En is veel beter geplaatst. En de eerste de beste orkaan die weer langskwam.

00:28:34 Spreker 2

Die liet weer zien dat er bij kleine elementen een beetje een gat ontstond dat ze toch weer naar beneden gegaan waren.

00:28:41 Spreker 2

Nou, dat aan de ene kant zou je dat niet verwachten. Maar een Amerikaans bureau wilde daar een rechtszaak aanspannen, dus die advocaat die is daar geweest. Ik ben op die golfbreker geweest.

00:28:52 Spreker 2

Maar kijk, Ik heb gezegd, van deze elementen die ontlenen hun haakweerstand ook een beetje zakken tijdens de bouw, dus de Als je eens 1 keer een stormpje hebt van een paar meter, dus niet ontwerp storm bij lange na niet, maar gewoon een klein stormpje zakken ze toch wat in elkaar en dat plaatst de laatste elementen naar de kruin toe en dan is er een stuk zakking geweest. De sterkte is er en de zakking eigenlijk ook maar Caribische Zee waarbij nooit een golf staat.

00:29:20 Spreker 2

En dus zonder een enkele golf een talud bouwt. Dan kun je verwachten dat als wat golven komen dat het een klein beetje zakt. Ook al heb je hem perfect gebouwd dan nog blijf je een beetje zakken en dat manifesteert zich bij de kruin en het is niet meer dan ½ diameter, maar die gap. Die krijg je wel, dus die kun je ook verwachten dat hoort bij het proces. Dat is niet de fout dat hoort gewoon bij het proces, dus Ik heb gezegd, hier heeft de aannemer geen fout gemaakt. Pak gewoon 2-3 elementen er weer uit, zet ze dicht tegen elkaar. Voeg nog een paar elementen toe en je bent klaar voor altijd, dus Dat is niet een rechtszaak geworden.

00:30:00 Spreker 1

Dus dan zie je dat de merknaam of je je reputatie denk ik heel belangrijk is en zeker in een ietwat conservatieve markt, want als men wel eens voor iets gekozen heeft, dan voelt men zich daar vertrouwd mee.

00:30:10 Spreker 2

Ja nou ja, Dat heb ik ook wel mee gemaakt. Die Franse slag is niet altijd even sjofel in hoe ze de dingen doen. Heeft voor mij de voorkeur wel gegeven voor de Xbloc.

00:30:28 Spreker 2

In sommige situaties qua vorm ook wel aan de Cubi-pod. Vond het ook wel aardig. Die kan je ook in twee lagen leggen trouwens. Dat heb ik bij het ene project ook gedaan waren naar een twee lagen systeem moesten. Dus we hebben kubussen bekeken, maar ook de Cubi-pod en die komt toch lichter uit dan een kubus en stabieler.

00:30:49 Spreker 2

Ja, dat ligt onder andere aan de vorm, Maar ik denk dat Accropode II en de Xbloc nu een beetje ja als twee gelijkwaardige concurrenten naast elkaar zitten, waarbij de Xbloc zien iets minder beton verbruik met vierkante meter maar aan de andere kant denk ik een iets kleinere veiligheidsfactor heeft.

00:31:09 Spreker 2

Dus alles met elkaar. Die twee vind ik vergelijkbaar en dan is de keuze van nou ja, wat je zegt als ik het in mijn land een golfbreker hebt met dat element en het voldoet goed, dan is mijn keuze automatisch al gemaakt bij een volgend project om weer hetzelfde type te gebruiken.

00:31:23 Spreker 2

Ik heb in Maleisië meegemaakt dat Ik daar eigenlijk liever de Xbloc wilde hebben dan een Accropode, Maar de opdrachtgever had de keuze gemaakt voor Accropodes want er was een andere golfbreker daar al met Accropodes.

00:31:38 Spreker 2

Is een hele duidelijke keuze die ervaring, dan heb ik als opdrachtgever al ervaring met een element. En, die is goed, dan is de keus voor de volgende meestal ook bepaald. Dat is zeker

00:31:50 Spreker 1

Oké nou dan goed om te horen. Ik heb nog een paar kleine vraagjes en dan vat ik het even samen, dan laat ik nog eventjes iets zien. Maar goed, dat komt zo.

Question 10-11

00:31:59 Spreker 1

Wat maakt deze industrie lacking? Zijn er dingen in deze markt waar u van zegt van nou meer innovatie op een bepaald gebied is nodig of een meer standaardisatie van ontwerpformules? Waar liggen de verbeterpunten in deze markt in uw ogen?

00:32:22 Spreker 1

Of ook niet dat kan ook.

00:32:24 Spreker 2

Nou, Dat is moeilijk, want er is wel heel veel ontwikkeld.

00:32:30 Spreker 2

Dus Ik denk wel ontwerpformules voor de blokken zelf nou die zij vrij eenvoudig ook omdat de stabiliteit zo hoog is, speelt schade ontwikkelingen speelt niet, de invloed van de periode speelt niet, dus eigenlijk heeft het ontworpen op stabiliteitsgetal en dat is een heel eenvoudige Formule.

00:32:48 Spreker 2

Daar zit de ontwikkeling niet in.

00:32:54 Spreker 2

Ik denk dat wat ontwikkeld is bijvoorbeeld een symmetrisch blok zoals de Cubi-Pod dat was een nieuwe ontwikkeling die is anders dan de Accropode en de Xbloc die niet symmetrisch zijn.

00:33:03 Spreker 2

Nou, dan heb je nu de XblocPlus die je ook regelmatig kunt plaatsen. Dat geeft een heel ander aanzien en soms is esthetica belangrijk. Soms helemaal niet, maar soms wel.

00:33:14 Spreker 2

Dat is een qua esthetica is dat weer een stap vooruit terwijl het ook heel stabiel is en je ook vrij makkelijk kunt plaatsen.

00:33:23 Spreker 2

Ik denk formules valt het wel wat mee wat het blok zelf betreft.

00:33:28 Spreker 2

Qua aanzien en al dat soort dingen zijn er ontwikkelingen geweest. Maar ik zie het niet dat vergelijkbare ontwikkelingen zijn. En wat altijd belangrijk is bij doorsnede is de stabiliteit van de teen. Daarbij kun je niet zeggen het blok zelf is de teen.

00:33:44 Spreker 2

Je mag hier bij niet een blok horizontaal liggen of twee. En zeggen dat is de teen, dat werkt niet. Het moet een breuksteen teen zijn en als je daar iets voor kunt vinden dat dat niet een breuksteen hoeft te zijn, maar iets anders.

00:33:57 Spreker 2

Maar wel wat stabiel is, zoals wat er nu voor de Accropode is ontwikkel (Accroberm) Xbloc heeft ook zoiets dan ligt hij plat op de grond en dan kan ik de eerste rij mooi op zetten. Maar dat is alsnog geen teen

Spreker 2

Een betonnen element dat echt de teen stabiel maakt, dat zou een innovatie zijn, denk ik.

00:35:41 Spreker 2

En je weleens dat je ja lage damme hebt dat er heel veel energie overheen gaat. Misschien dat daar nog wel eens wat, want dan wordt de kruin echt het punt waar die het meest wordt aangevallen en ook het minst stabiele is.

00:35:50 Spreker 2

Want ja, die ligt ook horizontaal. Je hebt overgang van talud en horizontaal daar zitten de blokken niet ingeklemd

00:35:57 Spreker 2

Dus dit soort elementen is vaak minder stabiel bij een lager kruin als daar een innovatie zou kunnen komen, dan zal het zeker mooi zijn.

00:36:08 Spreker 1

Oké

00:36:11 Spreker 2

Het is dat we een heleboel al ontwikkeld hebben

00:36:17 Spreker 2

Ja, maar de teen en een lager krui. Daar zou nog wel wat innovatie kunnen plaatsvinden.

00:36:23 Spreker 1

Misschien dat de Fransen nu weer eens een keer wat gaan ontwikkelen.

00:36:28 Spreker 2

Die Accroberm van ze is natuurlijk een idee van hoe je de teen stabiel maakt.

00:36:31 Spreker 1

Ja ja, die is die. Dat is echt de recentste ontwikkeling.

00:36:35 Spreker 1

Goed nou nu even het laatste, dan is het interview ook klaar.

Selecting Factors

Question 13

00:51:30 Spreker 1

Goed, Ik heb dan nog twee korte vragen, u heeft het, denk ik net al genoemd dat die technologische superioriteit die hangt van onder andere stabiliteit.

00:51:40 Spreker 1

Is het belangrijk hoe het geplaatst wordt?

00:51:46 Spreker 2

Gemakkelijkheid waarin het geplaatst wordt, telt mee zeker mee. Ja, ja.

00:51:50 Spreker 1

Die twee dingen zijn als u kijkt hoe technisch goed een product is of een blok is, dan kijkt u daarnaar.

00:51:56 Spreker 2

Ja

E

Transcript Expert 4

Question 2-5

Speaker 2: Oh ok. OK, well let's start with the was the interview part ok. Could you describe the company's activities where you are currently employed. SO CLI

Speaker 1: CLI, in which terms?

Speaker 2: Just the company's activities. What is CLI doing?

Speaker 1: What we doing, knowing just the CLI I joined CLI last year. after 30 years of study and consulting activity, mainly because first of all, I'm consulting engineer, engineer. For the activities of CLI. The management of the ongoing projects. And we have now, I think, more than 20 ongoing projects all around the world. And innovation is always important. Every time you have to compete with the competitors, but also with the sometimes the new competitors. And commercial activity, even if during the. The pandemic, the possibility to meet clients or consultants is very difficult, but we can say commercial and marketing activity management of ongoing projects, research and innovation. Do you know CLI is part of the Artelia Group? .

Speaker 2: Yes, I know.

Speaker 1: Yes, I think the group is the is the owner of the patent and trademarks that's distribute. And we have an internal laboratory where we can develop these commodities whenever we need it. Yes, this is what we do.

Speaker 2: Yeah. You are the director of CLI

Speaker 1: I am the director of CLI. To succeed Michel Alfonse. And Michel Alfonse was the previous director and he's retired at the end of 2020.

Speaker 2: OK, OK, that's clear to me. You just mentioned it. Could you describe some of your current activities regarding the concrete armor units?

Speaker 1: And regarding the concrete units, we are we can see from a commercial point of view, we are in contact with many consultants because you have to know that the clients is the same. with DMC and the other competitor. With Cubi-Pod, you know?

Speaker 2: it's Spanish. I Know. Yeah.

Speaker 1: Spanish block. Yes. And our clients are the contractors. So every time that is that we can find the use of our blocks. Let's say ACC CL or ACCB the last block we invented and we patented I think some years ago before I joined CLI in my client's contract, but. In the in the projects, we can find ACC or other blocks, like XB if the consultant decided to adopt these kind of blocks. So from a certain point of view, the consultant is the first.

Speaker 2: You're the first person where are you going to work, the first in line

Speaker 1: The consultant should be aware about the advantages and disadvantages of the block as so many projects are Royal Haskoning or Mott MacDonald or other consultants decided to use ACC for many reasons, I think. And for that reason, we are in contact both with a contractor to evaluate the issues about the installation, about the precast of the blocks. And we, the consultants have all the advantages of our block.

Speaker 2: OK. OK. And one last question about the activities and especially about your activities. Do you consider yourself an expert in the industry and how many years of experience do you have?

Speaker 1: Concerning my experiences we can say I started in nineteen eighty seven, 1987 as a consultant in an Italian engineering firm. My first project was the Venice Project. Everybody knows what we have done in Venice with the floodgates to protect the Venice. I know. I know. We we were I was working with Deltaris for a certain lab analysis of the modeling for that model, physical model and mathematical model and with the Institute (..) for the Mathematical Model of the Lagoon. So my experience is, first of all, as a consultant. So I know very well what the consultants would like to know

of the armour layer selection process and the second experience I have done was with (..) which is a an industry manufacturer. I think in some instances also (..) this time is market leader. Very well known all around the world. And for that reason, I can combine my experience as a consultant and as. Commercial manager , the we can see that technical manager especially focused on the marine sector for an industry like(..) , for that reason, I participated in a research program with Deltares, together with the main contractor in the Netherlands Van Oord and Boskalis. So going back to my experience, I have an experience both as a consultant, as an industry manager. We can say, OK, and I decided to to leave (..) and to join CLI for a new for a new challenge. You can say,

Speaker 2: OK,

Speaker 1: yeah, even if a very, very difficult period like the pandemic.

Speaker 2: Yeah, that must be really difficult, especially from working from another country.

Speaker 1: Yes, because it is very difficult to visit the clients, to develop the technical assistance, the job site. We have many projects in India, so you you probably know what is the situation of a pandemic in India.

Speaker 2: That's not really good over there.

Speaker 1: Yes, OK. But the intelligence and the resilience of the company, the most important quality you have to demonstrate.

Question 6-9

Speaker 2: Yes, that's true. OK. Further further about your experience, what is your experience with a particular armour units like TP or ACC and XB, CL and CB. Do you have experience with multiple units?

Speaker 1: In my experience, starting in 1992, with the building of the breakwater in Venice. And at that time I used the TP because the TP well presence seems to be in the in Venice. OK, when I was a consultant. I my experience was focused just to the TP . Why? Because my director has a long experience with the TP, many times like that. So if you go Mott Macdonald or Atkins or Eikon, many times there are the old engineers and they select the ACC for the why because the TP is being extensively used as being successfully used in many projects as and CLI developed more nearly 400 products in the book. So I have no experience with the other blocks. And that is very important, in my opinion, to know what the competitors are doing in a competitive market. You can be the leader, but if you want to continue to be a leader, you have to really to study what happens around you.

Speaker 2: Yeah, that's especially when a market is really conservative in choosing a new product.

Speaker 1: You are right. These are very conservative. Sometimes there are some clients that are telling you I don't want to be the first that in using a new product. We recently built a new a new block. And you are right, is very difficult to convince the client. And now. And now many times the main parameter , the main parameter, the client is considering to select one block or another one is the final cost of the technical assistance of CLI or DMC. And in my opinion, they should they should consider the not only the cost of the technical assistance and the use of the of the model of the trademark of the patent, if they steal of it is still in place. But the decision the problem is that you have a discussion with the technical department of the contractor, you know, for example, one order, but at the end you will sign the contract after that very difficult negotiation with the 'putting' department. The 'putting' department is not interested in to the quality of the technical assistance to that's just the final price of the schedule of the invoices and nothing else. OK, but I don't want to we can say. To lower the price, to get a new contract, to lower it, you can say, oh, yes, I don't want to do a dumping activity. In my opinion, there is a certain level of quality level that has to be maintained if we are the market leader. I think is that is why we are giving to the contract high level technical assistance.

Speaker 2: No. OK, that's your main selling point. So to say that you're a technical assistance is superior in comparison with other company

Speaker 1: Maybe is you have to take into

consideration that they join CLI because of that So I, you know, try to develop (..)

Speaker 2: it's OK.

Speaker 1: So the technical assistance and the. If I can give you an additional information, if you want to get a new contract, if you want to expand your activity, tailor a solution.. This is what you have to do because every client has a specific name and every client would like to have tailored technical assistance.

Speaker 2: OK, um, then elaborating a little bit about the Tp and ACC, and there you have a lot of experience in, esspecially TP. Um, uh, they proved to be very successful in terms of projects and number of units placed. What is in your opinion, what caused that success and what factors contributed to that success, in your opinion? Well.

Speaker 1: TP That is being invented by the Sogreah in 1950. Yes, and I think that at that time was probably the first block. I don't know. It was the. The only block invented of that time, I remember in the rock manual and roll and in the coastal engineering manual that there are the all the other blocks, TP probably demonstrate that there is capability to withstand the waves better than the others and probably the technical assistance I was not an engineer at that time So probably the technical assistance of Sogreah of the time and we can see the number of successful projects demonstrate the performance of these of these kind of blocks. OK. And then. Now, there are still some. Contractors that are asking us technical assistance from the TP about the every time I see the TP is something that has been invented seventy years ago. But like the iPhone, if you want to buy the iPhone, you should try to buy the last iPhone, the iPhone. But you are not asking for the iPhone 3G invented a few years ago. So there is an evolution on the on the computer, especially from the TP. So double a block to the next block and the single day a block. But is, as you mentioned it before, in a very conservative market where many contractors say, I will do that because I did it for a long time, you know, and in my opinion is very dangerous because the evolution that is due to innovation is the engine to improve your solution to and to expand your activity. But you can imagine it depends on the contractor. OK, so there are very interesting two new products that are contracted that are interested and prefer to go with the solution extensively tested.

Speaker 2: Yeah. OK, so that's. Yeah, well, well in conservative markets therefore, I think it's really important that you have a certain brand's credibility or that's your reputation. Yeah, well successful products, successful products leads to a sort of a good reputation. Do you think that is really important in this industry because it is so active conservative?

Speaker 1: You are right, because in my opinion, the reputation is is it seems to me is all that you have. Because if we have some huge projects where many times the contract is, we can say is not easy to convince the contractor to do the install the blocks in the proper way to consider that our ACC is not just a concrete block, but is a technology then. So the correct application of this technology is the correct application of the technology. They need the technical assistance. But many times the contractors say, I already stole it. They are using ACC another project is being easy. I know I already know what I have to do. But as I told you before, every project is different from the other, you know, and so the. The reputation is really important in many times, so we gave an additional technical assistance, even it was not required because we were aware that the difficult situation, the most important. Results that we did we want to get to is the stability of the armour layer later, that means the stability of our reputation, you know, because you can imagine a failure on an armoured layer. This is really a damage of what our reputation and sometimes because it happens there is a counterfeit of our all our blocks so that I know that there was the famous, we can say ChinaPod, but that China is something very similar to ACC. So,, we know that an application of the ChinaPod without any technical assistance for CLI was really just after the first storm, the latter was completely destroyed. This sort of demonstrated that the technical assistance is very important, is not enough to copy the shape of the block to to build the armour layer that is able to withstand the waves. But the. I can say and many times the discussion with the contractor that sometimes they are not really in favor to pay the technical assistance, I told them, OK, you can do what you want. You can do you can change the block because they say, no, Francesco, I don't want to pay three

hundred thousand euro. I prefer I the maximum budget is thirty thousand. OK, you can change it to block. Forget the ACC that you can use whatever you want. You want to develop the laboratory test. To to understand if it's really stable in terms of position, orientation, interlocking, and then you can do what you want, but please don't use the ACC without the technical assistance of CLID first, because he's not allowed by the law, and secondly, because he's very dangerous for our reputation. Coming back to your question, the reputation, in my opinion, is the most important thing that we have.

Speaker 2: OK, yeah, that's something where our other clients have to rely on other more non technological factors that are contributing to the successful implementation of your products. Besides the reputation.

Speaker 1: In my opinion, the commercial activity is very important because many times it seems that the report is very well known everywhere. Yeah, but in reality, there are many consultants that are not really aware. About the market Products, because they I know that are sometimes the consultants that are using the CL because the another job site very close to the job site you have designed, and that is the same block. So the activity, the commercial activity to. Made to make the consultant aware about your product. So in this sense, LinkedIn or the of the website are really important to you to disseminate information about your products is not as you, as you say, is not just a technical issue, but is also a commercial. And we can say now. The capacity to sell that technology is very important because and you have to develop it to develop it before the technical aspects and the participation to the conference of Breakwaters to present what you have done. Now we are in the era of communication, so the communication is easier than the 20 years before you go for papers and participation to the conferences. Is really important to show what you have done and an innovation in my opinion. And the many times that a a test to tell you the difficulties. I had some problem to convince a client to use a ACC instead of TP, and they told him probably TP that is something that should should disappear. This was the first block. But we have to look forward

Speaker 2: TP has very much use of a very high concrete use, for example.

Speaker 1: Yes. This is an. Even if there are some contractors that say OK is. I don't have to pay for the technical assistance with CLI so I can precast and lay the TP according to my experience, know 50 percent more for the total quantity of concrete they get to to cast. But probably many times, in my opinion, the contractor is not to be able to correctly evaluate the advantages that he can get with the technical assistance. He and I compare it to the advantages and of the job side. The many times they say, OK, I have to spend three hundred thousand euros, but for what? For just to buy at all. Just to pay a royalty or something like that. You know, that is not like

Speaker 2: OK, but do you think that that is lacking in this industry to the acceptance of technological assistance?

Speaker 1: In my opinion, yes, because if you think if you intend for industry, the contractors, the contractors, many times consider that the fee to be paid to CLI is something that they are obliged to pay because they have to install ACC. But if they are free to install the ACC without paying CLI, sometimes, in my opinion, that the contractor that we prefer to do that, even if there is a sort of the what you can say, they don't really understand that we are talking about a technology, not just a concrete block. Is that technology is in terms of casting and they think that was that easy. It's like this is like the rocks we had. We have to cast the blocks and then we had to install the blocks. You know, around the contractors, there are many divers that are assisting the installation, I can help you to intstall the blocks without CLI's technological assistance recently. And Pieter Bakker, We have been contacted on LinkedIn because we had to fight with the diving company.

Speaker 2: Yeah, I've read it. I read it.

Speaker 1: So I don't know if you are aware of that.

Speaker 2: I'm aware of that. What's the name of this guy?

Speaker 1: Oh, yes. The company's name is Class. Class, yes. Diving company. It knows they made the longest period she does, but they. Because they think that without a patent every contractor can do what they want, but it's not like that because there is a trade market to respect and there is a technology. He is a diver and he's not an engineer.. Beeing a diver is valuable but an engineer is another point of view.

Speaker 2: I know, that's that's true. Yeah, that's true. Yeah.

Speaker 1: And the. But it depends on the contractor on when we are cooperating with the contractor, like, Jan de Nul you know, like Boskalis. you know, in the Netherlands and the Netherlands, in the marine sector is probably the driving sector. Yeah. So it is quite easy to discuss at a certain level. On the other side, you and I are working with the Indian contractor or a Chinese contractor. That every time you stop trying to avoid to pay CLI for the proposed use is not easy because many contractors think that they have that they have enough experience for the marine sector. But there's not only that.

Speaker 2: And where does the technological assistance consist of what what's that about? At about constructability or designing?

Speaker 1: Technnical assistance that the CLI is giving to every contractor staff from the full marks construction. For the and then analysis of the concrete mix design, analysis of the pre cast of the blocks you're stacking of the blocks howling of the blocks and then installation of the blocks, because we are giving them for every breakwater the laying plan, and we decided we the we decided that we are giving our point of view to the contract about the equipment, the best equipment to be used for the installation of the ACC. I think I mean, a proposal with other blocks is the same. Sometimes there is a good cooperation with the with the contractor like Besix from Belgium. Mm hmm. That is really interested in the innovation in this field. OK, can you imagine Besix as a 3D printing system in Dubai that is able to fabricate concrete structure, quite large concrete structures in a very short time? So there are some contractors that are really. Interested in the innovation and other contacts that prefer to continue their own business in the traditional way.

Question 10-11

Speaker 2: OK, and could you could you tell me in general, without asking about some confidential things about your company, what kind of innovation could you expect in this industry and do in this industry needs, in your opinion?

Speaker 1: In in my in my opinion, to the because, say, the usual discussion between the ACC and the XB in terms of the concrete consumption is something that doesn't have really a huge importance, because in my opinion, the difference between the concrete consumption of our block and its block is really small. And it doesn't impact the. The final price of the block. Mm hmm. And the. And in the marine industry. Is not easy to propose new solution because every solution has to be tested. This is a huge investment in terms of the physical model test it is now with the computer fluid dynamic is easier, but is quite complicated structure of the armour layer . But you have to propose something that should be, in my opinion, easier from an installation point of view.

Speaker 2: So a better, better constructability or installation constructability.

Speaker 1: Yes the constructablity. And but at the same time that. This success also passed through the more tailored technical assistance by the Bisi. Like I said, I intend to do that. You have to you need a certain number of engineers with the huge experience, because every specific project, as is proper, is just in terms of the connection between the U.S. and around the world or in terms of constructability of the two of them or delay or the transition between a couple to be different size or this is very and many times that is the contractor that is telling you this is my equipment. So please tell me what I can do with that, given that is already available. I don't want to have to hire another kind of equipment. So if you have a very large experience. You can suggest that the best solution for that reason, in my opinion, the. You cannot propose to every client the same solution, you know.

Speaker 2: Well, and the design criteria are different also for projects, I guess.

Speaker 1: Yes, sometimes sometimes it depends on the design of a deed in terms of overtopping, stability is very well known according to Van de Meer stability formula, so that sometimes the client is not aware about the design detail. OK, yeah, right.

Factor Selection

End Recording

F

Full overview of selected factors and quotes

Table F.1: Total selected factors round 1

Category	Factor	Expert 1	Expert 2	Expert 3	Expert 4
Characteristics of the format supporter	Financial strength	■			
	Brand reputation and credibility	■	■	■	■
	Operational supremacy			■	
	Learning orientation	■	■	■	■
Characteristics of the format	Technological superiority	■	■	■	
	Compatibility				
	Complementary goods				
	Flexibility				■
Format support strategy	Pricing strategy	■	■	■	
	Appropriability strategy	■	■	■	■
	Timing of entry				
	Marketing Communications	■	■	■	■
	Pre-emption of scarce assets				
	Distribution strategy			■	
	Commitment		■	■	■
Other stakeholders	Current installed base				
	Previous installed base				
	Big Fish			■	
	Regulator				
	Antitrust laws				
	Suppliers				
	Effectiveness of the format development process		■	■	
	Network of stakeholders	■			■

Table F.2: Additional quotes per selected factor

Additional quotes per selected factor					
Factor category	**Factor**	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**
Characteristics of the format supporter	Financial strength	"You have to keep substantially investing in product development" "I found it important, but there is nobody in the market checking companies regarding those units whether they are financially healthy."	*Not selected*	*Not selected*	*Not selected*
	Brand reputation and credibility	"When we introduced a new block, we were in the business for more than 10 years. Having a reputation helped us to bring a new block to the market." "Cubi-Pod exists for almost 10 years, but the number of projects is low." "CLI (Artelia) Has a huge advantage that they are active in this business since 1950, and has therefore built extensive knowledge." "Track record is your reputation"	*No further quotes given*	"I would choose a block over another one, because of the image of the company"	*No further quotes given*
	Operational supremacy	*Not selected*	*Not selected*	*No further quotes given*	*Not selected*
	Learning orientation	"It is very important to keep learning"	*No further quotes given*	"It is not only simply developing a block, there is a lot of things around this. You have to keep inventing in order to be competitive."	*No further quotes given*
Characteristics of the format	Technological superiority	"If you could develop a significantly better product, you can get an advantage in the market" "First of all, the main purpose is to be hydraulic stable Secondly, structural integrity is very if almost even important as hydraulic stabilty Placebility: some blocks have even 11 placing restrictions, that is not doable"	*No further quotes given*	*No further quotes given*	*Not selected*
	Flexibility	*Not selected*	*Not selected*	*Not selected*	*No further quotes given*
Format support strategy	Pricing strategy	"We could for example develop a superior product. But the clients are interested in the price." "Competition is lowering the prices."	*No further quotes given*	*No further quotes given*	*Not selected*
	Appropriability strategy	"A patent is valid for 20 years, and the time it takes for a product to become obsolete is very long. Therefore it makes sense to protect our products." "In the industry it is common to 'extent' your patent by patenting a similar product with slight adjustments."	*No further quotes given*	*No further quotes given*	*No further quotes given*
	Marketing Communications	"You have to put a continuous effort in marketing in order to stay known to clients."	*No further quotes given*	*No further quotes given*	*No further quotes given*
	Distribution strategy	*Not selected*	*Not selected*	*No further quotes given*	*Not selected*
	Commitment	*Not selected*	*No further quotes given*	*No further quotes given*	*No further quotes given*
Other stakeholders	Big Fish	*Not selected*	*Not selected*	*No further quotes given*	*Not selected*
	Effectiveness of the format development process	*Not selected*	"Important to ensure independent testing and not a single company recommending their own product"	*No further quotes given*	*Not selected*
	Network of stakeholders	"Besides marketing, we have also obtained projects by having a network." "This industry there are examples of block which became not a success due to the lack of network."	*Not selected*	*Not selected*	*No further quotes given*

G

Best Worst Method Data

G.1. Consistency

Table G.1: ζ^* values of the linear Best Worst Method

Consistency ratio (Ksi*)					
Expert number	Internal factors	Technology factors	Strategy factors	External factors	Average
1	0.095	0.085	0.083	0.255	0.130
2	0.039	0.085	0.047	0.089	0.065
3	0.098	0.087	0.061	0.123	0.092
5	0.112	0.000	0.116	0.111	0.085
6	0.191	0.129	0.092	0.193	0.151
7	0.106	0.073	0.000	0.173	0.088
8	0.072	0.085	0.000	0.000	0.039
9	0.069	0.049	0.000	0.173	0.073
10	0.189	0.080	0.077	0.100	0.112
11	0.085	0.052	0.000	0.000	0.034
12	0.139	0.119	0.054	0.111	0.106
13	0.081	0.102	0.034	0.160	0.094
14	0.092	0.089	0.000	0.100	0.070
15	0.141	0.095	0.000	0.155	0.098
Average	0.108	0.081	0.040	0.125	0.088

G.2. Weights

Table G.2: Total individual BWM weights

Factors	Financial Strength	Brand Reputation and Credibility	Operational Supremacy	Learning Orientation	Structural Integrity	Hydraulic Stability	Constructablility and Placebility	Maintainability	Flexibility	Pricing Strategy	Appropriability Strategy	Marketing Communications	Distribution Strategy	Commitment	Big Fish	Effectiveness of the Format Development Process	Network of Stakeholders
Expert number	Classic linear Best Worst Method weights																
1	0.012	0.133	0.052	0.039	0.050	0.126	0.075	0.013	0.030	0.049	0.012	0.123	0.037	0.074	0.109	0.016	0.051
2	0.033	0.156	0.028	0.018	0.126	0.075	0.050	0.013	0.030	0.055	0.096	0.065	0.010	0.068	0.114	0.020	0.043
3	0.014	0.123	0.049	0.049	0.033	0.054	0.137	0.016	0.054	0.074	0.074	0.097	0.011	0.038	0.014	0.046	0.117
5	0.012	0.110	0.068	0.045	0.065	0.065	0.065	0.065	0.033	0.040	0.013	0.127	0.032	0.081	0.059	0.020	0.098
6	0.146	0.048	0.014	0.027	0.133	0.034	0.057	0.057	0.014	0.010	0.079	0.090	0.079	0.035	0.025	0.012	0.140
7	0.032	0.135	0.016	0.053	0.079	0.136	0.039	0.026	0.014	0.069	0.058	0.115	0.029	0.023	0.032	0.013	0.131
8	0.010	0.061	0.104	0.061	0.050	0.075	0.126	0.030	0.013	0.059	0.059	0.059	0.059	0.059	0.025	0.076	0.076
9	0.014	0.031	0.052	0.139	0.082	0.082	0.024	0.010	0.096	0.124	0.015	0.015	0.015	0.124	0.032	0.013	0.131
10	0.013	0.136	0.026	0.060	0.071	0.118	0.047	0.047	0.012	0.090	0.068	0.023	0.068	0.045	0.035	0.088	0.053
11	0.012	0.092	0.104	0.028	0.102	0.102	0.039	0.011	0.039	0.137	0.069	0.034	0.034	0.020	0.101	0.025	0.050
12	0.013	0.134	0.056	0.033	0.036	0.146	0.036	0.060	0.016	0.061	0.097	0.070	0.009	0.057	0.059	0.098	0.020
13	0.017	0.136	0.052	0.031	0.071	0.112	0.071	0.028	0.012	0.060	0.060	0.025	0.110	0.040	0.042	0.035	0.099
14	0.019	0.115	0.034	0.068	0.131	0.079	0.039	0.032	0.013	0.024	0.095	0.095	0.032	0.048	0.088	0.053	0.035
15	0.014	0.143	0.044	0.035	0.078	0.129	0.052	0.022	0.013	0.039	0.013	0.104	0.035	0.104	0.130	0.015	0.032
AVG BWM	0.026	0.111	0.050	0.049	0.079	0.095	0.061	0.031	0.028	0.064	0.058	0.074	0.040	0.058	0.062	0.038	0.077
AVG Bay BWM	0.027	0.097	0.053	0.059	0.086	0.099	0.071	0.038	0.033	0.055	0.047	0.064	0.044	0.066	0.055	0.038	0.068

G.3. Comparison with classic linear BWM versus Bayesian BWM

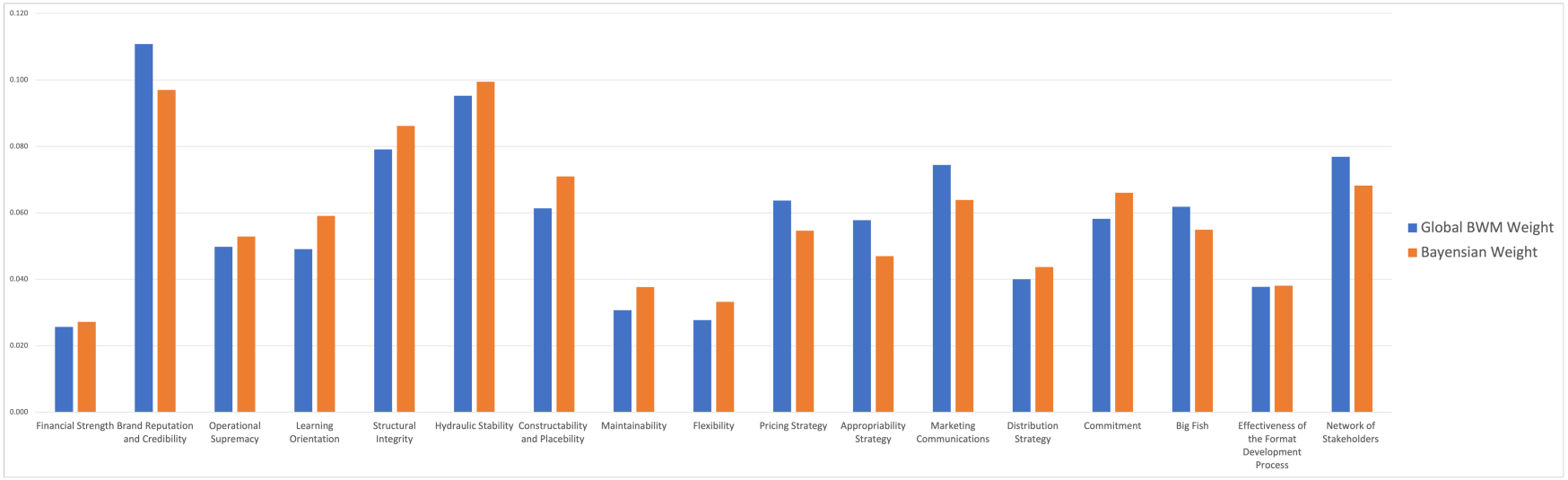

Figure G.1: Classic linear BWM versus Bayesian BWM

Table G.3: Ranking table of the weights of the linear BWM versus the Bayesian BWM

Factor	BWM	BBWM	Rank BWM	Rank BBWM
Brand Reputation and Credibility	0.111	0.097	1	2
Hydraulic Stability	0.095	0.099	2	1
Structural Integrity	0.079	0.086	3	3
Network of Stakeholders	0.077	0.068	4	5
Marketing Communications	0.074	0.064	5	7
Pricing Strategy	0.064	0.055	6	10
Big Fish	0.062	0.055	7	9
Constructablility and Placebility	0.061	0.071	8	4
Commitment	0.058	0.066	9	6
Appropriability Strategy	0.058	0.047	10	12
Operational Supremacy	0.050	0.053	11	11
Learning Orientation	0.049	0.059	12	8
Distribution Strategy	0.040	0.044	13	13
Effectiveness of the Format Development Process	0.038	0.038	14	14
Maintainability	0.031	0.038	15	15
Flexibility	0.028	0.033	16	16
Financial Strength	0.026	0.027	17	17