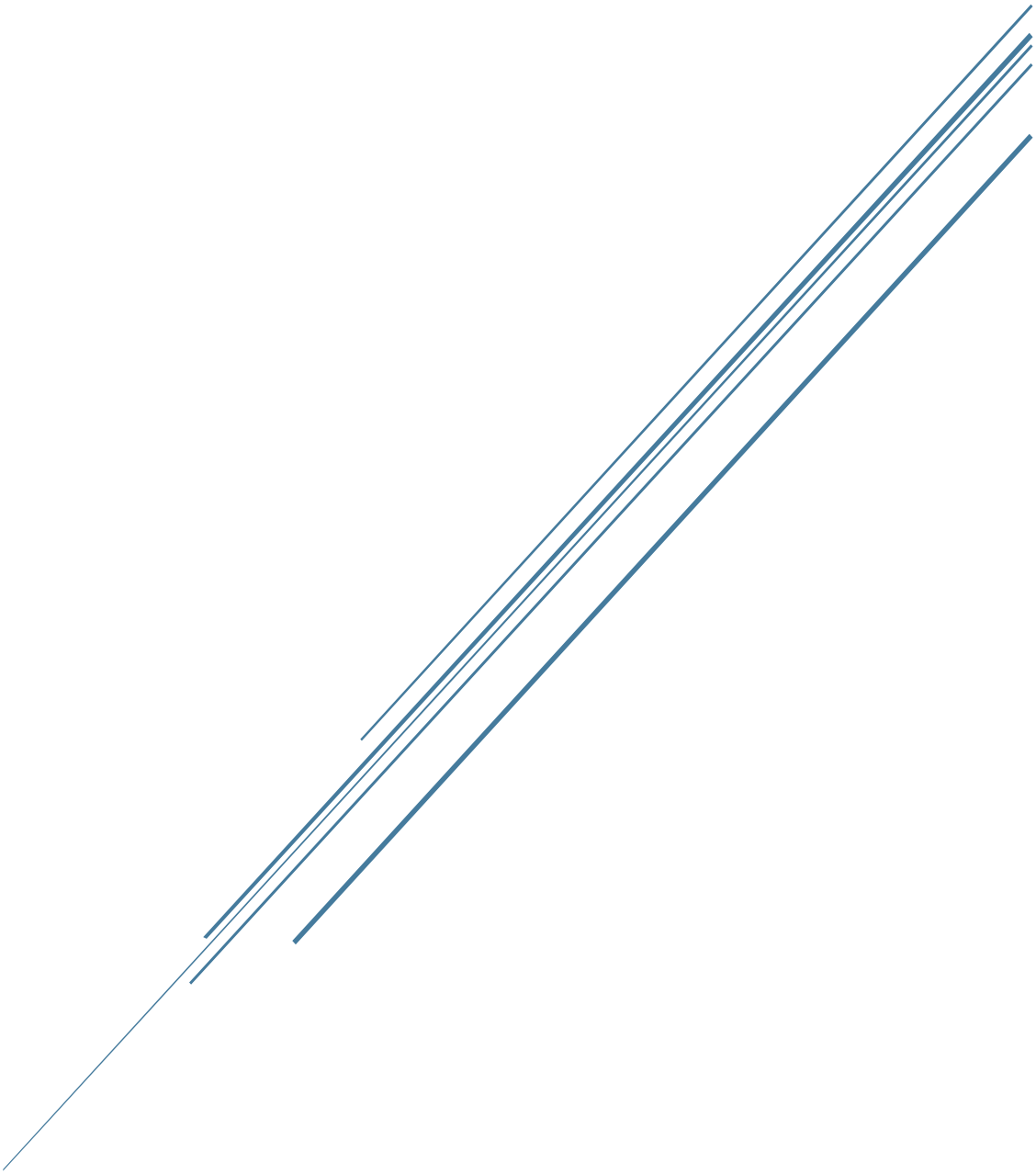
THE EMERGENCE OF THE BUILDING MATERIAL HUB

A study identifying building material hubs for a circular built environment and the factors explaining their emergence



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31-10-2022

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Version	P5 Report
Presentation date	31-10-2022

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Master	Architecture, Urbanism & Building Sciences
Master track	Management in the Built Environment
Graduation laboratory	LDE Centre for Sustainability: Circular Building Materials and (re)Manufacturing Hub

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Preface

In front of you lies the graduation thesis 'The emergence of the Circular Building Material Hub', that focuses on factors that explain the emergence circular building material hubs.

This thesis is a result of more than one year of research and has been written in the context of graduating from the master track Management in the Built Environment at Delft University of Technology.

Acknowledgement

Doing this thesis was not possible without the help and support of people who were directly or indirectly involved in this research. I would first of all like to express my gratitude to Karel Van den Berghe, my first graduation supervisor, for his comments, suggestions, and the time and effort he put into assisting me during the research. I also like to thank Ruben Vrijhoef, my second supervisor, for his insightful criticism, professional counsel, and assistance with this study and general supervision. I am appreciative of Karel and Ruben's participation in this study because they significantly raised the standard of the work as a whole. Thirdly, I want to thank Gert-Willem van Mourik and Helmut Thoele from the province of South Holland for linking me with several interesting people as well as for supplying pertinent reports and suggestions when they were required.

I would also like to thank my research group, The Circular Building Hub. First the coordinators of the lab Karel Van den Berghe and Saskia Ruijsink, for your guidance and assistance during the interdisciplinary thesis lab. And thank you Alex, Arjan, Batuhan, Karismi, José-Luis, Manon, Twan, Wenhui and Yajuan for the interesting and fun collaboration during the thesis lab.

On this occasion, I would also like to thank all the respondents for their time and effort during the interviews, which enabled me to collect necessary information and results. In addition, even though my voluntary internship had nothing to do with this research, I'd like to thank the company VKZ b.v., where I did my internship, for giving me the chance to develop myself in the field of project management. Ramon van Schaick has my sincere gratitude for his insightful criticism and help with this thesis.

Finally, I would like to thank my family and friends for all the support and motivation you have given me during the education and graduation process. Without your support and encouragement, I would have never been able to obtain both the pre-master and the master. This means a lot to me.

I hope you will enjoy reading this thesis.

Koert Nieuwhoff

October 2022

Abstract

One of the most significant strategic societal objectives for long-term sustainable development is the circular economy, or CE for short. The Dutch building sector has a big impact on reaching the set ambitions of a CE in 2050. The reuse of secondary materials will be important in achieving a circular built environment. But now, this is challenging since material streams are not synchronized in terms of space and time. Building material hubs, a location where materials are gathered, examined, and momentarily stored before being packed and sent to the building site which, are a way to better organize the flow of goods between parties, might be the answer as they have a positive effect on fewer transit movements, reduced traffic, and better air quality in the city or region.

By identifying building material hubs in relation to the realization of a circular build environment and by defining the factors that shape the emergence of the hubs, this study fills a gap in the literature. The primary research question is therefore: **"***What different building material hubs in relation to a circular built environment exist, and what factors explain their emergence?***".**

This explorative research is divided into two main parts. First, a review of the available literature has been done to gather data and learn more about the evolution of circular areas. With all the available data on circular building material hubs, an analytical framework is developed for assessing four typologies. Second, multiple case studies and interviews have been undertaken to acquire insight into the different factors explaining the emergence of the different typologies of circular building material hubs. In total also four cases are examined.

This study identified six primary factors that explain the establishment of construction material hubs, based on 26 sub-factors. These primary factors include (1) land-based, (2) economic, (3) logistical, (4) technology and knowledge, (5) social, and (6) governance factors. Every circular construction material hub begins with a circular business case that demonstrates how the materials may be used more effectively and with more efficiency. The hub's strategic location connects the supply and demand of building materials, ideally used ones. The building material hubs are shaped by a variety of knowledge and experience as well as logistical accessibility to the main road network. The initiator from the hub contributed equally by raising awareness and offering white label facilities. In relation to the circular built environment, there are four distinct typologies of circular building material hubs: (1) the circular craft centre, (2) the circular multimodal building material hub, (3) the circular building material hub and (4) the circular raw building material hub. This study emphasizes the development of typologies and their connections to relevant territorial factors that explain their emergence, something that, as far as is known, no other study has done. This study is consistent with the body of research from research organizations on the topic of (circular) building material hubs and its potential. The report's findings provide an intriguing parable for cities and regions that have set the challenging objective of attaining a circular built environment. A reasonable next step when enhancing the circular activities in a region may be to implement a CBMH. The finished framework in table 1 may be thought of as a two-sited design tool for the creation of CBMH.

Table 1: Compressed analytical framework

	Circular Craft Centre	Circular Multimodal BMH	Circular BMH + BMH with urban development	Circular raw BMH
Land Based				
Economic				
Logistical				
Technological & knowledge				
Social				
Governance				

Important for the emergence of the CBMH
Less important for the emergence of the CBMH
Not important for the emergence of the CBMH

This report was done in collaboration with LDE Centre for Sustainability: The Circular Building Material and (re)Manufacturing Hub and the province of South Holland to contribute to the exploration of the relevant factors of building material hubs.

Keywords – Circular economy, circularity, built environment, circular building material hub

Contents

1 Introduction

The circular economy, hereafter CE, is becoming more widely recognized as one of the most important strategic social goals for long-term sustainable development. In 2016 the Duch national government initiated a government-wide programme aimed at developing a fully CE in the Netherlands by 2050 (Rijksoverheid, 2016). Within the economic system, CE emphasizes the redesign of processes and material cycling. It seeks to use renewable energy to "design out" waste, recover nutrients, and recycle durables (Williams, 2021).

This research will focus on the Dutch built environment as the construction sector is the most material-intensive sector in the Netherlands accounting for half of all material consumption in the nation with a mass of 28.9 million tonnes and a value of €95.6 billion (Circle Economy, 2020). The realisation of the Dutch built environment involves employment and activities beyond the building industry, such as professional services and manufacturing, and employs roughly 685,000 people (RIVM, 2015). Next to the relevance of the construction sector for the Dutch society, the sector has a big impact on reaching the set ambitions of a CE in 2050. The Netherlands' construction sector uses 50% of the raw materials, 40% of the nation's energy, and 30% of its water. Construction and demolition waste make up an estimated 40% of national waste, and the industry is responsible for 35% of CO2 emissions (Rijksoverheid, 2016). One contributor to these emissions is construction traffic that causes a lot of harmful emissions substances (CO_2, NO_x, PM10) and has a major impact on both the climate and the quality of life, accessibility, and air quality in the cities (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B).

To realize a circular built environment, the re-use of secondary materials will play a role (Adams, Osmani, Thorpe, & Thornback, 2017). But currently this is difficult since material streams do not match in terms of geographical location and time (Hiete, Stengel, Ludwig, & Schultmann, 2011). But if re-use of secondary material to catch on, there is still a lot of work to be done. It will be necessary to develop an adequate supply and demand first (Loeber & Snoek, 2020). The supply needs to effectively be made public so that information on materials that have been released and their state is available (Verhagen, Sauer, van der Voet, & Sprecher, 2021). Thirdly, these harvested secondary materials need a temporary storage location to bridge the mismatch in time (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). The idea of a hub may help achieve several policy objectives, including making it possible for high-density care-free zone communities and maintaining and improving accessibility in declining regional areas. Although the idea has received a lot of attention lately (Vastgoedmarkt, 2019), hubs are still being developed and is seen in various ways (Witte, Alonso-González, & Rongen, 2021).

A (circular) building material hub could be a solution as building material hubs are a way to better organize goods flows between parties. This leads to fewer transport movements and therefore less congestion and better air quality in the city or region. Materials come together here, are checked, and temporarily stored before being bundled to the construction site are transported (De Bes, et al., 2018). Moreover, smart use of materials promotes circular construction (and demolition) (Joensuu, Edelman, & Saari, 2020).

A lot of studies has been done on a CE and in recent decades. Though, according to (Kirchherr, Reike, & Hekkert, 2017) there is no agreement on what the definition of the CE and the definition of a (circular) building material hubs (Ramli, 2020). Furthermore, many papers have been written regarding how circularity may be implemented on a building scale, through the means of circular design. However, the number of articles on the implementation of a CE at a city or regional scale is minimal (Pomponi & Moncaster, 2017).

Consequently, the purpose of this study is to fill a gap in the literature by identifying building material hub in relation to the realisation of a circular build environment and identifying the factors that shape the emergence of the hubs. Therefore, the main research question is:

What different building material hubs in relation to a circular built environment exist, and what factors explain their emergence?

The following sub-questions are formulated to answer the main research question:

1. What is the concept of a circular economy?
2. What is the concept of a circular built environment?
3. What are the characteristics of construction logistics?
4. What type of different building material hubs exist?
5. What are the factors shaping the building material hubs?

This thesis aims to get a better understanding of circular building material hubs by researching the different typologies and the factors explaining their emergence. The first chapter presented a brief introduction to the problem and relevance of the research. Moreover, it presents the research questions that structures the thesis. The second chapter includes the literature study where the concept of circularity, circular built environment and construction logistics are explored. The second chapter concludes with an analytical framework. The third chapter contains the methodologies for answering each sub-question of this thesis. The fourth chapter presents the results of the case studies and makes a cross-case analysis of the factors influencing the emergence of the building hubs. The fifth chapter contains the discussion. Chapter six is the conclusion, where an answer to the sub-questions and main research question is presented. Finally, the seventh chapter is the reflection of writing the thesis.

2 Theoretical Framework

2.1 Circular economy

Circularity derives from an ecological conceptualisation of the world (Williams, 2021). With circularity the emphasis shifts from linear systems that consume an infinite supply of new resources (inputs) and produce "waste" (outputs) to circular systems. It used the distinction between various gradations or options for circularity in the R-principle, ranging from the 3 R's (Reduce-Reuse-Recycle) through the 5 R's (Reduce-Reuse-Remanufacture-Recycle-Recover) to the 9 R's that can be seen in figure 1 (Kirchherr, Reike, & Hekkert, 2017). All the forms of the R-framework share a hierarchy as their main feature with the first R view to be a superior gradation to the second R and so on (Van Buren, Demmers, Van der Heijden, & Witlox, 2016). The principle of circularity has been applied to industrial systems (industrial symbiosis), production processes (cradle-to-cradle) and economic systems (CE).

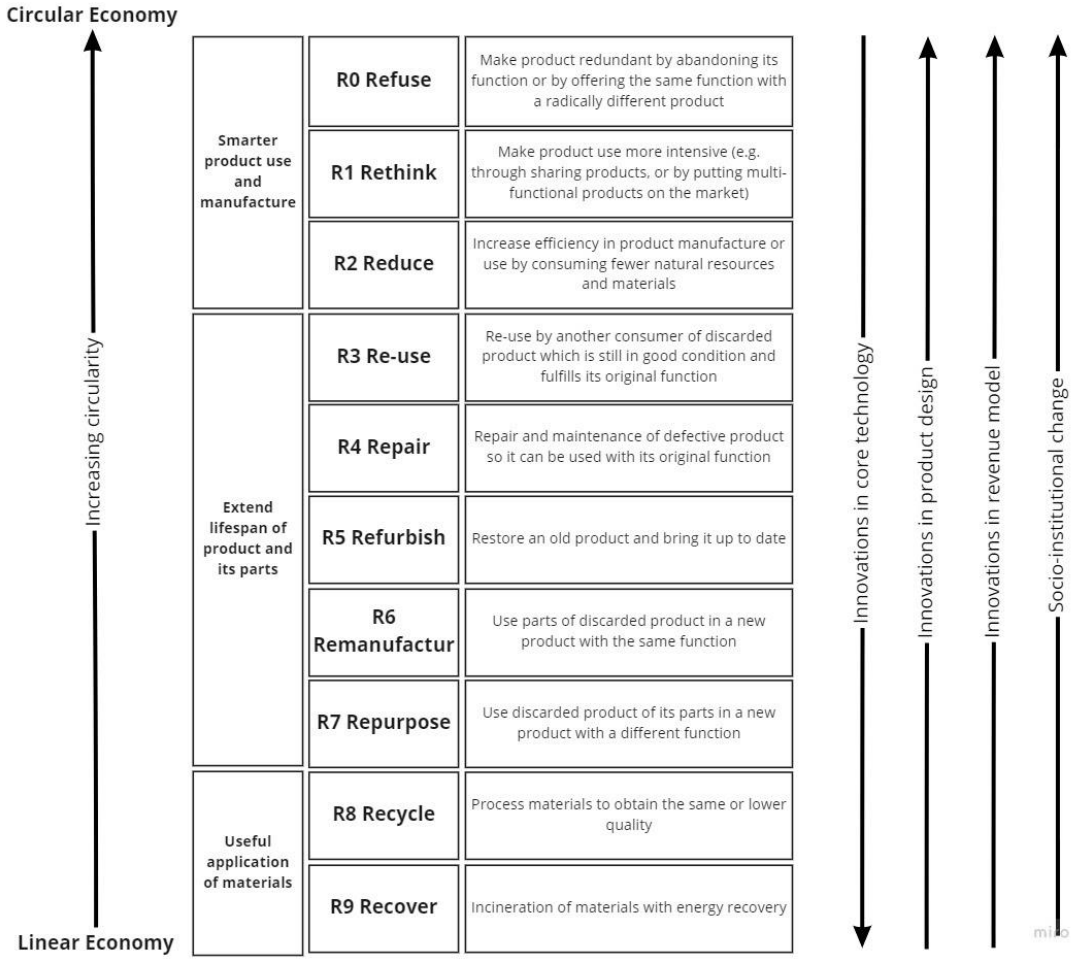


Figure 1: R-framework (adapted from Krichherr et al., 2017)

The concept of industrial metabolism was created by industrialists in the nineteenth century. Resources were metabolized by industries, resulting in outputs that were frequently categorized as trash but were useful to other sectors (Simmonds, 1862). Industries developed symbiotic connections with one another, allowing the utilization of resources, energy, and water by-products from one industrial process by another. Physical closeness frequently made this easier (Williams, 2021).

Cradle-to-cradle thinking has been used in the design and manufacturing processes for the manufacture of goods. Through resource recovery, recycling, and reuse, it seeks to minimize waste

generated during the lifecycle of a product. The present concept is based on a "lifecycle development" framework that was introduced in the 1990s (McDonough, 2002).

Currently circularity is a hot topic among academic institutions, organizations, and governments. There is a discussion about the definition of the concept, due to the argument that it means different things to different people (Kirchherr, Reike, & Hekkert, 2017), pointing out the restraint on global resources in 'Spaceship Earth' (Boulding, 1966), the urgency for closing the loop (Pearce & Turner, 1990) and general systems theory (Bertalanffy, 1968). Arguably, the concept of CE is a model for production and consumption (with a focus on production), has the aim to achieve the decoupling of economic growth from the depletion of natural resources and environmental damage (Jackson, 2009).

Arguably the most well-known framework showing the CE, was developed by The Ellen MacArthur Foundation (EMF) and is called RESOLVE (figure 2). It defines CE as a set of multiple value-creation mechanisms that are not dependent on the consumption of finite resources. It outlines six crucial steps in the transition to a CE (Ellen MacArthur Foundation, 2012):

1. Ecological regeneration through a shift to renewable energy and materials, alongside the return of recovered biological resources to the biosphere
2. Keeping components and materials in closed loops (reuse, recycle, recover, remanufacture), prioritising inner loops (e.g., reuse) and thus reducing waste
3. Sharing resources to keep product loop speed low and maximise utilisation of products to reduce waste
4. Optimisation of the performance and efficiency of products, alongside the removal of waste in production and supply chains, leveraged by big data
5. Dematerialise resource use by delivering utility virtually
6. Replace existing products and services with lower resource consuming options.

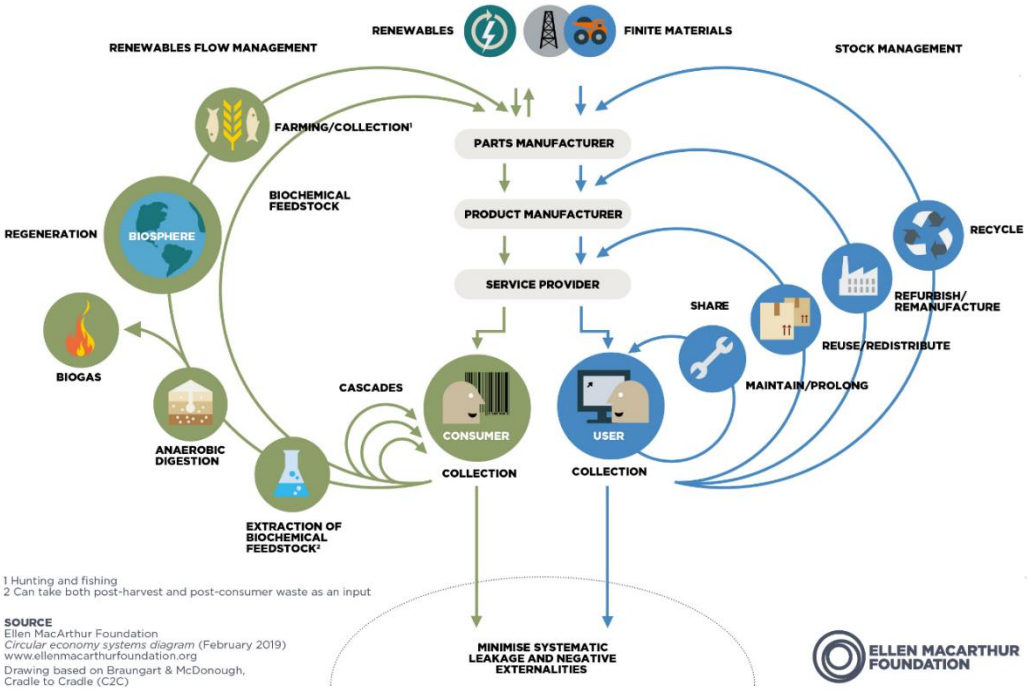


Figure 2: Butterfly Diagram (Ellen McArthur Foundation, 2019)

2.2 Circular Built Environment

Buildings are special objects because they frequently originate from one-off projects. Due to the fact that each of the materials employed has a distinct life cycle and interacts dynamically in both space and time, this aspect increases their intrinsic complexity. Additionally, their long longevity and changing uses throughout their service life raise the ambiguity of potential future events. As a result, even though structures are built of manufactured parts, when those parts are put together, they produce an entity that defies the logic of manufacturing (Pomponi & Moncaster, 2017). Furthermore, buildings are typically thought of as finished, permanent structures with an average technical and functional life span of 50 to 75 years (Debacker & Manshoven, 2016). Despite having a long physical lifespan, they do not provide the flexibility needed to prolong life. It is usual practice to separate structural and sealing components for modifications, upgrades, and replacements (Munaro, Tavares, & Braganca, 2020). Because buildings no longer suit the needs of their users, most of them are currently demolished after an average of 20 years. This shortens the facility's service life and causes returns on investments to occur more quickly (Debacker & Manshoven, 2016).

The concept can be defined as “a system designed for closing resource loops at different spatial-temporal levels by transitioning cultural, environmental, economic & social values towards a sustainable way of living (thus enabling society to live within the planetary boundaries)" (TU Delft, sd). The concept depicts different scales, starting with the fundamental construction ingredients: materials and Components. Buildings are the next scale as they are constructed as assemblages of numerous building products, materials, and components. The neighbourhood scale, which is one level higher, illustrates how circularity is currently prevalent areas or districts. The most significant resource flows that enter, move through, and depart the urban environment each day are examined in Cities Scale. And finally, the regional scale relates to the characteristics of urban metabolism and the significance of examining economic activity to pinpoint material, product, and waste movements and stocks (TU Delft, sd).

When the notion of CE is applied to the built environment on for example the material and component scale, the purpose is to maximize the use of building materials by determining if the material may be reused in new structures. The entire supply of virgin materials will be conserved, or reduced at a slower rate, in this fashion. Assessing how much building material will be utilized and how much will be made available through future demolition in a specific location can be critical to increasing construction material supply and decreasing material demand (Ramli, 2020).

According to a recent study by Circle Economy and Metabolic (2022), downcycling in the Netherlands is greatly facilitated by the built environment. According to their numbers, the built environment in the Netherlands is on paper, a champion of circularity: as we've seen, less than 10% of building and demolition debris is landfilled or burned, and 88% is recycled (figure 3).

Though low-value cycling—where valuable and complex materials are crushed and used as aggregate for backfilling, for example, roads—is prevalent, just 8% of building materials come from secondary sources, despite the fact that over 90% of the sector's waste is "cycled." Increasing circularity involves more than just cycling; it also involves keeping materials' worth and complexity as high as possible (Circle Economy & Metabolic, 2022).

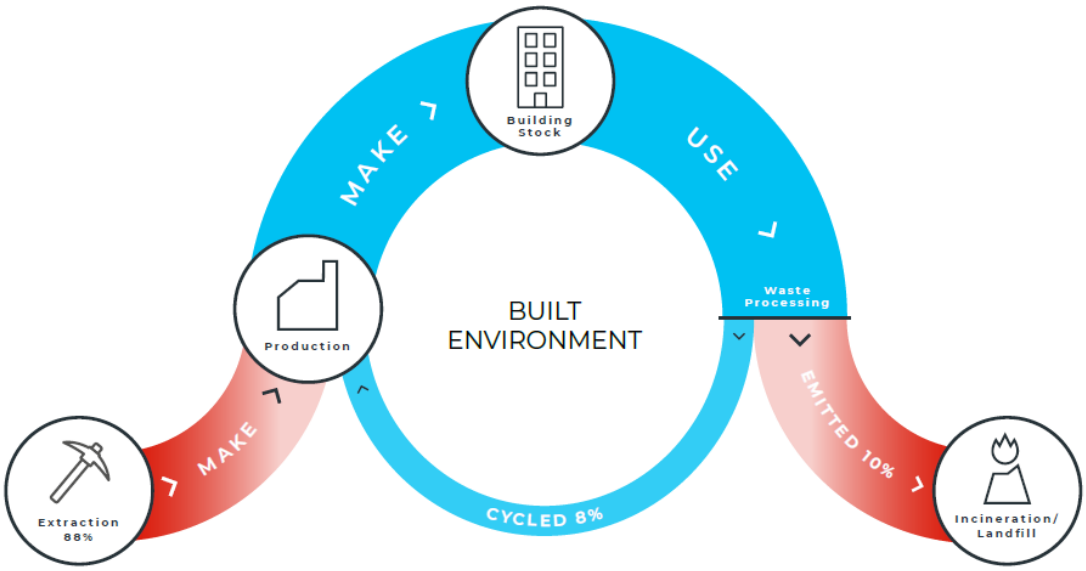


Figure 3: Material cycles for the built environment (Circle Economy & Metabolic, 2022)

2.3 Construction logistics

The effective and timely delivery of goods or services has been referred to as logistics. It is a very broad and ubiquitous term. Today's logistics paradigm includes computing and smart planning (Szymanska, Adamczak, & Cyplik, 2017), and challenges are continually being solved through innovations. For instance, as e-commerce expands, pressure is placed on logistics service providers, and technologies are being created to further boost efficiencies (Ghajargar, Zenezini, & Montanaro, 2016). An aspect to consider is the requirement for the distribution of goods within the city for the so-called "last mile" in order for delivery systems and packages to reach customers. The "last mile" of a supply chain is the least effective and can contribute to urban congestion and pollution (Ranieri, Digiesi, Silvestri, & Roccotelli, 2018). This issue could be resolved by modelling how the goods can be routed from a central hub to the destinations (spokes) to reduce last mile efforts (Greasley & Assi, 2012; Zäpfel & Wasner, 2002). Hubs exist, in practice or in concept form, at different scale levels, from a neighbourhood facility to an (inter)national main port. Hubs also differ in the transportation services they offer. This can be a multimodal switch, but also access to shared mobility and light electric freight vehicles (LEVV) (Witte, Alonso-González, & Rongen, 2021).

It is clear that logistics optimization has been employed over the years when it is necessary for the distribution of commodities in metropolitan areas to be affordable, low-disturbance, and low-polluting. The logistics of the built environment and the constructed sector can both be easily applied using this justification, as construction logistics is one of the most important logistical flows of the Netherlands, as in 2017 232 million ton was transported and accounts for almost 20 % of the total transported volumes. In terms of modal split, the in-depth analysis of the composition of construction logistics shows that most construction logistics volumes concern road transport (approximately 70%). In addition, a substantial part of the volumes is transported by inland shipping (approximately 30%). Rail transport is hardly used (Topsector Logistiek, 2020).

When looking more in depth at the supply chain of the building sector, it can be characterized by the fact that it is a convergent supply chain that channels all supplies to the building site, where the product is put together from the materials that arrive dependant on the building phase. It is, with a few exceptions, a transitory supply chain that produces one-of-a-kind building projects by reorganizing project organizations on a regular basis (Balm, Berden, Morel, & Ploos van Amstel, 2018). As a result,

the building supply chain is described by instability, fragmentation, and notably by the separation between the design and the production of the completed building. The process can be very similar for projects of a particular kind. Vrijhoef and Koskela (2000) identified four roles of supply chain management in construction, where logistical gains can be achieved by improving the interface between the site activities and supply chain. An overview of the roles can be seen in figure 4.

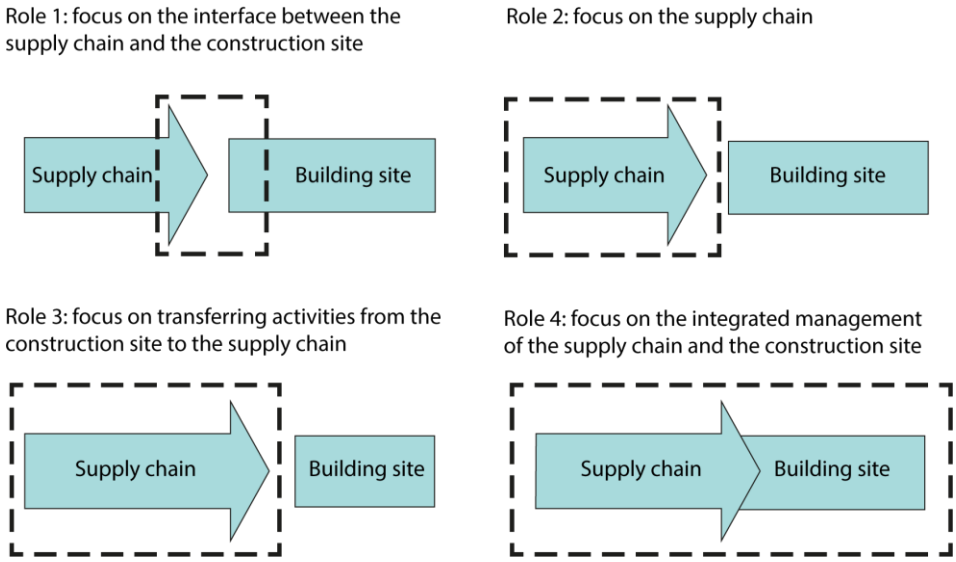


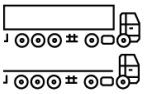
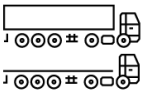
Figure 4: Roles of Supply chain in construction (Adapted from Vrijhoef & Koskela, 2000)

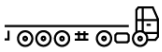
According to a recent study by Van Rijn, Rondaij, Van Merriënboer, Kin and Quak (2020), there are numerous ways to break down the logistics for the building sector. This study focusses on (large-scale) new construction projects and renovation in residential and non-residential projects. This indicates that ground, road, and hydraulic engineering is not included. The logistical arrangement inside and across the sub-segments differs significantly. The primary differences are:

- The party in charge of organizing and managing the logistics.
- The typical vehicles employed.
- The ride types.

Furthermore, Van Rijn et al. (2020) identified eight types of material streams that are typically delivered at a construction site. An overview of the eight types of construction flow types can be seen in table 2.

Table 2: Eight construction flow types. Adapted from (Van Rijn et al., 2020)

Type of material stream	Description	Currently most used type of transportation
1. Concrete	This concerns liquid concrete that is poured from a concrete mixer on the construction site. About 30% of the current rides can be attributed to this construction flow type.	
2. Structural work – Large	Larger and heavier elements, such as prefab, piles, floor elements, etc. Approximately 10% of the current journeys can be attributed to this type of construction flow.	
3. Structural work - Load carriers	Smaller elements on frames/pallets, for example facade parts, fronts, glass plates, etc. Approximately 10% of the current journeys can be attributed to this type of construction flow.	

4. Bulk	For example, soil or gravel. Approximately 0% of the current trips to construction sites can be attributed to this construction flow type.	
5. Finishing	Finishing work, installations and smaller building materials transported on pallets or in containers. Approximately 35% of the current trips can be attributed to this construction flow type.	
6. Waste	Construction and demolition waste, but also packaging materials and packaging. About 5% of the current trips can be attributed to this construction flow type.	
7. Equipment	For example, construction machinery, construction cranes and scaffolding. About 10% of the current trips can be attributed to this construction flow type.	
8. Personnel	Transport of personnel to and from the construction site.	

Since each stakeholder in the construction supply chain runs their business independently of the others, there is minimal to no optimization (apart from personal activity optimization). The logistics flows are not managed in an integrated chain. Due to inadequately specified preparations, supply firms have unpredictable supply. Construction planning is challenging because last-minute changes to plans frequently make it difficult to carefully coordinate production and inventories. The low load factor, which is a difficulty for transporters due to shoddy planning, impulsive ordering, and rushed deliveries to numerous cities building sites, is also a result of these factors. Additionally, transporters encounter unclear delivery specifications, restricted access to building sites, and ad hoc interactions with foremen *(Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B)*. A schematic overview of the current construction logistics can be seen in figure 5. The Point-to-point deliveries with heavy vehicles in construction flow types (1) concrete, (2) structural work: large, (3) structural work: load carriers, (4) bulk and (7) equipment, are represented with the green arrow in figure 5. The yellow arrows represents the irregular deliveries at different locations in the construction flow type (5) finishing. And finally, the point-to-point deliveries in the construction flow type (6) waste, represented in blue, generally go directly from the construction site to the supplier or the waste plant.

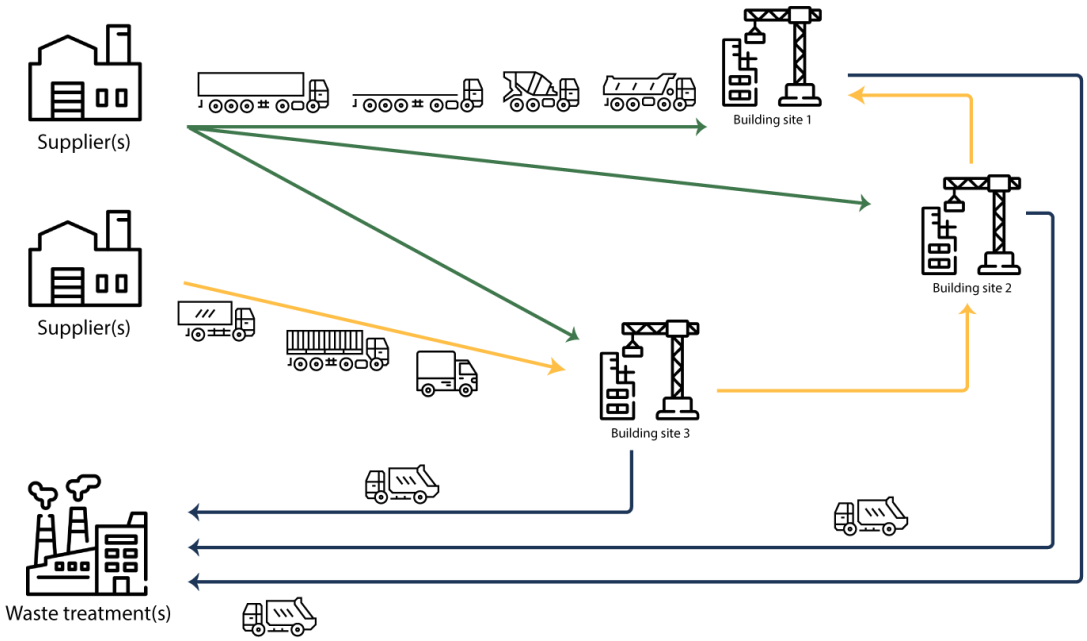


Figure 5: Current construction logistics. Adapted from (Van Rijn et al., 2020)

2.4 (Circular) building material hub

Although the idea of reusing discarded materials for new projects is not new, it is challenging to pinpoint the exact beginning of the "circular building material hub". It is conceivable that the phrase derives from the idea of reverse logistics for delivery optimization. According to Leighton and Coakly (1955), the word logistics is an old word that was taken from the Greek word "logistikos," which means "skilled in calculating." Even if they do so in the context of armies and a country's economy, the writers contend that supply and transportation are the most crucial elements of logistics. According to Cooper, Lambert and Pagh (1997), logistics is the process of efficiently and economically planning, implementing, and storing raw resources, products, and inventory. The authors continue by introducing the idea of "Supply Chain Management," which entails the integration of business activities that go beyond logistics, from suppliers to end users, including information, services, and products of added value. Reverse logistics are systematically linked to recycling, according to Brito (2004), who also notes that names like "Reverse Channels" and "Reverse Flows" were already in use in the 1970s. However, the author also acknowledges that it is challenging to trace the concept precisely. O'Kelly (1986) developed straightforward models for the placement of hub facilities to service a group of interdependent cities and described the relationship between the location of a facility and spatial flows. Numerous tasks that call for effective connections between different nodes, such as communication or distribution, can be applied to this idea.

The term "circular building material hub" is likely a reference to a central "hub" that employs effective logistics and contains materials that must be "circular" in terms of production and waste management. The search for the term's origin can be regarded as arbitrary, although the purpose of such a system is much more important (Ramli, 2020).

To deliver materials as effectively as possible, logistics were first employed, which necessitated careful planning and storage. Smart computing, which may further reduce the cost and time associated with transportation and storage, was part of the second wave of logistics. What can be argued is that a new stage of logistics is emerging right now. Closed-loop supply chains, which recover end-of-life or end-of-use products for reuse, have gained popularity recently in addition to smart computing and careful planning to reduce waste (Guide & Van Wassenhove, 2009) and forward and reverse logistics are now much more integrated (Yi, Huang, Guo, & Shi, 2016). Since such a hub can incorporate reverse logistics, circularity, and emission reductions, the concept of a CBMH can be seen as a reaction to reverse logistics and waste management.

In literature there are three main functions of CBMHs defined (Gemeente Amsterdam, 2022). The most popular and well-known function of a hub is a construction logistics hub, which functions as a logistics location outside of the city for the storage and distribution of construction supplies needed for the building project. The construction logistics hub as a concept takes many different forms, such as consolidation at the supplier, at a location of the municipality, at the construction site itself or at a location chosen by a logistics service provider (Ludema, 2013). The LCCC (London Construction Consolidation Centre), a successful pilot of a construction logistics hub for the delivery of construction projects in London, has shown that the number of transports (and therefore also the transport costs) decreases when using a construction logistics hub. For example, a 68% reduction in the number of vehicle movements has been achieved at the LCCC, resulting in a reduction in CO2 emissions of approximately 75% (Lease, Excellence, & James, 2008). Furthermore, TNO provided advice on the implementation of construction logistics ideas to nine new construction projects, and the performance and environmental effect were assessed. At three trial projects, much data was gathered, and cost reductions were proven. Over 260,000 kilometres of travel were avoided in these three initiatives, with savings of 50 percent, 65 percent, and 80 percent. CO^2-emissions were reduced by 40%, 85%, and 50%,

respectively, because of these actions (De Bes, et al., 2018). Though, to its lack of attention to the logistics surrounding the supply of secondary materials, its core function purpose is not always in line with circularity principles and a circular built environment.

The second function of a CBMH is to store secondary materials that are harvested from local demolition projects. Materials must be temporarily held since they are typically not used right away or because of misaligned project timetables. These functions can be found both inside and outside the city (Gemeente Amsterdam, 2022).

The third function is a repository and marketplace for released and unused building supplies from various construction projects and firms. Here, the materials are repaired and recycled for a different use (Gemeente Amsterdam, 2022).

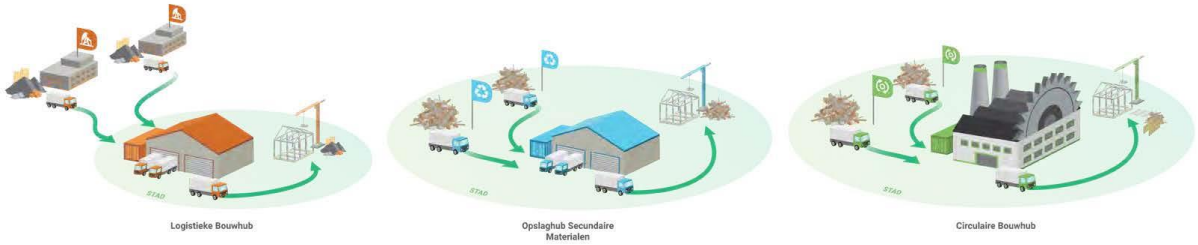


Figure 6: Functions of circular building material hubs (Gemeente Amsterdam, 2022)

According to Gemeente Amsterdam (2022), the lines between these three main functions are not clearly drawn and can sometimes be blended in different configurations. A hub can also establish supplementary businesses such as prefabricating items and providing smart logistics for both equipment and building site employees, in addition to serving the main objectives. Other secondary activities can involve setting up and maintaining a physical store for secondary products or offering a venue for educational exhibits, performances, and visitor centres. It's crucial to keep in mind that a construction hub serves as a means, not a goal, and that the demands of the local construction chain are what it most primarily serves (Gemeente Amsterdam, 2022).

Table 3 provides a short description, or an example of building material hubs found in literature. The table also indicates what role the type of hub plays in this thesis. The circular craft centre, circular building material hub, building material hub with urban development, circular multimodal building material hub and circular raw building material hub are treated in the literature study and elaborated as a case study. The mandatory building material hub, multimodal building material hub, raw building material hub and prefabrication building material hub are only discussed in the literature study. Other hub types fall outside the scope of this study as they are not in line with the internal circular functions earlier mentioned.

Table 3: Type of (circular) building material hubs

Type of building material hubs and source	Description	Circular function (Gemeente Amsterdam, 2022)	Role in this thesis
Construction site hub (Vrijhoef, 2022; Ludema, 2013)	A dedicated location on the construction site where materials are temporarily stored.	Not circular function is facilitated	Not discussed
Suppliers' building material hub (de Nijs en Zonen, 2022; Ludema, 2013)	The location of a preselected supplier where construction materials and equipment are consolidated.	No circular function is facilitated	Not discussed
Floating building material hub (Vrijhoef, 2022; Fynly, 2021; Mulder, 2020)	A floating location that can used for temporary storage and transhipment of building materials and equipment if the construction site is located adjacent to water.	No circular function is facilitated	Not discussed
Circular Craft Centre (Neuberger, Weidner, & Steane, 2019; Werner, Albers, Verschuurden & Dierdorp, 2020)	A location where a collection of existing (or new) initiatives are cleverly situated and organized in relation to each other, to realize high-quality product and material reuse.	Repository and marketplace	Literature and case study
Mandatory building material hub (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B)	A location where building materials are consolidated for several construction flows and is that is made mandatory for large new construction projects in a city.	Construction logistics	Only literature study
Circular building material hub (Van Merriënboer, Bastein, Rondaij & Rabbie, 2022).	A location where the collection, sorting and processing of non-bulk waste into secondary materials takes place.	Secondary material storage and repository and marketplace	Literature and case study
Multimodal material hub (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B)	A location that, depending on the construction phase, type of transport flow and construction site, uses other modalities next to the road where possible to transport construction flows.	Construction logistic	Only literature study
Circular multimodal building material hub (Van Merriënboer, Bastein, Rondaij & Rabbie, 2022).	A location where the collection, sorting and processing of bulk and non-bulk waste into secondary materials take place	Construction logistics and secondary material storage	Literature and case study
Building material hub with urban development (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B)	A location that coordinates construction logistics across multiple projects in an urban area.	Construction logistics	Literature and case study
Raw building material hub (Van Merriënboer, Bastein, Rondaij & Rabbie, 2022).	A (production) location that is primarily used for the processing bulk flows, such as concrete, gravel and asphalt.	Construction logistics	Only literature study
Circular raw building material hub (Van Merriënboer, Bastein, Rondaij & Rabbie, 2022).	A (production)location where bulk construction and demolition materials are processed into circular (raw) building materials.	Construction logistics, secondary material storage	Literature and case study
Prefabrication building material hub (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B)	A production location where prefabricated elements are produced for modular construction.	Construction logistics	Only literature study

Even though there are many definitions and terms like the term 'circular building material hub', there is no clear agreed definition or term for the concept of a location where secondary materials are collected and reused to reduce the use of virgin materials. Therefore, a CBMH can be considered an umbrella term for similar concepts of reusing building materials originating from demolition and construction waste.

Circular craft centre

This first typology of a CBMH can be characterised as a circular craft centre (figure 5). The term '*craft*' refers to a collaborative and individual activity applied in various ways and encompassing various meanings such as tinkering and small manufacturing (Anderson, 2012). The goal of these type of CBMHs is to make sustainable and circular material loops operational. To compensate for their limited scale and lack of resources, circular businesses typically operate in local networks. They believe that the CE is based on networks, which include not only value chain partners like users and complementing enterprises, but also associations, research institutes, and occasionally local governments (Zucchella & Urban, 2019). It is a location where people can meet, share knowledge, and create awareness around circular activities by giving the practical tools to move beyond traditional concepts of reuse, repurposing, and sharing to address more basic concerns of consumption (Neuberger, Weidner, & Steane, 2019). This type of hub is usually capable of generating income by providing space and equipment for companies and individuals interested in circular practices, providing educational services like workshops and teambuilding activities, and selling second hand construction materials that can be used for DIY-projects, this represented with the red arrow in figure 7. The materials originate from a variety of sources, including local building and demolition projects, people and businesses, and cultural events like exhibits and festivals (Buurman, sd), this is represented with the yellow arrow in figure 7. By using the network and collaborating with local waste separation stations, certain quality materials can be 'saved' from the circular activities lower on the circularity framework. However, some materials cannot be saved and will be transported to waste treatment, represented in the blue arrow.

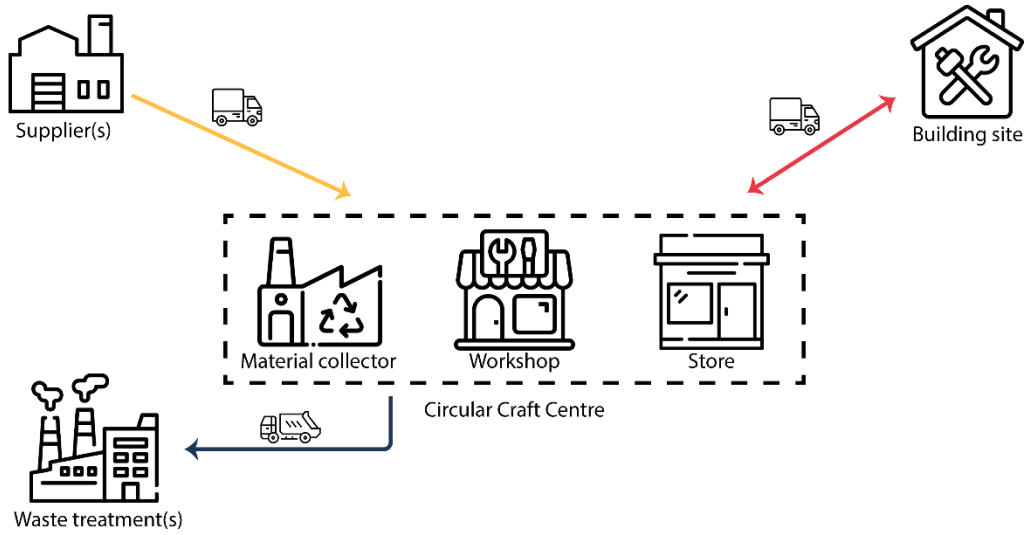


Figure 7: Scenario Circular Craft Centre (own figure)

A circular craft centre consists of collaboration between multiple 'building blocks' but generally incorporates a recycling centre, thrift shop and repair workshop. But other parties that can contribute to reuse secondary building materials can also take part in the network. There is a great opportunity for an online marketplace where all the materials will be visible for other local companies and residents (Werner, Alberts, Verschuuren, & Dierdrop, 2020).

The circular craft centre is made up of multiple main physical locations that will be briefly discussed below:

1. Material collector
The material collectors' main aim is to collect raw resources, materials, and products independently from residents to reuse as much as possible. Wood, metal, minor chemical waste, textiles, paper, and cardboard, (big) yard waste, and electrical appliances are only a few examples of materials that are collected at the location. Pursuant to Article 10.22 of the Environmental Management Act, each municipality in the Netherlands must ensure that there is at least one location where residents can dispose of bulky household waste (municipal recycling centre). For receiving and stocktaking the incoming materials that are send in by the public.

2. Dismantling station/ workspace
With the function of dismantling and (re)manufacturing the materials that have been received from the recycling centre and finally.

3. Hardware store or thrift store
The thrift store receives reusable products and parts for sale, such as: furniture, second-hand bicycles (and parts), clothing, audio equipment, toys, household items and books. But there are also second-hand building materials stores springing up, in the municipalities of Utrecht, Amersfoort, or Rotterdam.

Mandatory building material hub

In this second type of hub, the focus shifts to practices within the construction sector. The goal of this type of building material hub is to better cope with construction logistics and decrease construction traffic into the city. This is achieved by making the building material hub mandatory for several construction flows for one specific project. Here the materials will be consolidated into week/ day packages to be more efficient use of the transport capacity, these material flows are represented in yellow in figure 8.

The consolidation in week/ day packages does not apply to structural construction flows like as bulk and concrete, which are already delivered to the job site on fully loaded trucks, represented in green. These are already quite effective as they are point-to-point deliveries. By making this type of building material hub mandatory, a series of construction hubs will function on the outskirts of the city and the logistics of all construction logistics flows, both construction materials and construction equipment per construction project, are organized via these hubs (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B). A visual representation of the building material hub can be found in figure 8.

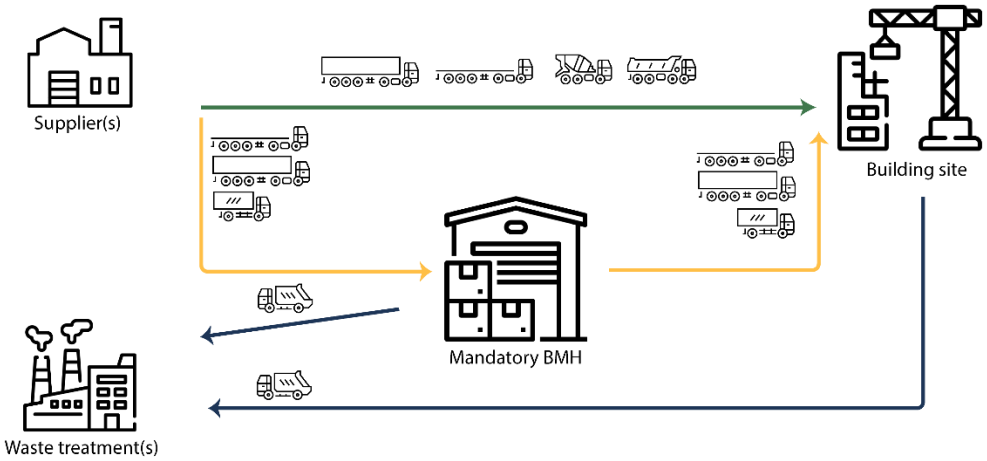


Figure 8: Scenario mandatory material hub (adapted from Van Rijn et al., 2020)

Existing cases

There are some cases where the building material hub is set up by a main contractor for one or more specific projects, in a local work area. In principle, this hub has a temporary character and is not open to access for third parties (Van Luik, 2021). An example of this is BAM's hub for the Zalmtoren in Rotterdam, where the building material hub is used for consolidation, buffering and prefabrication. In this particular case the trucks with structural elements and concrete also arrive at the mandatory building material hub first as this increased the predictability of the delivery (Rozendaal, 2020).

Circular building material hub

The third type of building material hub is the circular building material hub. This is a hub where the collection, sorting and processing non-bulk construction and demolition waste to secondary materials takes place. Furthermore, the hub can provide (temporary) storage space for secondary materials that were harvested from demolition sites and has a secondary logistical function. This hub is typically run by an independent business with a permanent character. The materials are primarily finishing materials, such as frames and doors and wooden products (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). As the CBMH has a marketplace function, the secondary materials are sold to suppliers that resell it for other construction projects (see red arrow in figure 9).

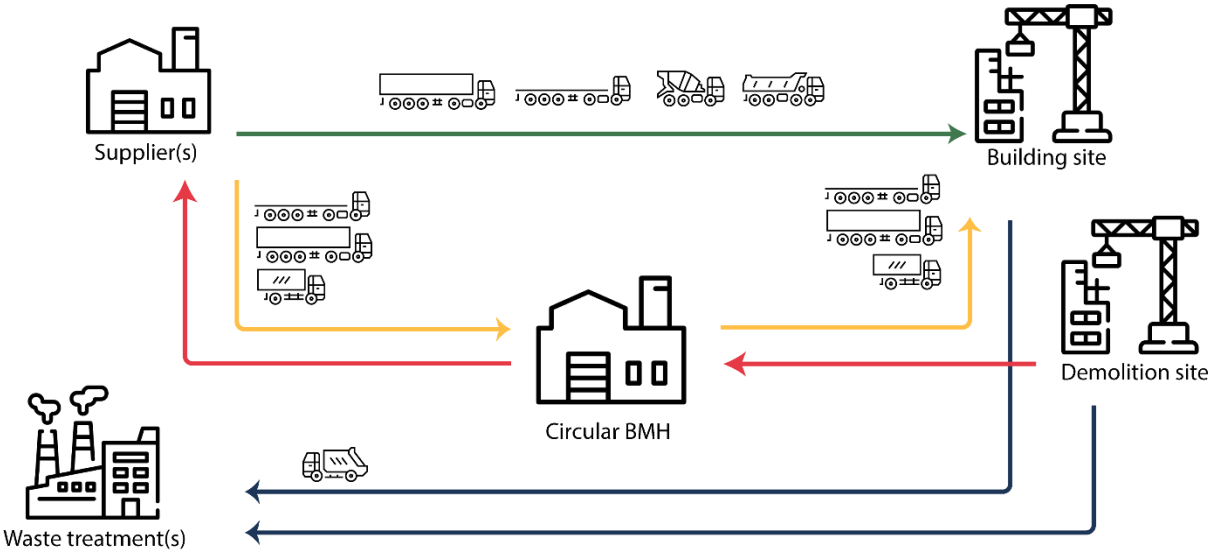


Figure 9: Scenario circular building material hub (own figure)

Multimodal building material hub

The fourth type is a multimodal material hub (figure 10). Partly due to the EU policy to remove transport flows from the road, transport modalities other than road transport are used in this scenario. Depending on the building phase, type of transport flow and location, other modalities are used where possible to transport the building material flows. The use of water, and to a lesser extent rail, requires multimodal building material hubs, where the transfer of building materials and building equipment takes place from road to water and/or vice versa, this is represented with the light blue arrow in figure 10. In that case, the building hub serves as a decoupling point on the edge of the city from which the material and equipment can be transported just-in-time to the building site in a bundled manner (Rijn et al., 2020). This type of hub is typically run by an independent business with a permanent character that acts as a logistical centre of various construction projects, supporting a greater surrounding area (Van Luik C. , 2021).

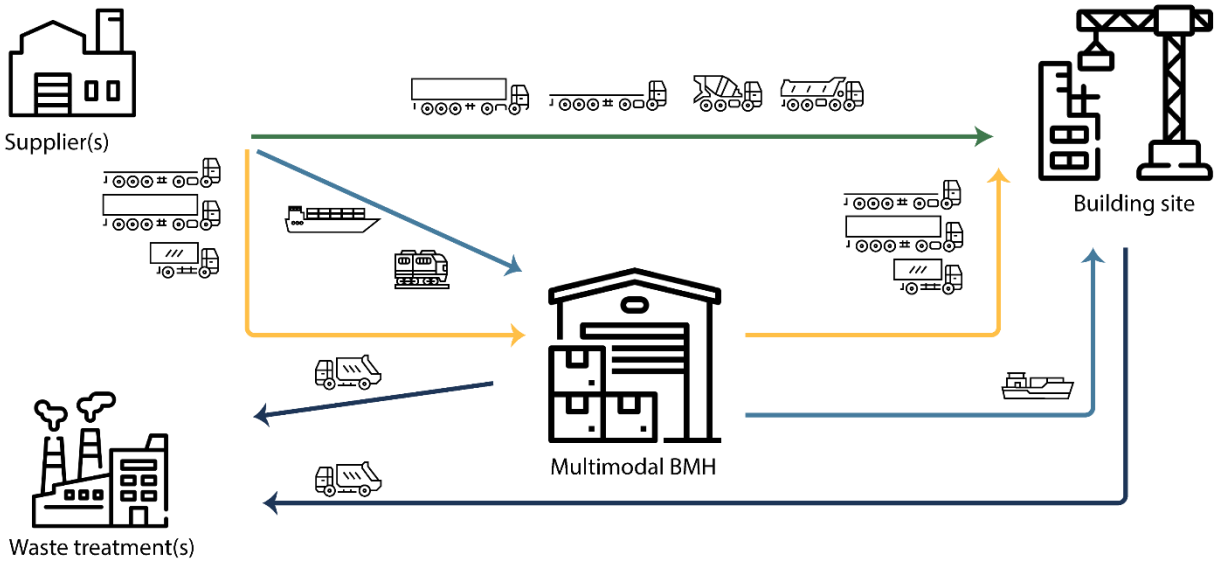


Figure 10: Multimodal building material hub. Adapted from (Van Rijn et al., 2020 B)

Existing cases

This type of building material hub can be found in Brussel, Belgium. There the 'Building Material Village' is a critical link in the transition to a CE, it is home to construction materials companies that, among other things, may recycle materials from the city's destruction of buildings into new building materials for the city. Furthermore, the Building Material Village is suitable for businesses who want to take advantage of the location next to the canal (Dudal, sd). The waterway and the Vergote Dock can activate inland shipping and contribute towards the huge logistical turnaround that is designed to keep heavy goods traffic out of the inner city since they carry shipping deep into the heart of the capital (De Caigny, sd).

Another example can be found in Amsterdam where multimodal building material hub has been set up to facilitate the last mile over water. Because of the difficult accessibility of the construction project by road in the centre of Amsterdam, the starting point for this project was that all logistics to the building site will go by water, unless this is not possible (Van Rijn, Harmsen, Rondaij, & Eckartz, 2020 A). The hub was in Amsterdam North and was accessible by road for the suppliers. From there the supplies were delivered twice a week by a barge, that was powered by a hybrid engine. A large part of the inner-city journeys by road consists of transport of small and light construction materials. These are transported to the construction site in an electric delivery van (Van Rijn, Harmsen, Rondaij, & Eckartz, 2020 A).

Circular multimodal building material hub

The fifth type is the circular multimodal building material hub. This typology is based on the multimodal building material hub, but has that added facilities for collection, sorting and processing non-bulk construction and demolition waste to secondary materials (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). Furthermore, this hub can also provide (temporary) storage space for secondary materials that were harvested from demolition sites. The processed secondary materials are supplied to suppliers who then resale them for use in other construction projects as part of its market function (see red arrow in figure 11). This building material hub had a permanent character and is operated by an independent company.

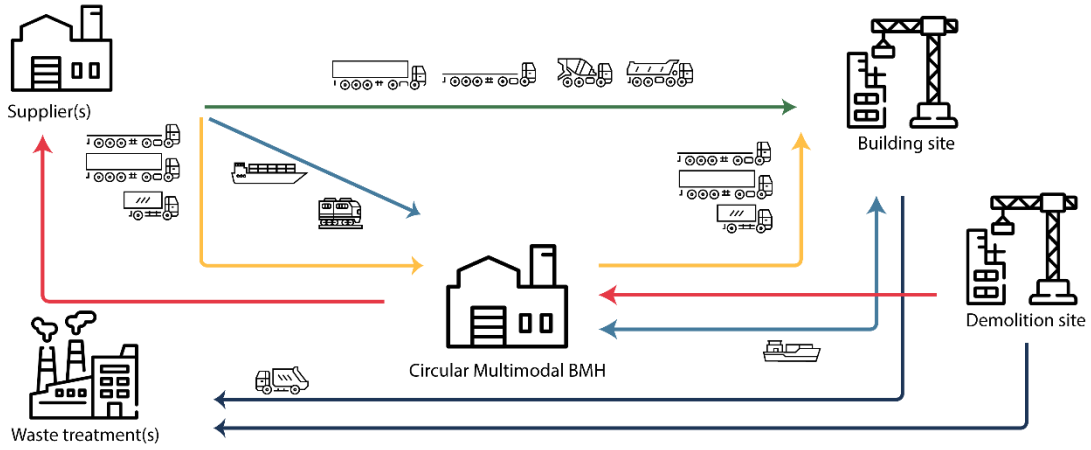


Figure 11: Scenario circular multimodal building material hub (own figure)

Building Material hub with urban development

This type of building material hub integrates the construction logistics of an urban development of a city. This can be assisted by an area-oriented control tower in conjunction with a construction hub results in more accurate and faster construction logistics processes and reduced construction logistics traffic within cities due to the high integration of ICT technologies in different development phases. The difference between the mandatory building material hub and this typology is that the supply chain management of all construction flows occurs here at the individual project level (per construction project) over all construction flows between the suppliers of one construction project and the construction site, rather than across multiple projects that overlap in time. This type of hub is characterized with a permanent location central to the urban development of a region and run by an independent business (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B). The suppliers are unloaded without waiting times, the deliveries are consolidated into day packages and are transported to the construction projects in the inner cities in the smartest way. Open data is used for this. Products are also prefabricated on the construction hub. Furthermore, the construction hub also serves as a parking space from which the construction site employees are brought to the construction site.

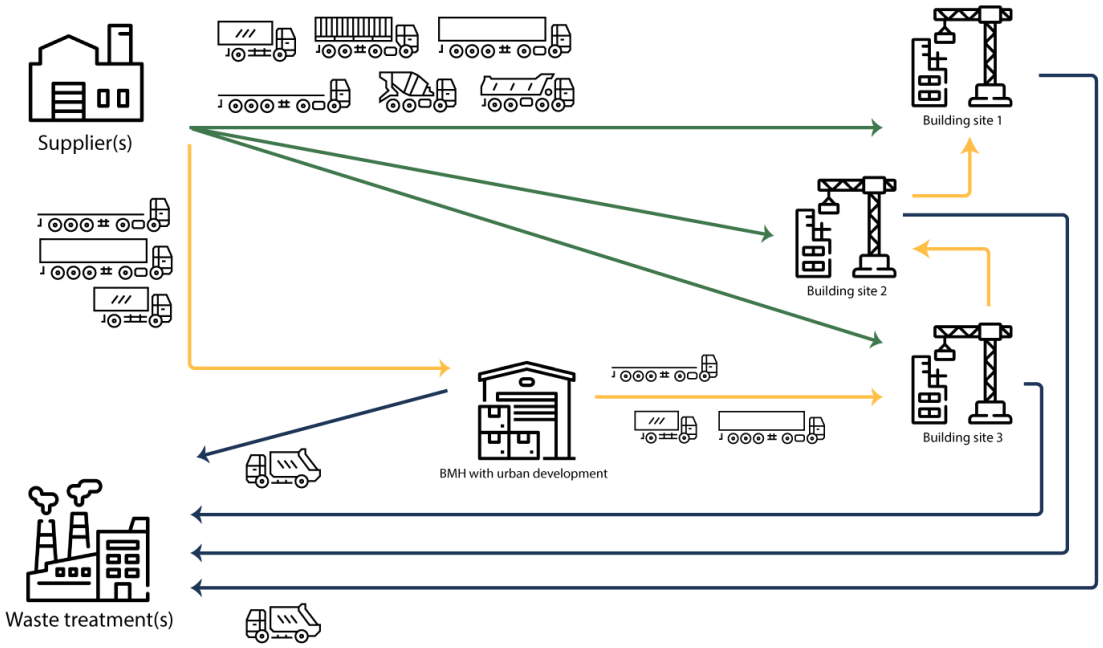


Figure 12: Scenario building material hub with urban development. Adapted from (Van Rijn et al., 2020 B)

Raw building material hub

The raw building material hub is a (production) location that is primarily used for the processing bulk flows, such as concrete, gravel and asphalt. This concerns a collection of companies, often with a high environmental category, which means that obstacle circles must be taken into account (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). This type of hub is characterised by with a permanent character and is run by multiple independent companies.

Existing case

Binckhorst is an example where two concrete batching plants, a waste processor and a sand trade are close by.

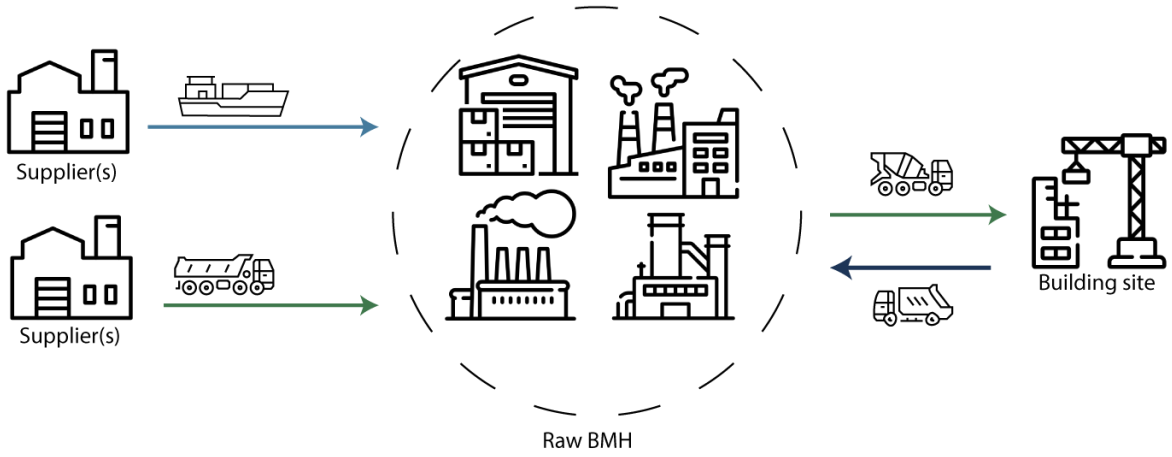


Figure 13: Scenario raw building material hub (own figure)

Circular Raw building material hub

Even though they share a common basis, the circular building material hub' and a circular raw building material hub are fundamentally distinct from one another. A CBMH is a point of spatial logistics that aids in the construction process by providing a central location for the storage and delivery of building materials. A CBMH is substantially smaller than a circular raw building material hub. Due to the fact that obstacle circles is a grouping of high environmental category 4+ (HMC4+) firms, it must be taken into consideration (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). One circular raw building material hub is frequently sufficient for each big city and/or region due to its size (Kreeft & Vonk, 2019). These processes in the building logistics affect the flows inside and beyond the city, in terms of deployed vehicles and frequency of deliveries. This hub us characterized by the manufacturing companies with a high environmental level will be clustered that lay a bigger claim on the available space. In this location high energy demanding facilities like concrete, asphalt plants and the production of other materials will be there. As these manufacturing facilities will share the energy, the accessibility to mass energy is a key consideration in this type of cluster (see red arrows in circle in figure 13). Furthermore, bulk materials that come from urban mining can be remanufactured in this location. Urban mining is a concept for recovering and high-level recycling resources from the built environment can be used to avoid this wasteful kind of reuse.

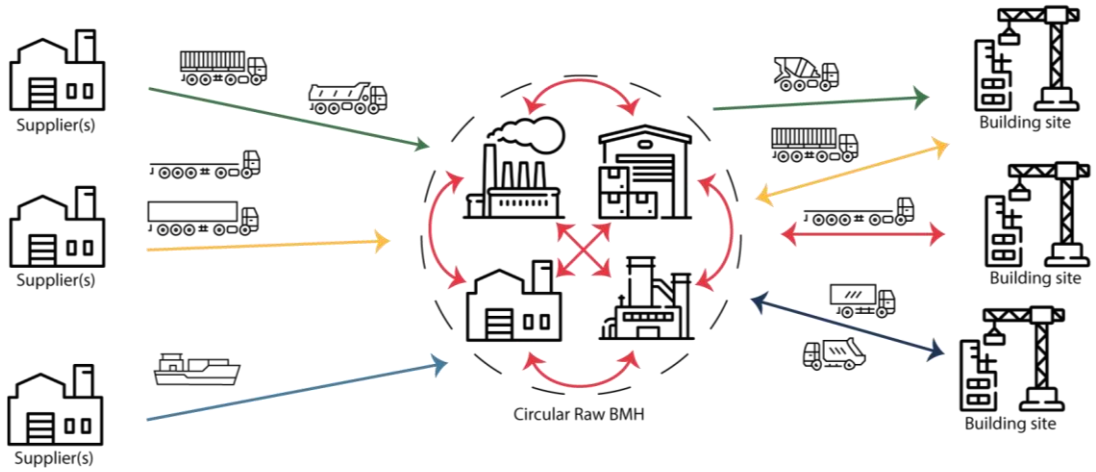


Figure 14: Scenario circular raw building material hub (own figure)

Prefabrication building material hub

In this final typology, new (logistical) construction processes, such as prefab and circular construction, are central. Building with prefab building elements (modular) is widely used, which significantly reduces the amount of construction logistics flows in the cities. Here, construction work is moved from the construction site to the front of the logistics chain, i.e., to the factory/production location. During construction, the prefab building elements are transported directly from the factory to the construction site for assembly. The easiest way to explain the logistics idea that matches this working technique is as a logistics chain process, wherein when many prefab building pieces are placed on the construction site, serial logistics actions are performed. A logistical train between the factory and the construction site will be created by carrying out these operations in succession for an entire series of homes in a housing project or building layers in a non-residential building project, allowing for the application and improvement of logistical optimizations (Van Rijn, Rondaij, Van Merriënboer, Kin, & Quak, 2020 B).

Existing cases

In Dokkum, the first prefabrication building material hub of Dijkstra Draaisma, opened its doors in 2017. On the 'Kanaal' business park in Heerenveen, construction company Van Wijnen is constructing a prefabrication building material hub now. The factory is 15 meters tall and has a 1.4-hectare size. Starting in 2022, 4,000 dwellings can be built annually. The plant produces the components. Small teams work on assembly on the construction site after that. The homes are entirely modular, allowing for rapid disassembly and assembly in a different site. The first of five manufacturing halls for the residential factory being built by Plegt Vos in Almelo's Business Park Twente will be operational in 2022. 6,000 dwellings are intended to be built per year. (Warringa, Juijn, van Heest, & Hagens, 2022).

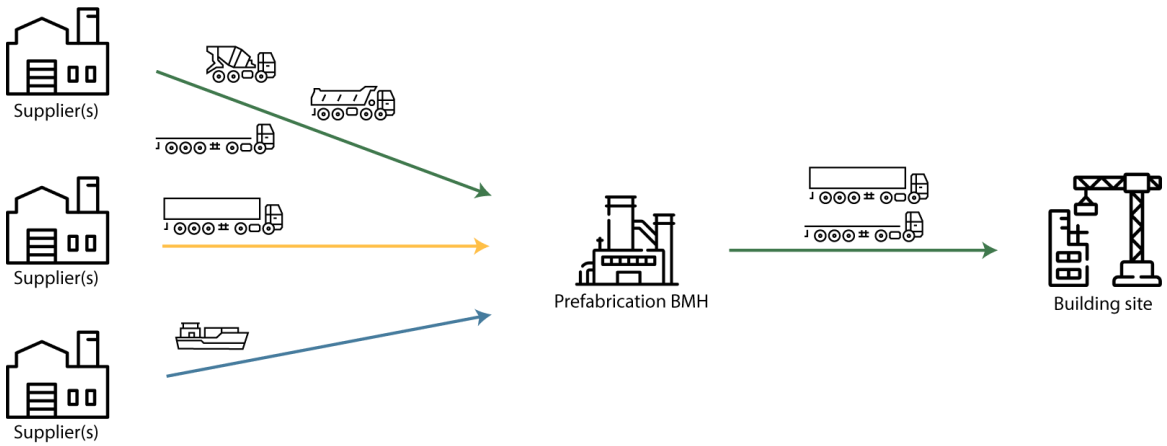


Figure 15: Scenario prefabrication building material hub. Adapted from (Van Rijn et al., 2020)

2.5 Territorial factors of CE

Despite globalization, there are still notable variances in economic specialization, competitiveness, convergence/divergence patterns, and general socio-economic differences among territories (Iammarino, Rodriquez-Pose, & Storper, 2019). These include aspects connected to the physical endowment, such as infrastructure, as well as immaterial assets derived from social constructions, such as political and administrative jurisdictions, institutions, cultural values, and so on. According to Tapia, Bianchi, Pallaske, & Bassi (2021), there are six territorial factors that shape the closed-loop systems, upon which a territorial definition of the CE is developed. The factors are: (1) land-based factors, (2) economic factors, (3) logistical factors, (4) technical and knowledge factors, (5) social factors, and finally (6) governance and institutional factors. These six external factors are adapted to analyse the emergence of the different typologies of (circular) building material hubs in this thesis. The twenty-six sub-factors must be considered as a whole rather than individually in order to fully understand the concept of each typology. Isolated approaches towards the individual factors might result in incomplete and, therefore, less effective conceptualizations of the various types of the (circular) building material hubs.

Land-based factors

Land-based factors emphasize the relevance of natural building resources to satisfy the growing demand for (secondary) raw materials for a circular built environment in the province of South Holland. Even though energy and CE transitions may reduce demand for some types of basic raw materials, the demand for metals and biological materials is predicted to grow significantly in the next decades as fossil-based fuels and materials are replaced by alternative biobased sources (Bell, Paula, Dodd, & Németh, 2018). Therefore, the availability of secondary and biobased raw materials and (construction) elements will be an essential starting point for project developments and the development of (circular) building material hubs. Currently, there is a significant concentration of natural resources in buildings and infrastructure, products, and waste deposits, implying that these accumulations may become temporary material storage to meet the future demand (Sanchez & Haas, 2018). At a time when resources are becoming severely scarce, these techno-spheric resource reserves can offer a chance for more environmentally sustainable development, or at least provide a local alternative to imported, virgin materials and waste recycling (Krook, Svensson, & Eklund, 2012). However, until the building stock is fully saturated a mismatch in the availability of circular material flows will occur (Heeren & Hellweg, 2018).

Central to demolition and construction projects

Typically, there is not much room on the construction site to store construction materials or waste until they can be used or disposed of in inner-city construction projects because of the confined spaces. Therefore, the circular construction hub can serve in the first place as a storage facility to deal with the time variance of supply and demand, making one-on-one reuse (R3 on R-ladder) feasible (Loeber & Snoek, 2020). Modular construction also requires the hub to be close to the construction sites, because otherwise logistic become too expensive. A circular construction hub with a regional supply area is best situated on the outskirts or right outside the city. Locations on the outskirts or close to the city keeps supply traffic separate from urban traffic. Moreover, the location of the construction hub should be carefully considered in respect to the source of workers too. However, the degree of fit of certain sites and the likelihood of developing a strong business case are significantly influenced by the scarcity of open space and the high cost of land (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). The location of the construction site largely determines the real need for a construction logistics hub. If the area is densely built-up and difficult to reach with large trucks, it is necessary to deliver to the construction site with adapted transport (De Vries & Lundema, 2012).

Insights to available materials and status

Building material databases have recently been released to harmonize the current data on building materials and to enable cross-national comparisons of research and data (Verhagen, Sauer, van der Voet, & Sprecher, 2021). Buildings as Material Banks (BAMB), an EU-funded project, is one of the key projects in Europe to drastically convert the industry into a circular construction economy. Information about the kind, configuration, volume, and location of materials can be recorded and shared throughout the value chain by creating a database of materials known as materials passports. This opens the possibility of generating a market for the reuse of building materials. But obtaining accurate information on the materials used in the current building stock is still a challenge when generating materials passports. It is not sufficient to know where and what materials are present to ensure that measures can be implemented to collect and utilize the materials (Chan, De Wolf, & Koutamanis, 2021). Besides, the speed at which the buildings are plotted is still rather slow (Loeber & Snoek, 2020). At best, current estimates are untrustworthy, particularly in the localized context and in relation to renovation projects; there is a knowledge gap in knowing the precise context of a building component so that information about how it is assembled and the changes to its state may be collected to assist extraction for reuse, repurposing, remanufacturing, or recycling (Koutamanis, van Reijn, & van Bueren, 2018).

Temporary or permanent character

Local governments find it challenging to maintain control over the locations and the quantity of construction hubs in each area when construction hubs are implemented on a wide scale at the individual project level. This may result in unpleasant circumstances that cause considerable annoyance in a particular location (Van Merriënboer & Rondaij, 2020). To be able to play a fundamental role in the construction objective for the next ten years in the region, the permanent circular construction hub is situated in a strategic location. It must be possible to set up the location "robustly" because it must be used for a longer amount of time (i.e. not briefly or accidentally) (Van Luik C. , 2021). However, some locations are not suited for the permanent intention of a circular building hub, this is an important for addressing the main objective of the hub and select the most suitable type of circular building hub to be implemented (SUCCESS, 2017).

Use of existing hubs

According to Van Merriënboer, Bastein, Rondaij, & Rabbie (2022), the conversion of a construction hub for non-bulk flows into a CBMH represents one of the biggest potentials for increasing the sustainability of the process of delivering building materials towards a circular process.

Space to expand business

It is necessary to consider the significant use of space for the longer-term storage of reusable secondary building components. Even when spread out among so-called satellite hubs, the entire process from recycling construction and demolition materials to using secondary building materials in new projects eventually results in a bigger storage requirement in the overall chain (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). In a study for the space requirements for a circular building sector for the Metropolitan Region Amsterdam by Kreeft & Vonk (2019), that a total of 30 to 50 hectares needs to be added for reaching the circularity ambitions.

Economic factors

Economic factors are referred to as clusters of enterprises, consumers, and/or production elements required to carry out specific CE activities. When diversity and complementarity are crucial enabling variables, such as in industrial symbiosis programs, industrial agglomerations establish the appropriate conditions for all CE projects (Brown, Bocken, & Balkenende, 2019).

Economies of scale can also help with the recovery of low-value materials that require large volumes to keep the reclamation facilities financially viable. It is generally understood that the lower the material's value, the greater the quantity required for a profitable process (Zeller, Towa, Degrez, & Achten, 2019). As argued by Remoy, Wandl, Ceric, & Van Timmeren, (2019) the CE should be designed and executed structurally and on a large scale, expanding beyond cities, to produce a resource-efficient built environment. Local governments, individuals, and other stakeholders will require a collaborative and science-informed decision environment to create diverse waste and resource management choices and analyse their implications on the environment, resilience, spatial quality, and quality of life to achieve this. Furthermore, there is great pressure on existing manufacturing parks in South Holland through space claims from the housing crisis, energy transition and climate adaptation. In addition, there is still an expansion demand for industrial estates (De Bouwcampus, 2020).

Operational scale

This subfactor relates to the capacity and the operational scale of the hub. According to De Vries & Ludema (2013) the operational scale of the hub is an important variable as it relates to the capacity for storage of materials and space for parking trucks and trailers. The operational scale of the hub is also determined by the range of ZE vehicles (electric trucks, vans, and cargo bikes) (Van Luik C. , 2021).

Facilities on R-ladder

Various parties are currently experimenting with the mechanical recycling of material fractions in concrete. For example, the knowledge platform CROW has developed a method with which sand and gravel fractions can be recovered from used concrete, and the Rutte Group has developed a technique with the Smart Liberator for recycling cement (CE Delft, 2020). In addition to mechanical recycling, thermal recycling is also possible. With the combination of mechanical and thermal treatments, concrete rubble can in theory be completely recycled into individual fractions.

Business case

According to Loeber & Snoek (2020), a positive business case is where the CBMH's success begins. If a hub is solely losing money, it is not serving its intended purpose. For firms to be willing to operate one, it must have a compelling business rationale or at the very least be cost neutral. According to a recent study on circularity in the built environment, having an undefined business case is the biggest obstacle (Adams, Osmani, Thorpe, & Thornback, 2017). According to TNO (2022), to achieve a positive business case for circular reuse of non-bulk construction and demolition materials, operating on a regional scale is required to cover the transport cost and the high land prices. Within the different typologies of Building Material hubs the amount of circular business cases varies.

Connecting supply and demand

Temporary storage to bridge the supply and demand of secondary materials. Considerable use of space for the storage of reusable secondary building materials for a longer period of time must be taken into account (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022).

Logistical factors

Powerful CE networks may not only involve markets in terms of size and shape. Closing building material loops also necessitates businesses having easy access to secondary materials and by-products, as it can greatly affect running expenses of firms adopting circular business models or participating in industrial symbiosis (Holgado & Aminoff, 2019). Industrial symbiosis is a branch of industrial ecology that brings together historically separate organizations in a cooperative effort to gain a competitive edge through the physical interchange of materials, energy, water, and by-products. Collaboration and the synergistic opportunities given by geographic closeness are the keys of industrial symbiosis (Chertow, 2000). Another driver of accessibility factors is infrastructure facilitates as it determines the

efficiency of transportation and re-allocation of stocks. As argued by Malinauskaite, et al. (2017) having in place efficient (inter)national transportation systems and logistic hubs can be significantly advantaged when it comes to triggering the economies of scale related to for example the processing of secondary raw materials and/or low value waste collection and recycling. However, as stated by TNO (2022), due to the poor economic worth of many building materials, the viability of reuse is immediately constrained by an increase in logistics costs.

The port area of Rotterdam is of course an important import location for the province of South Holland, importing wood now takes place a lot from within Europe and follows the Rhine and Waal. In addition to the North Sea route, much use will be made of the Dutch inland waterways to supply raw materials and materials for construction (Van Schaick, 2021).

Accessibility to main road network

De Vries & Ludema (2012) argued that the accessibility to the road was a determining factor for the location of the construction hub. Given the relatively heavy vehicles that are used to supply the hub, a location at a (very) short distance to the main road network is important. When the location of the hub is on the edge or just outside of the city, it prevents supply traffic from mixing with urban traffic (Van Luik C. , 2021). Moreover, if approach routes to the construction site have limited capacity or vehicle restrictions apply, the hub can bundle loads and thus reduce the number of trips to the actual construction site.

Accessibility to water quay

De Vries & Ludema (2012) also took into account the accessibility via the water as a determining factor for the location of a construction hub. This is especially useful for transporting (bulk) materials between the hub and building sites (if these are located on the water). Because transportation by water is not always practical, everything associated to water gives the location an added bonus but is not a requirement (Van Luik C. , 2021). Only a water-bound construction hub with extensive harvesting ('urban mining') and circular reuse of building and demolition materials might be necessary from a logistical cost viewpoint (Loef, 2021).

Zero Emission zones

According to the Climate Agreement, thirty to forty larger municipalities in the Netherlands will begin implementing medium-sized zero-emission (ZE) zones for city logistics as of 2025 (Zero Emissie Stadslogistiek, 2020). The ZE zone is the geographical area in a city to which this declaration of closure applies, and certain vehicles are not allowed to drive. Different municipalities within the province of South Holland are implementing ZE zones at varying rates. The implementation of ZE Zones in smaller municipalities has received little to no attention, in contrast to the G-40 municipalities that are actively working on this. It is also remarkable that the towns that do not create ZE zones are also startlingly ignorant of the effects that these ZE zones do have (Van Luik, Lubberding, Peskens, Jesus, & Regterschot, 2021). To permit the usage of ZE vehicles, the distance to the circular construction hub must not be too considerable (trucks, delivery vans, cargo bikes).

Logistical information system

There are various options for shaping collaboration. For example, the LCCC in London started as a partnership between various companies from the construction logistics chain and government authorities. A construction company in the Netherlands that has investigated the possibilities of using a dedicated construction logistics hub has held talks with a logistics service provider, an ICT supplier and several suppliers. Here the ICT supplier supplies the ICT system to establish communication between the various parties (web-based). The municipality employs a model for logistical forecasting in both Rotterdam and Amsterdam. With the help of this model, a prediction for (big) construction

projects and the associated construction traffic may be made (both passenger and freight traffic in the various construction phases). The model reveals whether and where in the road network accessibility or safety bottlenecks occur. These results might prompt actions to scale back transportation or to suggest a less obtrusive path for construction (Van Luik C. , 2021).

For information sharing regarding the logistics process connected to the tactical and operational planning of the construction process, the construction sector now lacks good supporting ICT (De Bes, et al., 2018).

The lack of coordination between the numerous parties involved is a significant issue in the building industry. Therefore, a comprehensive planning software is also necessary to make this better. To coordinate their operations, everyone involved in this will need to communicate information (Vleugel, et al., 2021).

Technological and knowledge factors

In today's dynamic business environment, decision-makers are frequently faced with the task of gaining a competitive advantage over their competitors. Technology-driven, innovation-based competition tactics are frequently used to seek and promote competitive advantage (Grillitsh & Asheim, 2018). Not only do innovation in technologies enable the adoption of CE activities along the value chain, but they also play a crucial role in unlocking the market for low-value secondary materials (Jawahir & Bradley, 2016). The significance of new technologies in supporting circular transformations and as a crucial facilitator for industrial variation. It connects automation and data exchange to industrial production using smart sensors, big data, the internet of things, automation/robotics, and other technologies. Existing products and processes develop in intelligence and efficiency. Moreover, manufacturing processes are becoming smaller, quieter, less destructive, and more diffused because of technological advancements (Hatuka, Ben-Joseph, & Peterson, 2017).

Changing construction method

The first technological factor is the changing construction method in the Netherlands. Modular construction (industrialisation) enhances the possibilities of one-on-one reuse of construction materials and can have a positive addition the scaling of a circular built environment in the province of South Holland. This necessitates the large production locations, storage facilities, specialized vehicles, as well as other things like wide access routes. This form of building goes hand-in-hand with an increase in prefab constructions and standardized and modular building parts. In the long run, this could have consequences for the net use of materials in residential construction, if efforts are made in time to facilitate the re-use of modules in residential construction (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022). The circular construction hubs can play a big role in facilitating this (Loef, 2021).

Innovation and product development

According to (Warringa, Juijn, van Heest, & Hagens, 2022) there is a clear trend in using reinforced concrete in more circular ways and biobased modular construction. A common factor in this shift will be the goal to lower CO2 emissions. The usage of reinforced concrete might be largely replaced by modern timber construction, which is a renewable material. Cross-laminated timber construction (CLT), timber frame construction (HSB), and timber module construction (HMB) are the three most popular types of wood building (Centrum Hout, 2021). Timber module construction combines cross-layer and timber frame construction; similarly, to the concrete chain, prefabricated components are assembled on the construction site. Compared to a terraced house built based on a concrete construction, CO2 emissions fall by about 30% (Centrum Hout, 2021). When the CO2 captured in wood also counts as negative emissions, this rises to more than 50%. Large, prefabricated building components need to be transported frequently when using modular construction.

However, the province of South Holland does not have forests to provide the wood and time to grow trees on this regional scale (Van Schaick, 2021). So next to the use of secondary materials and biobased materials from the region of South Holland, importing biobased materials like wood will be necessary to deal with the demand. Since January 1, 2022, the Russian government has imposed export limitations that have an impact on wood imports from Russia. Timber imports from this region of Europe are at a standstill due to European sanctions on Belarus and Russia as well as the conflict in Ukraine. It is anticipated that the other wood-producing nations, particularly Scandinavia, Germany, and the Baltic States, will only be able to take in a small portion of this volume (Houtblad, 2022).

Balanced mix of knowledge and skills

The availability of legal and technical capability, skills, and information, as well as access to advice and the ability to gather and absorb knowledge, are known as knowledge factors. For corporations, governments, and individuals, knowledge considerations are equally important. These considerations become essential in the private sector for the creation of more sustainable products and services through initiatives such as eco-design, life cycle thinking, and circular business models (de Jesus, Antunes, Santos, & Mendonça, 2018). As stated by (Marra, Mazzocchitti, & Sarra, 2018) a larger body of knowledge is required to pass information from micro to macro level policies for CE, as well as a deeper integration of varied skills. Regional places with the most balanced mix of knowledge sources, encompassing symbolic and analytical aspects of knowledge, have been the most innovative (Květoň & Kadlec, 2018). However due to digital knowledge sharing, the physical clustering of knowledge is not always required (De Bouwcampus, 2020).

Resource sharing

Collaboration across enterprises in the (high-tech) value chain is becoming increasingly vital to stay innovative and competitive. This leads to others sharing company premises, amenities, and services at the location level (Stec Groep, n.d.).

Social factors

The execution of circular transitions and the acceptance of circular consumption require the public's understanding and congruence between public and governmental interpretations of the CE (Borrello, Caracciolo, Lombardi, Pascucci, & Cembalo, 2017). The likelihood of a shift to circular construction and demolition decreases if there is little understanding that there are issues with resource scarcity, poor waste management, or emissions.

Initiator

According to Loef (2021) there are many reasons to initiate circular business models. The most important motivations for public parties are to play an exemplary role in challenging the climate crisis. They see circularity as a sustainable source of employment and making an impact through SRP. Furthermore, contractors are mainly driven by customer demand and ambitions of public parties. In addition, it has been found that for contractors the intrinsic motivation of sustainability pioneers has played an important role to act in the field of circular construction. There are social entrepreneurs in bottom-up urban development. These actors strive to provide social benefit while challenging established institutions because they are dissatisfied with conventional procedures and are taking advantage of opportunities presented by the 2008 financial crisis (Mens, van Bueren, Vrijhoef, & Heurkens, 2021).

Public awareness

Public awareness considers the perception of the public, government, and market on circularity in the built environment. Van Buren et al. (2016) claim that consumer and logistics industry awareness about circularity and optimizing construction flows is underdeveloped. This lack of urgency precludes a

widespread transition to circular building and demolition, and it places the onus of driving change on businesses with long-term goals (IMSA Amsterdam, 2013). In 2017 the Green Deal Sustainable Logistics in Construction (DLB) was launched that focuses mainly on increasing awareness in the chain and optimizing construction logistics processes, especially transport (GreenDeal, 2017).

White label

In previous study the term shared hub was use as a definition for a construction hub that was used for multiple construction sites. It was uses a one of the variables for the realisation of a construction hub (De Vries & Lundema, 2012). The Some transporters of construction materials are equipped with dedicated storage, making them capable of serving as their own hub. However, transporters also see chances in "white labeling," their hubs, which enables the delivery of bundled items from many suppliers to building sites in a single, time-saving journey. This already happens frequently in bulk deliveries (De Vries & van Duin, 2021).

Type of clients

According to Loef (2021), there is a wide variety of motivations among public organisations, housing associations, project developers, contractors and within the organization categories itself to ask for circularity during construction projects. Increasingly, socially responsible procurement and tendering practices include circularity. Because it is viewed as a source of employment, circular construction is a top priority in the big cities (Rotterdam and Amsterdam). The topic can develop greater administrative ability and, as a result, be profiled more effectively in the implementation of the circular policy by taking a more holistic approach to it (Loef, 2021). Next to that, the involvement of all parties in the process in a timely matter after the start of the project is important, from architect to skilled worker on the construction site, ensuring support throughout the whole team (De Bes, et al., 2018; Ludema, 2013).

Governance factors

Governance and institutional factors help to facilitate the circumstances for CE activities to take root and materialize in real acts (Kanda, del Río, Hjelm, & Beinkowska, 2019). One of the five sectors emphasized by the EU action plan on reducing transit loops to CE is "construction and demolition" waste (European Commission, 2020). Setting recycling standards for building and demolition waste, as well as embracing eco-design to increase competitiveness and reduce waste output, are the top priorities at this level. Governance and institutional arrangements not just to encourage the adoption of CE principals, but also the development of other variables such as information spreading and enhanced collaboration among businesses (Niesten, Jolink, Lopes de Sausa Jabbour, Chappin, & Lozano, 2017).

Environmental zoning category

Environmental zoning is the creation of a necessary spatial separation between environmentally harmful and environmentally sensitive functions in order to protect or improve the quality of life (Kenniscentrum InfoMil, sd). The publication Companies and Environmental Zonering (VNG, 2009) is an important standard work for environmental zoning. The publication indicates for many industries and installations: which environmental issues can play a role and which average distances to residential buildings are 'appropriate'. The environmental zoning that make certain (re)manufacturing activities possible on locations. In table 4 an overview of the different categories.

Table 4: Environmental zoning categories. Adapted from (VNG, 2009)

Environmental category	Description of category
Category 1	Activities, which by their nature are permissible between or immediately next to dwellings; greatest distances 0 and 10 meters
Category 2	Activities, which by their nature are only permissible between or immediately next to homes, if concentrated in a neighbourhood or community centre; greatest distance 30 meters
Category 3	Activities, which by their nature are permissible on the fringe of residential areas; greatest distances 50 and 100 meters
Category 4	Activities, which by their nature should be separated from residential areas, for example by means of green areas, public gardens, or water; greatest distances 100, 200 and 300 meters
Category 5	Activities, which by their nature must be quite far from residential areas; greatest distances 500, 700 and 1,000 meters
Category 6	Activities, which by their nature are only at a great distance from residential areas can be located; greatest distance 1,500 meters

Regulation

Regulations set by local authorities include restrictions on the use of roads for trucks, window times for inner-city delivery, requirements for emission standards for certain trucks, CO2 compensation cost schemes, rules concerning the disposal of waste, and the refusal to grant permits for certain trucks. storage, transhipment, and temporary parking and/or stopping on or near construction projects (sometimes in combination with a time regime) (Ludema, 2013). The BLVC includes 4 important aspects, accessibility, liveability, safety, and communication, that require a lot of attention during a construction project. Based on the BLVC system, clients of projects and their builders come to good agreements with the project environment, so that they experience as little nuisance as possible. Some municipalities, such as Amsterdam and Utrecht, have made the preparation of a good BLVC document a condition for obtaining a permit to perform work in public spaces. These municipalities see BLVC as a good instrument for properly managing the execution of work in a busy city (Van Luik C. , 2021).

Market

For some projects, fictitious discounts are given on tender prices to encourage circularity, so that tendering parties strive for maximum achievable circular performance. In some cases, tenders only ask for a vision on circularity, while in other cases circular criteria are used in the tender (Loef, 2021).

Financing

According to Van Buren et al. (2016), one of the primary barriers to circular logistics in The Netherlands is a lack of investing power. Businesses must invest in new systems, tools, and contracts, all of which have substantial up-front expenses and won't provide profits for several years. The Dutch government works to promote these kinds of initiatives through grants.

Factors of analysis

In summary, the six main factors on the building material hub result in 26 factors of analysis (table 5). The twenty-six criteria must be considered as a whole rather than individually in order to fully understand the concept of each typology. Isolated approaches towards the individual factors might result in incomplete and, therefore, less effective conceptualizations of the various types of the (Circular) Building Material Hubs.

Table 5: Factors of analysis with their description

	Factors of analysis	Description
Land Based	Central to demolition and construction projects	The location of the hub is central to demolition and construction sites.
	Insights to available materials	The hub is actively using material databases for monitoring secondary materials.
	Temporary or permanent character	The location of the hub has a temporary or permanent character.
	Use of existing hubs	The hub makes use of other existing construction hubs for the logistical flows.
	Space to expand business	The location for the hub was selected based on physical space to expand the hub.
Economic	Operational scale	The hub's operational scale, related to the warehouse capacity.
	Facilities (R-strategy)	The hub has multiple facilities related to the R-ladder.
	Business case	The hub has primary and secondary circular business cases.
	Connecting supply and demand	The hub has a key function in connecting the supply and demand for secondary materials.
Logistical	Accessibility to main road network	The location of the hub is located close to the national road network.
	Accessibility to water quay for transhipment	The location of the hub is located adjacent to water.
	Zero emission last mile	The hub actively works on zero emission last mile for the distribution of materials.
	Logistical information system	The hub uses a logistical information system for the optimalisation of the logistical flows.
Technological & knowledge	Changing construction method	The hub's role in industrial construction.
	Innovation and product development	The hub is actively working on developing new technologies and knowledge.
	Balanced mix of knowledge and skills	The hub adds to the deeper integration of varied skills.
	Resource sharing	The hub is actively sharing knowledge and insights with other companies.
Social	Initiator	Companies that have a main role in realising the hub.
	Public awareness/ societal pressure	Increasing awareness was a goal for the hub.
	White label hub	The hub has a white label and is available for other companies.
	Type of clients/ consumers	The hub is available for C1B and/or B2C.
Governance	Environmental zoning category	The environmental zoning for hub's location.
	Regulation	Policy instruments that have an impact on the hub daily operations.
	Market	The hub's collaboration with public and private parties.
	Financial	Public and private financing used for the realisation of the hub.

2.6 Analytical framework

Based on the theory about the (circular) building material hubs and territorial factors of the CE, an analytical framework (table 6) is created for assessing four selected typologies in relation their emergence. On the y-axis the six factors are placed, and on the x-axis, the four typologies are placed.

Table 6: Analytical framework with factors and typologies

	Circular Craft Centre	**Circular Multimodal BMH**	**Circular BMH + BMH with urban development**	**Circular raw BMH**
Circular functions	**Repository and marketplace**	**Construction logistics, secondary material, storage, repository and marketplace**	**Construction logistics, repository and marketplace**	**Construction logistics, secondary material storage**
Land Based				
Economic				
Logistical				
Technological & knowledge				
Social				
Governance				

3 Research design

3.1 Type of study

This study intends to distinguish the relevant factors of a CBMH to understand how they influence the emergence of it. Since there is little known about circularity in the built environment, and a CBMHs and there is no consensus on the definition, this research is explorative in nature (Kumar, 2014). New theories are being developed in the context of the explorative nature of this research and as a result, a qualitative research approach was chosen (Bryman, 2012).

3.2 Case studies

Multiple case studies were conducted to gain insight into Dutch practice regarding CBMHs. According to Yin (2002) a case study can be defined as "a contemporary phenomenon within its real-life context, especially when the boundaries between a phenomenon and context are not clear and the researcher has little control over the phenomenon and context" (p. 13). Case studies were chosen as the theoretical base about CBMHs is still limited. Multiple case studies were chosen, as this fits in with the explorative nature of this research (Yin, 2002). The participating companies are examined as separate cases, after which the insight and results of the various parties and their circular function are compared in a cross-case analysis. An overview of the case study data used can be found in appendix 8C.

Desktop research

In this desktop research, policy documents and socio-economic sources, also known as grey literature, will be investigated to deepening the knowledge of case's context. With this data the relevant sub-factors of the CBMH will be filled in that relate to the general factors that were identified in the literature study.

Research method of the case study

The findings of each factor are described in a separate paragraph because the case studies have numerous main and sub-factors. The separate paragraphs of the factors are then summed to create a summary of the entire case study.

Case study selection

Several criteria are set for the selection process in order to choose cases that are relevant to this research:

- The case is situated in or near de Randstad in the Netherlands
- The case has a primarily circular function.
- For the cases, both primary and secondary data are available.

For this thesis four cases were selected. The first case that was selected is the Circulaire Ambachtcemtrum Hoeksche Waard that correlates with the typology circular craft centre. The second case is Dura Vermeer Urban Miner – 's Gravendeel that relates to the typology circular multimodal building material hub. The third case is VolkerWessels Materieel en Logistiek & Bnext – Utrecht. This case has two relating typologies, the CBMH, and the building material hub with urban development. Because in this case the companies have a partnership and are situated on the same location, where the activities are blended, the factors relating to the hubs are presented in one train of thought. It has strengthened the data availability of the cases.

3.3 Semi-structured interviews

In addition to the pertinent literature, open-ended and semi-structured interviews were used to collect empirical data about the cases. For this thesis, both governmental and private entities were consulted.

To describe the various factors influencing the emergence of the circular building material and hub, information from the interviews was required, including perspectives and facts from pertinent parties. Semi-structured interviews were chosen as the research method because they are conversational in character, enabling a deeper comprehension of the issues covered and allowing interviewees to comment on pertinent case studies and speculative notions that are not present in the literature. An overview of all the interviews is given in table 7.

Table 7: Interviewees in relation to typologies

INTERVIEWEE	OCCUPATION	ORGANIZATION	TYPOLOGY	DATE
1	Advisor circular economy	Municipality Hoeksche Waard	Circular Craft Centre	19/04/2022
2	Founder	CityBarge	Multimodal BMH	07/04/2022
3	Circular manager	Dura Vermeer	Circular multimodal BMH	20/04/2022
4	Analyst urban construction logistics	VolkerWessels M&L	BMH with urban development	11/04/2022
5	Director	Rutte Groep	Circular raw BMH	04/04/2022
6	Spatial Designer	Province of South Holland	Circular raw BMH	12/04/2022
7	Consultant	Vliegende Brigade – Province of South Holland	Circular raw BMH	08/04/2022

Each interview lasted between 30 and 1 hour, was recorded, transcribed, and given to the subjects for confirmation. A full transcript of the interviews can be seen in appendix B1-B7.

3.4 Graduation laboratory and public interviews

Six public interviews were used (table 8), a full transcript of the public interviews can be seen in appendix C1-C6. As part of the graduation laboratory CfS: Circualar Building Materials and (re)Manufacture Hub of the Leiden-Delft-Erasmus collaboration there have been bi-weekly lectures, workshops and discussions with other graduation student investigating different topics within the concept of the CBMH (table 9).

Table 8: Public interviews in relation to typologies

	OCCUPATION	ORGANIZATION	TYPOLOGY
8	Commercial director	Bnext	Circular BMH
9	Director	VolkerWessels M&L	BMH with urban development
10	Strategic advisor	Municipality Delft	BMH with urban development
11	Employee circularity and sustainability	Vlasman Betonbewerkings	Raw BMH
12	Director	Hew Horizon	Circular raw BMH

Table 9: Lectures and excursions from LDE CfS lab: Circular Building Hub

Lecture/ excursion	Subject	Organization	Date
1	Circularity and a Circular Building Hub	TU Delft	22/02/2022
2	Circularity in Zuid-Holland	Province of South Holland	22/03/2022
3	Circular demolition	Vlasman Betonbewerkings	05/04/2022
4	Experience with building hubs from practice	Bnext	19/04/2022
5	Experience with building hubs from practice	Rutte Groep	04/05/2022
6	Expert panel	New Horizon, Minicipality of Leiden, TU Delft, Municipality of Rotterdam	17/05/2022
7	Geopolitical conditions	TU Delft	14/06/2022
8	Final presentation	Province of South Holland, Municipality of Leiden, Municipality of Alphen aan den Rijn, Economic Development Board Alphen a/d Rijn, Bouwend Nederland	05/07/2022

3.5 Data plan

Data protection

Based on (Wilkinson, et al., 2016) the data in this thesis, as well as the final study, is handled and published in line with the FAIR Guiding Principles. FAIR stands for Findable, Accessible, Interoperable and Reusable. For this thesis it results in the following actions:

- The final research thesis will be published on the Technical University of Delft's educational repository at https://repository.tudelft.nl. The draft research will not be publicly available until publication; however, it can be accessed by submitting an email request to the author.
- All data gathered, whether from literature, interviews, or other sources, will be referred or cited in APA-format, with full references included in the research's references chapter at the conclusion.
- To protect the confidentiality of the study participants, any sensitive information will be anonymized, obscured, or left out at the individuals' discretion.
- Interviewees will be requested to complete and submit an Informed Consent form. This form was created in accordance with the Delft University of Technology's Human Research Ethics Committee requirements.

Ethical considerations

Apart from the FAIR guiding principles outlined in the preceding section, there are a few significant ethical considerations to keep in mind when doing qualitative research. According to (Sanjari, Bahramnezhad, Fomani, Shoghi, & Cheraghi, 2014), the value of anonymity, secrecy, and informed permission cannot be overstated. According to (Fouka & Mantzorou, 2011) privacy and vulnerability are major ethical considerations that must be considered throughout the writing of a research document.

These five ethical issues will be protected as follows in this study. Anonymity and privacy are two concepts that can be combined. The participants' sensitive information from the interviews and study will not be disclosed. The participants' identities will not be revealed during the interviews, but information about their field of expertise and firm will be given if they approve. As previously stated, interviewers will get a letter of consent in which they can provide permission and demonstrate the interview's voluntariness.

4 Results

4.1 Case 1: Circulair ambachtscentrum - Hoeksche Waard

Hoeksche Waard is a municipality in the province of South Holland. The municipality is enclosed as an island between the Hollands Diep, the Haringvliet, the Dordtse Kil, the Oude Maas and the Spui. The island was shaped by severe flooding in the Middle Ages and was largely dyked in the sixteenth and seventeenth centuries (Leenders, 2005). The municipality Hoeksche Waard was established on January 1, 2019, following a municipal reorganization, and is now one of the newest municipalities in the Netherlands. The municipality, which has about 86,000 residents, is a shrinking region; between 2017 and 2030, a 2% loss in population is anticipated (Van Essen, Hazewinkel, Ligtvoet-Janssen, & Den Os, 2018). Furthermore, Van Essen et al. (2018) projected that the proportion of people between the ages of 15 and 74 will even decrease by no less than 8.2% in 2030 as a result of aging and hazing. With the Pact van de Waard (2014), that was signed by multiple municipalities and social non-profit organisations, the region began to prepare for this throughout the years 2014–2017. The region's viability as a place to live and its economic vitality have been ensured through innovations and coordination between social institutions. Along with other aspects, this agreement emphasizes the cooperative management of public spaces with social and recreational functions. The Pact van de Waard also sought economic opportunities for the Hoeksche Waard. The municipality is part of the Groot-Rijnmond COROP area, so cooperation with nearby regions around the Rotterdam metropolis is an obvious choice.

The main goal of the project was to bring parties together and motivate them to conclude cycles as effectively as possible, it is essential to gain insight into material flows, the range of prospective prospects, collaborations, and new networks. There are significant differences between the various material flows and economic sectors in the local and regional (circular) economy: knowledge of the volumes, value, CO2 impact, and numerous other ecological and social dimensions offers knowledge of the local economic and ecological opportunities and links new parties to create circular, social business cases (Cirkellab, 2020). The craft section where the secondary materials are processed, and the retail area are both around 600 m2 in gross floor area.

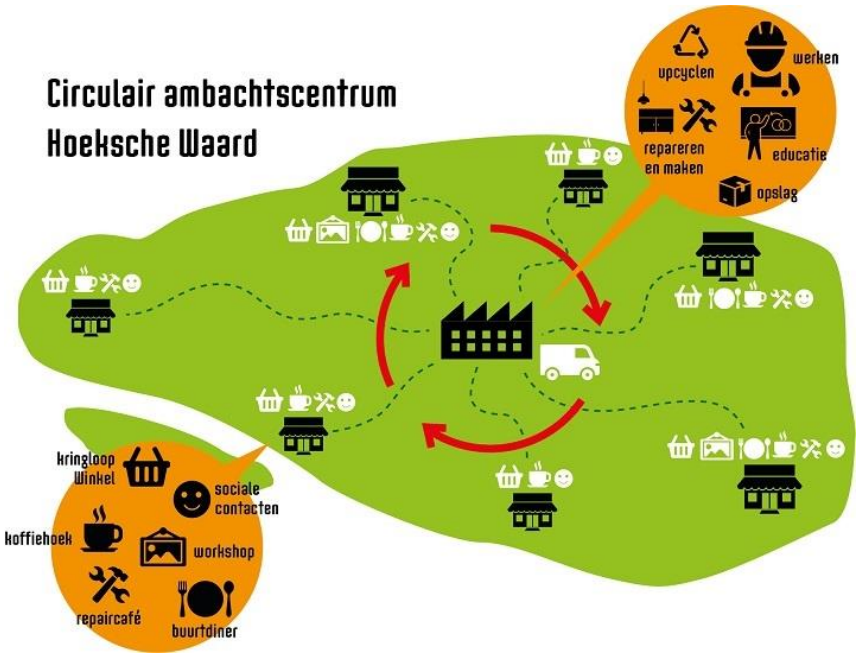


Figure 16: Circular Craft Center Hoeksche Waard (Cirkellab, 2020)

Factor assessment of Samen Circulair

Land based factors

In a different spot in the town's centre, there used to be a thrift shop serving the Hoeksche Waard municipality. Interviewee 1 argued that it was good for the items that were brought in and sold there because so many potential customers were passing by. The new location is next to a residential boulevard on an industrial estate. In this manner, it may also be able to draw passing customers. A different area in the middle of the meadows hosts the recycling centre, which is exclusively intended for the collection of materials. Due to the lack of passing costumers, this site is unsuitable for the shop (appendix B1). Since all parties intend to use the area for a longer period of time, it is not a temporary location. As previously said, collaboration with other businesses and thrift stores is a crucial first step in the launch of the circular craft centre. In figure below all the different locations of thrift stores are shown, where the recycling centre is located in the middle.

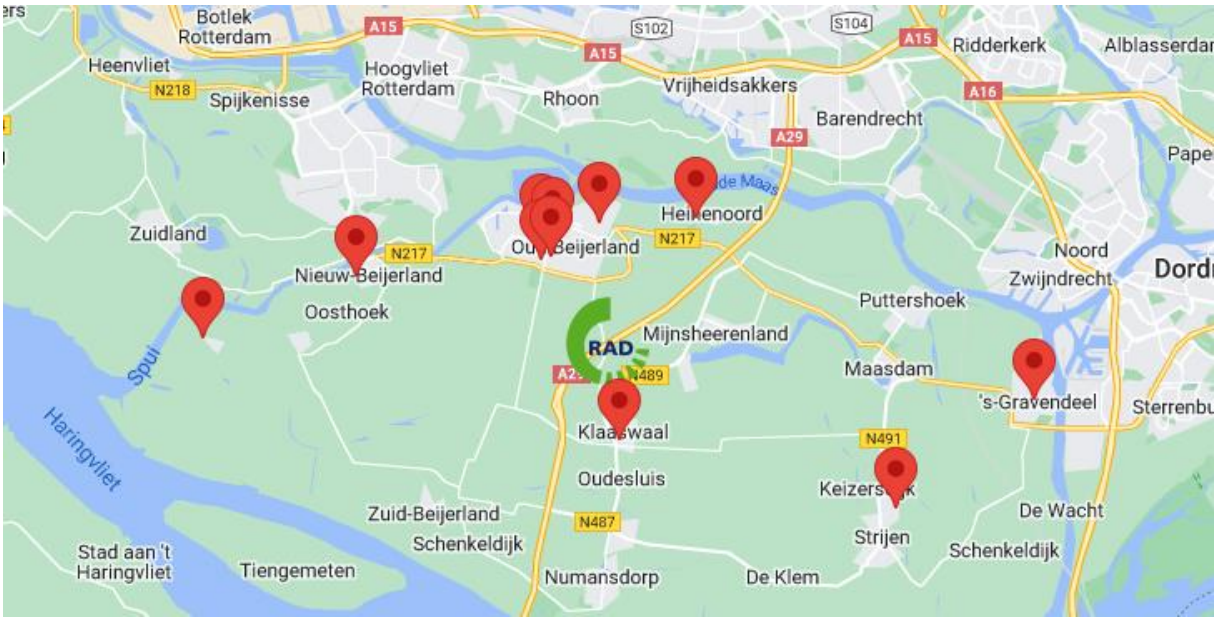


Figure 17: Locations of thrift stores and recycle centre (Samen circulair, n.d.)

Moreover, the limited physical space at the previous location was in particular a bottleneck for the realisation of the circular craft centre. This meant that the circular craft centre had to be developed at a new location, where there was more physical space to store and remanufacture the materials or products that were handed in. Here the transport flows for supply and demand were considered for the final location (appendix B1).

Economic factors

The project was financed through a grand from the national government. The municipality Hoeksche Waard had to hand in a formal application, and it was assessed by an independent jury. The jury consisted of members of the Ministry of Infrastructure and Water Management, Rijkswaterstaat, Branchevereniging Kringloopbedrijven Nederland, NVRD and the Repair Café Foundation (Rijkswaterstaat, 2021). In the application for the business case of the circular craft centre was awarded with a maximum of €50.000, -- that was used during the starting phase of the project to cover the initial investment. Furthermore, the municipalities on the island are working together to finance the project through a regional deal. The initiators of the circular craft centre hosts various circular activities, re-using (R3), by directly selling the product and materials that were tuned in in the thrift store. Repairing (R4), refurbishing (R5), and repurposing (R6) through the workshop that is hosted within the circular craft centre (Samen Circulair, n.d.). According to interviewee 1, the warehouse

capacity is related to the physical space and business case. The costs associated with certifying waste processing activities were another factor to consider for the business case. Under the current laws, consumer goods and materials might be produced without incurring significant costs. However, things became challenging because the goal was to also treat waste streams from businesses (appendix B1). The locations will be used to connect the supply and demand over the whole island. As seen in figure 10, each thrift store will have its own business case consisting of selling secondary materials, but they can also have additional business cases like catering or providing workshops. There is no defined formula for circular activities and the 'best' business case, it is dependent on the local context (Cirkellab, 2020).

Logistical factors

The CE faces a lot of challenges, including the need to streamline material movements. It is desirable to have logistics in order from a social, environmental, and economic perspective. The issue is how to gather, process, upcycle, store, and distribute the material flow in an efficient manner. The location(s), transportation, storage capability, costs and benefits, regulatory frameworks, emissions, necessary labour capacity, and simplicity of use are all taken into consideration while building the logistics concept (Werner, Alberts, Verschuuren, & Dierdrop, 2020). The location for the circular craft centre must be accessible via the main road network. As Interviewee 1 argues that area must be reachable for those who work there. Since this target audience frequently lacks a personal vehicle, the location must also be convenient to reach via public transportation. Furthermore, the location also must be accessible for small trucks for the delivery of fresh stock of secondary materials (appendix B1). Distribution of the secondary materials via small-scale multifunctional recycling centres subsequently strengthens the vitality of the small village centres that are characteristic of the area (Stantec, n.d.).

Technological and knowledge

Interviewee 1 argued that as the municipalities Goeree Overflakee and Nissewaard have joined the regional deal. The next quote clearly explains the collaborative vision behind the realisation of the circular craft centre. With the close collaboration between the different municipality, it has the potential to scale up the facilities (appendix B1). The municipality organises discussion rounds, as they are researching whether certain companies have opportunities to become circular if they work together. Moreover, they invite prominent figures that are active in realising a circular built environment to speak during the entrepreneur day.

> *"In the regional deal, the idea is really that we share the knowledge we gain with each other and that they (other municipalities) also start working together. So, all centres will become linked together. It also works the other way as we of course benefit from the experiences they gain there because the areas are comparable." -* ***Interviewee 1***

The circular craft centre is setting up a shared digital platform where all the products will be shown. This was part one part of the business plan. The province of South Holland provide valuable insights by joining the discussion rounds with transition managers. They have a connecting and driving role during these sessions (appendix B1).

Social factors

This foundation originated from an initiative of Welzijn Hoeksche Waard, an entrepreneur, the Regional Waste Service (RAD) and the province of South Holland and is supported by the municipality of Hoeksche Waard (appendix B1). As stated by interviewee 1 in the quote below, the social character of the hub shows that social factors are important. Furthermore, the goal of the hub is to unite and inspire parties for realising circular strategies.

"This [circular craft centre] has a social function. Apart from the fact that work and the meeting places for people, it offers opportunities to people on a limited budget. But in addition, it is very clear that, it is also something to stimulate the circular economy, so we also want them to focus on expanding target groups."

- ***Interviewee 1***

Governance factors

The locations used for the circular craft centre in the municipality Hoeksche Waard don't need a high environmental category. It has the requirements of a zone 3. The municipality Hoeksche Waard initiates that companies enter into discussions with each other about realising a CE. Another point of attention for the business case is the costs of certifying waste processing activities. Consumer products and materials could be made without major investments within the existing regulations. But since the ambition was to also process waste streams from companies, things get complicated (appendix B1).

Summary of factors

In table 10 a summary of the factors is shown.

Table 10: Summary of factors of case 1

	Factors of analysis	
Land Based	Central to demolition and construction projects	Important, but only central to the demand.
	Insights to available materials	Not important.
	Temporary or permanent character	Permanent location.
	Use of existing hubs	Important, connecting to the thrift stores already on the island.
	Space to expand business	New location with expansion.
Economic	Operational scale	Local.
	Facilities (R-strategy)	Re-use (R3), Repair (R4), Refurbish (R5) and Repurpose (R6)
	Business case	Important, selling secondary building materials and refurbished products
	Connecting supply and demand	Important, throughout the island
Logistical	Accessibility to main road network	Important, as suppliers come by truck.
	Accessibility to water quay for transhipment	Not important
	Zero emission last mile	Not important
	Logistical information system	Not important
Technological & knowledge	Changing construction method	Not important
	Innovation and product development	Not important
	Balanced mix of knowledge and skills	Important, incentivising workers with a distance to the labour market.
	Resource sharing	Important, sharing the location with multiple organisations.
Social	Initiator	NGO, entrepreneur and recycling centre.
	Public awareness/ societal pressure	Important, it was one of the main goals of the project.
	White label hub	Available for al inhabitants.
	Type of clients/ consumers	B2B and B2C.
Governance	Environmental zoning category	Zone 3.
	Regulation	Certifying waste processes.
	Market	Collaboration with local entrepreneurs, recycling centre and NGO.
	Financial	Initial fund from national and local government.

4.2 Case 2: Circular Multimodal BMH – Dura Vermeer Urban Miner – 's Gravendeel

Dura Vermeer is a Dutch construction company that was created in 1998 through a merger of construction company Dura, founded in 1855 by Job Dura and Aannemingsmaatschappij P. Vermeer, founded in 1961. Currently the company realizes both construction and infrastructure projects and is in third place among the largest construction companies in the Netherlands with almost 3000 employees and a turnover of 1.5 billion euros (Dura Vermeer, n.d.). The business where the construction, real estate, and infrastructure divisions join together to collaborate and work on realising a circular built environment is called Urban Miner, which began operations at the beginning of 2021. The circular construction market is expanding quickly, but raw resources are limited. With the Urban Miner, Dura Vermeer hopes to adapt to these developments quickly and keep playing a socially innovative role based on its goals for sustainability (Duurzaamgebouwd, 2021).

The Urban miner is located near the town 's Gravendeel in the municipality Hoeksche Waard. The 7-acre site of the circular construction hub is situated on the waterway Dordtsche Kil. The amount of space allows one to concentrate on bigger secondary materials. The Urban Miner contains storage areas for bulk products like sand, gravel, and cement for making concrete. The circular building hub has three main business cases. First, the recycling and storing of (bulk) materials like granulate and asphalt. The second business case is the 'up-cycle' where building elements are 1-on-1 reused in another project. Here the hub offers temporary storage space for these elements to deal with the mismatch in time between supply and demand. These materials come from both building projects and infrastructure projects. And the third business case are the logistical functions, here the Urban Miner is used for the storage and solidification of the packages for construction sites in the region and the efficient deployment of (zero-emission) transport. The degree to which design, raw materials, and planning come together seamlessly ultimately determines how successful the Urban Miner is. To be able to harvest the right materials on time and employ them in new projects, cooperation with all stakeholders in the chain is essential (Dura Vermeer, n.d.).

Factor assessment of Urban Miner

Land based factors

The specific location for the Urban Miner was chosen because of the accessibility to the Dordtsche Kil and as it features a very attractive intersection on the waterway leading, among other places, to the city of Rotterdam. Additionally, it is possible to target several southern cities for secondary building materials from this location. However, for the purely logistical business case the Urban Miner does not focus on the south as VolkerWessels recently launched a construction hub for logistical activities in Eindhoven. Lastly this location was attractive because of the three road routes that are available for transportation at this site (appendix B3). Dura Vermeer intents to also use the other white label logistical hubs when it is feasible for the construction project. Interviewee 3 stated that Dura Vermeer also make use of the construction hub of VolkerWessels and Bnext in Utrecht. There are no logical reasons to develop their own construction hub in a competing operating area (appendix B4). With the introduction of the Urban Miner, Dura Vermeer announced to digitalize demolished buildings to gain insights into the available materials (Dura Vermeer, n.d.). The location has a lot of room to grow, this is important because Dura Vermeer wants to investigate whether they can work on projects in a transcending manner to reduce cost.

Economic factors

The operating scale of for the upcycling is difficult to determine, due to the variety of material streams. The bulk materials have a smaller operating area than secondary steel that is harvested. According to interviewee 3, this is mainly due to the value of the material. If the material has a high value, the transport costs will be relatively lower, and it will be possible to drive further. It also has to do with the

transportability of the materials. Think here of transport restrictions when transporting long beams. The shareholders consist of 50% of the infrastructure and 50% of construction property. That is the distribution within the entire company of Dura Vermeer. Despite being funded by Dura Vermeer, Urban-Miner is an independent organization and cannot be utilized only for Dura Vermeer initiatives. As a result, the business is healthy according to interviewee 3 (appendix B3).

Logistical factors

All inner-city logistics are handled via EV- transport from the Urban Miner, substantially lowering CO2 emissions. As stated earlier, the site features a harbour on the Dordtsche Kil, allowing the first leg of the journey to be completed by water as well, reducing traffic on the A15. Making use of an already existing harbour (appendix B3). The Urban Miner intends to concentrate heavily on maritime transportation in the future since it is more environmentally friendly, because one ship may replace four trucks on the road. Particularly given the numerous issues with the regional logistics that already can be seen. The logistical models of Dura Vermeer show that shipping from the periphery of the city is actually just as quick by water as it is by ordinary shipping by road (appendix B3).

Technological and knowledge factors

Interviewee 3 predicted that the use of prefabrication would increase in the near future. The various construction flow patterns will come together as a result. Detachability, which is crucial for achieving circularity of 1-on-1 elements, will also be used more frequently (appendix B3). Thus, this guarantees that more can be supplied on logistical returns rather than it is disintegrating into granulate. Interviewee 3 added that for the so-called 'upcycling' activity, Dura Vermeer cannot yet make a direct link with the digital hub between the demand and supply of the released material. That is why storage is always required to temporarily store those materials. It almost never overlaps one-on-one in time, precisely because the lead times of projects are so long (appendix B3).

Within the Urban Miner, the "circulair loket" has also been introduced. This is a circular advisory service meant to help Dura Vermeer's projects utilize the hub's resources and expertise. Additionally, these consultants are the ones that suggest in these tenders that circularity and the other two business cases be promoted and spread the ideas to other parties. The hub's overall business case only comprises a very small portion of this. The purpose is primarily to advertise the cyclical activities the hub offers. By actively working on the circular issue, Dura Vermeer Urban Miner collects knowledge and experience. Both in the storage and processing of materials. Pilots are initiated and monitored in the knowledge centre of Dura Vermeer Urban Miner. In this way, a unique collection of knowledge based on the practical processes throughout the supply chain grows. Because collaboration with chain parties is crucial for the timely harvesting of the right materials and reuse in new projects, there is close collaboration with producers, suppliers, universities, and all kinds of start-ups (Cirkelstad, 2021). There is a wide group of employees working on the site, including operational personnel and consultants (appendix B3).

Social factors

Since the infrastructure part of Dura Vermeer also had B-residuals locations, the infrastructure department was more responsible for realising the upcycle portion of the Urban Miner. B-residual location are places that are solely concerned with recycling asphalt and granulate. Additionally, more use was made of the logistical construction hubs such as VolkerWessels in Utrecht, on the real estate part of Dura Vermeer, where it was also believed that the Urban Miner should make use of that development. Therefore, the Urban Miner is also a white label hub for construction logistics. However, in the current market logistics services for the construction sector are frequently viewed as additional expenses to make it more effective and sustainable (appendix B3). This can be seen in the quote below.

"With the current technology Dura Vermeer can already see which materials have to be harvested and used in new projects. This information can be included in upcoming tenders. However, then you often see risk-averse behaviour from managers in construction projects, because time is also a lot of money in this case. For many others, the throughput and the time factor is even more relevant."
*– **Interviewee 3***

Governance factors

The site is located in environmental zone 4 based on the activities of the Urban Miner on the site. As the infrastructure department of Dura Vermeer already had permits for recycling and waste treatment, the use of mobile equipment on site was not a challenge. To create more awareness and speed up the transition to ZE logistics, the local and regional government should with the use of new regulation force companies to work on the transition. The ZE zone in Rotterdam is a good example, but still Interviewee 3 experiences that the awareness is not where is should be to make the transition (appendix B3).

*Stimulation through subsidies or other means is an incentive, but not a solution. I have an example of a subsidy application that was there that only had to be signed but was not done and as a result the subsidy has not been received. This is because the importance is not (yet) seen in it. It must hurt to not use this kind of opportunity and it's not now. – **Interviewee 3***

Summary of factors

In table 11 a summary of the factors for case 2 is presented.

Table 11: Summary of factors of case 2

	Factors of analysis	Dura Vermeer Urban Miner
Land Based	Central to demolition and construction projects	Central to demolition and construction in the region.
	Insights to available materials	Important trough data received from Dura Vermeer's projects.
	Temporary or permanent character	Intended as permanent location.
	Use of existing hubs	Important, they also use other white label hubs in the Netherlands.
	Space to expand business	New location with room for expansion.
Economic	Operational scale	Regional.
	Facilities (R-strategy)	Re-use (R3), Recycle (R8).
	Business case	Logistic construction hub, 'circular loket', upcycling, storage of materials.
	Connecting supply and demand	Important, through digital means and space for material storage.
Logistical	Accessibility to main road network	Important, three connections to main road network.
	Accessibility to water quay for transhipment	Important, close to node in regional water network.
	Zero emission last mile	Important, in relation to the ZE zone of Rotterdam. The hub fabricates day- and week packages.
	Logistical information system	Important, in calculating efficiency of transport over road and water.
Technological & knowledge	Changing construction method	Important, as prefabricated building modules will be construction flows.
	Innovation and product development	Important, connect the planning of building projects in embedded system.
	Balanced mix of knowledge and skills	Important, wide range of practical and theoretical employees on the site.
	Resource sharing	Not important
Social	Initiator	Dura Vermeer, partly through infrastructure department and real estate department.
	Public awareness/ societal pressure	Important, one of the reasons for the initiation of 'circulair loket'.
	White label hub	White label hub for logistical services.
	Type of clients/ consumers	B2B and B2C.
Governance	Environmental zoning category	Zone 4 based on upcycling activities.
	Regulation	ZE zones in Rotterdam.
	Market	Prescribe the use of efficient construction logistics in public works.
	Financial	Public subsidies are an incentive, but more action is needed.

4.3 Case 3: VolkerWessels and Bnext Bouwhub – Utrecht

Koninklijke Volker Wessels Stevin (or: VolkerWessels) is the name of the company created in 1997 through the merger between Koninklijke Volker Stevin N.V. and Kondor Wessels N.V. This company is the second largest construction company in the Netherlands. The turnover of the construction group in 2018 amounted to more than € 5.9 billion. In 2018, the group had an average of 16,630 employees, spread over branches in the Netherlands, the United Kingdom, the United States and Canada (VolkerWessels, 2019).

VolkerWessels Materieel & Logistiek (VW M&L) is part of VokerWessels and rents out construction equipment, provides equipment-related services and shares knowledge in the field of equipment. The basic principle here is maximum value creation for all stakeholders. VW M&L was among the first to begin utilizing a construction hub for the consolidation of construction logistics, as the 'De Trip' building project in Utrecht neared completion. VW M&L currently operates a number of construction hubs, like the one in Utrecht, Amsterdam, and also a recently opened construction hub in Eindhoven (VolkerWessels Materieel & Logistiek, sd). An example of a circular construction hub is the Talent Hub in Amsterdam, a partnership between VW M&L BeelenNext and Level5. Here, leftover materials are processed into so-called circular material and equipment pieces for reuse in picket posts, roof constructions, garden benches, etc. For the time being, this is done primarily from leftover wood and concrete products on a small scale (BouwCirculair, 2021).

This is a typical location for the hub as the operational scale of the construction hub depends on the proximity of the highway outside the ZE zone per city when announced. As a result, the location often comes down to logistics or industrial locations. And often 10 to 15 minutes from the projects in the city centre, because then the construction hub can deliver materials with a very high reliability (appendix B4).

Materials are delivered in bulk from the manufacturers to the VW M&L construction hub, where they are buffered for as little time as possible before being transformed into daily packages. They perform this across disciplines for numerous parties and load them onto the truck for last mile delivery. They then deliver those materials to the specific work locations when take any residual material or retour flows to the construction hub.

Bnext

Bnext is a construction demolition, waste treatment and recycling company that originated in 1999 by entrepreneur Wim Beelen. In 2017 the "D&Ri annual ranking of the world's largest demolition contractors" determined that Beelen was the 10th biggest demolition company in the world based on turnover. Currently is 8 operational locations with more than 400 employees. It has an annual turnover of €127,4 million (2021) and processes around 2.1 million tonnes (Bnext, n.d.).

This hub has evolved into the new hub for the storage and transhipment of secondary construction materials because of its strategic location. In the full-fledged wood workshop, demolition and leftover wood are also converted into reusable wooden building materials (Bnext, n.d.). Work and training was already created during construction for 5 young people with a distance to the labour market from the municipality of Utrecht. The Municipality of Utrecht and other local governments work closely with Bnext.nl on this. To provide youth with assistance, SROI-Coach Louis Altelaar works full-time at the Hub. The total site area of the hub is between 1 and 2 hectares.

A distinction is made between high-quality circular products that can be sold right away after "polishing" (through online platforms) and low-quality raw materials like wood and other bulk

materials. Reusing wood can be difficult, which makes it challenging to provide a compelling business case (Van Merriënboer, Bastein, Rondaij, & Rabbie, 2022).

Factor assessment VolkerWessels and Bnext Bouwhub

Land based factors

Since VW M&L see the greatest possibilities for new building or restoration projects in mayor in the Netherlands, they currently favour the placement of the construction hubs on the outskirts of the main cities. On top of that, knowing how all construction projects in a certain area are planned can help construction hubs work more effectively and at a lower risk of failure. Here chain coordination is crucial since the less disruption the transportation of materials cause in the city core, the cleaner and more intelligent our construction can be (appendix C2). The time it takes to put up a construction hub site can go by quickly. VW M&L can set up a site extremely flexible because VW M&L has equipment service as its primary function. At the same time, there are large urban developments that are so intricate that it is interesting to set up a hub site for an extremely long time, possibly permanently (appendix B4)

Bnext has begun posting all the secondary materials they have in stock on an online platform, and they are already doing the same for the materials that are currently still in buildings but will be available in a month or two. This means that they can save transportation, because they won't have to put it in storage first; instead, they may move right from the previous project to the current one. The next step is the ability to see one, two, or even three years ahead instead of one or two months. Then, using the secondary materials that become available, architect may create better designs (appendix C1).

Planning for space and availability in existing facilities at the site is doable with a white label hub. It is just a less appealing business case if businesses have a need for space that still needs to be planned and reserved. Creating a project-specific equivalent of a construction centre. Aside from the fact that these kinds of locations for temporary housing are becoming harder to find. There aren't many places to go (appendix B4). However, VW already has many locations in the Netherlands, so first they look at the locations within their own portfolio and make a list with 'must haves' and 'nice to haves' to select a final position.

Bnext added that the circle of secondary materials depends on the availability. That circle is as small as it can be. They therefore consider this very carefully, in part because to CO2 and other nuisance, but also because of the cost of transportation (appendix C1).

Economic factors

The VW M&L construction hub is built to take materials into the city, because the hub has the space, and the logistics facilities for temporarily buffering the resources that come out of the city. To bridge the gap between when the resources are harvested and when they can be used once more. Here the biggest cost factor of the material flows is the transport (appendix B4). By implementing the construction hub, significant savings can be achieved in the areas of sustainability, labour productivity, the volume of freight movements, load factor, and waiting periods (appendix C2). VW M&L is also working on reducing material use, because they handle the day packages with smart data and therefore reduce the margins of error. So that is also part of circularity in preventing the use of materials (appendix C2). Additionally, there is a significant flow of materials used but not processed for the projects, such as formwork materials and custom packaging components, ensuring that no deposit is made. Previously viewed as waste, VW M&L is currently working to maintaining the materials in the high value chain. With this, they return it and hand it off to Bnext for processing. The building components that Bnext select need to be carefully disassembled if they are to be reused. Cleaning, some repairing, or once a tiny modification. After which they are transported to be temporarily stored. All these expenses must be considered because labour is costly. Using new materials in comparison to

secondary materials is cheaper due to the modifications that are not needed for the product (appendix C1). Therefore, there are different categories in secondary materials, the first category is the materials that are already commercial or are starting to become commercial, such as wood. It is easy to process on the hub and easy to remove from a building and interesting to put back on the market.

In the business process Bnext added that separating the material flows always pays off. As much as possible at the source, but when it is not possible to sort on the demolition location the sorting happens at one of the sorting centres of Bnext (appendix C1). Bnext is trying to do the operations at the demolition site, so they are demolishing a building and the materials that cannot be reused high-quality go through the rubble crusher there on site, creating raw material for road construction on site. This is taken directly from the to the place where they are building a road in this case, so that a step is skipped, and it must go to one of the Bnext branches. So, there they try to make an efficiency gain, since the margins of materials are small. Bnext also sees that there is a high demand in road construction for mixed granulate that there is sometimes a tension between the road construction and concrete industry, because the materials are becoming scarcer (appendix C1).

Logistical factors

This is a typical location for the hub as the operational scale of the construction hub depends on the proximity of the highway outside the ZE zone per city when announced. As a result, the location often comes down to logistics or industrial locations. And often 10 to 15 minutes from the projects in the city centre, because then the construction hub can deliver materials with a very high reliability. One of the wishes VW M&L has been that they remain water-bound, so that they can use the facilities multimodally (appendix B4). VW observes that market participants are looking at a new decoupling point for their logistics as a result of the Zero Emission zones. The construction site is currently the decoupling point. Nowadays, almost all vendors carry their goods directly to the construction site by truck. With several of these suppliers, the construction hub is attempting to relocate the decoupling point to the city's periphery (appendix B4). According to VW M&L, their logistical information models demonstrate that there is still a sizable amount of profit to be gained in terms of cost reduction as the construction hub has an impact on the business case of the contractor and the supplier (appendix B4). Charging infrastructure is a current significant challenge. Even with the standard connection request, it can be difficult to complete this task, let alone if additional capacity is required (appendix B4).

Technological factors

The process of prefabricated construction is more efficient and can be done with less waste. But at the product level, there is not yet an industrial construction product for the inner-city construction hub. VW does have that with Finch Buildings where they make it completely in the factory. In the inner city, the semi-finished products are still assembled on the construction site. The second is truly moving forward if buildings are put together today that can be taken apart by constructors who are creating the circular stock of the future. However, they can only serve for a very long time because they are just now being created (appendix B4).

VW M&L collects data on each project to gain insight into the improvement potential, but also to further shape the new economic chain model. It also allows them to use this knowledge to make the chain work together smarter (appendix C2).

Since VW M&L is pushed by their concept 'MorgenWonen', they are aware of the location and method of building and are aware that effective logistics should always result in profit. They increasingly frequently encounter projects in urban locations that present a challenge or a lack of space in the planning, necessitating a rapid delivery (appendix B4). In the transition to emission-free transport, the collaboration with Bnext is interesting because of the sharing of the items that are present on the site,

such as forklift trucks. If VW M&L and Bnext share this and use it efficiently, less is needed when it needs to be replaced (appendix B4).

Social factors

VW M&L have written a plan in which they have translated the ideal construction sequence into logistical planning across the chain parties. This is how the BouwHub was born (appendix C2). As Bnext already have a network, such as the sales network and purchasers of certain material flows and they have the demolition network, so they can also find the materials in the different projects. As a construction hub, of course, part of VW and we have our own sustainability ambition and there is an intrinsic motivation from there. In addition, clients also ask. So, it's nice that that reinforces each other, and it makes it easier for VW M&L to also set certain requirements, they would like to have an emission-free version, then it is very easy for them.

In terms of social return, the circular construction hub is a safe and easily accessible location, with a good view of the people who are working there. At the Language Hub, people really have the opportunity to develop themselves there. A safe environment and that makes it easier for us to get on board than at a traditional construction site. And that it is easier to facilitate that guidance more efficiently (appendix B4). This is also generally accepted within Bnext that good materials that have to been thrown away is a waste. As stated earlier the construction hub is a white label hub, that is becoming more accepted by the whole supply chain (appendix B4).

Governance factors

The circular construction hub is not permitted to establish itself at all locations in accordance with the environmental law and zoning plan. As the cities are getting progressively more restricted in terms of logistics, construction continues to increase in the city core. Local authorities are placing greater demands: there must be less frequent, and it must be cleaner, quieter, and safer (appendix C2).

Even though it first appeared to be more efficient, VW M&L would have preferred to integrate the procedures. However, doing so would have required them to deal with numerous permissions, taxes, and other issues. So certain procedures are also prohibited for VW M&L.

Consider the recently announced ZE zones as an example of some rules that are currently influencing the market. The market is simultaneously set in motion by this move, but enforcement and clarity can further stimulate the adoption. One of the things that sticks out about it is how regionally organized it is. Organizations who operate nationally in all those locations should pay attention to this because they will encounter legislation that is largely the same and is being applied consistently (appendix B4).

VW M&L has seen that municipalities are willing to make contributions within their means. From that perspective, municipalities, provinces, the government, as well as clients, can also adopt that stance to create or conduct better tenders. It naturally gets simpler to join or chase the market once it is moving, if there are instances, and the first question is no longer necessary. In any event, avoid falling behind. There is also the conflict with influencing local entrepreneurs. So, municipalities are now playing around with that, from where do they draw the line? (appendix B4)

The construction hub facilitated that the construction personnel can park their vans on the outskirts of the city and then enter the city with shared mobility. There are various reactions from the municipality, on the one hand positive by the departments that deal with nuisance, but on the other

Summary of factors

In table 12 a summary of the factors for case 3 is presented.

Table 12: Summary of factors of case 3

	Factors of analysis	
Land Based	Central to demolition and construction projects	Important, close to demolition and construction, at the edge of the city.
	Insights to available materials	Important, trough data received from Volker Wessel's projects.
	Temporary or permanent character	Intended as permanent location.
	Use of existing hubs	Important, they also use other white label hubs in the Netherlands.
	Space to expand business	Not important, current location does not have additional space for expansion.
Economic	Operational scale	City scale
	Facilities (R-strategy)	Reduce (R2), Re-use (R3), Remanufacture (R6), Repurpose (R7) and Recycle (R8).
	Business case	Primary circular business case in remanufacturing secondary materials and selling secondary materials.
	Connecting supply and demand	Important, providing temporary space for material storage.
Logistical	Accessibility to main road network	Important, close to main road network.
	Accessibility to water quay for transhipment	Important, but it was not realised on this location.
	Zero emission last mile	Important, moving the decoupling point from the construction site to the hub.
	Logistical information system	Important, in calculating efficiency of transport over road.
Technological & knowledge	Changing construction method	Important, as the concept 'MorgenWonen' was an incentive for the realisation of the hub.
	Innovation and product development	Important, as VW M&L are improving the efficiency of construction logistics.
	Balanced mix of knowledge and skills	Important, wide range of practical and theoretical employees on the site.
	Resource sharing	Important, sharing space and machines between the companies.
Social	Initiator	VW through their own sustainability goals.
	Public awareness/ societal pressure	Important, as the hub promotes reducing environmental impact.
	White label hub	White label hub for logistical services.
	Type of clients/ consumers	B2B
Govern ance	Environmental zoning category	Zone 4.1
	Regulation	ZE zones in Utrecht
	Market	Prescribe the use of a construction hub in public works.
	Financial	Private financing but making use of local subsidies.

4.4 Case 4: Smart Circular Products and Urban Mine – Zaandam

The Rutte Group received a patent for “parcelling” in 1983. The business found that removing old tiles off the street with a specially designed machine made it simple to repurpose them. The business also concentrated on road development when the third generation Rutte became available in 1994 and they submitted the required licenses. The construction of underground garbage collection systems has been a new development for the Rutte Wegenbouw division since 1997. (O.A.I.S.).

Smart Circular Products (SCP) specializes in the sustainable production of (prefab) concrete products such as stackable concrete blocks, concrete slabs, pits for underground waste containers and prefab quay walls. Old, abandoned structures and objects from Amsterdam and the surrounding area are the source of all raw materials used. As a result, the production process is entirely circular (Rutte Circulair, sd). SCP closely works together with the Urban Mine that is also located on the site in Zaandam.

The Urban Mine specializes in upcycling old concrete and demolition rubble into sand, gravel and (hydratable) cement for making new concrete mortar. A unique, patented device is used for this: the Smart Liberator. The energy for this process is provided by a 19.000m2 field of solar panels on the roof of the site (Rutte Circulair, sd). Moreover, the site as a greywater buffer storage of 750.000 litre to produce concrete. The site is about 4 hectares in sites and is located adjacent to the Noordzeekanaal.

SCP is part of New Horizon’s Urban Mining Collective. The location of SCP provides a hub function for the Urban Mining Collective. The harvested materials from the city can be brought here by the various partners that are part of the collective directly to be upcycled. This while the recycled materials can be returned directly to the construction site to be used again (Smart Circular Products, sd).

SCP has a KOMO certified Concrete Plant. The power plant is specially equipped with machines to produce products with several circulating systems. Circular prefabricated concrete is produced at the Recycling Wegenbouwmaterialen Amsterdam location. The sand, gravel and cement used in the concrete are completely replaced by secondary raw materials coming from the Smart Liberator. Secondly SCP also has the option of storage and transhipment of materials for other contractors. There is room for storage and there are various possibilities for transhipment for logistics by water and by road. The quay is suitable for the storage and transhipment of bulk materials such as sand and gravel AEC Bottom ash (Smart Circular Products, sd). Thirdly the partnership between SCP and Grondbalans BV also results in the provision of soil bank services.

Factor assessment Smart Circular Products and Urban Mine

Land based factors

Prior to the determined location, there were three ‘must haves’. First, the location should be close to the city, in order to keep the transport distances of the materials short. Secondly, the location had to be on the water for the transport of bulk goods and the possibility of ZE logistics over water. After that, it was important to work in a covered location, since the cement that has not yet reacted with water, does not come into a reaction with water during the circular process. The location needs to be accessible for large volumes of materials. Therefore, this location is suited for the annual production of 400.000 to 450.000t of raw materials for circular concrete and a smaller amount of 15.000t raw materials for the production of circular bricks. All the materials are coming from Zaandam and on the west and north of Amsterdam. The buildings where SCP is located are completely modular, this is a strategic decision as the expansion of the city of Amsterdam and Zaandam at some point, the location will have to move. The location is not suitable for further expansion as it is surrounded by other industrial functions. Only if these function move, space becomes available for expansion (appendix B5).

Economic factors

As stated earlier, the site is around 4 hectares in site, but this is too small for the different functions that are serviced there. Within the network of Rutte Groep, the parent company of SCP that is also active in infrastructure and logistics, other locations are used to form a cluster of functions within the supply chain.

With the diversity of function, there are several business cases for Rutte Groep on this location. The white label hub function for ZE logistics into the city of Amsterdam is one of the income streams. The other way around the location functions as a waste processor, where the materials is upcycled. The materials are processed in circular concrete that is mixed on the site and results in another income stream. Moreover, the soil bank, where soil is temporarily stored for 1-on-1 reuse is another income stream. Additionally, they also facilitate the temporary storage of construction materials for the 1-on-1 reuse. As an example, one of the satellite buildings of the Dutch Bank that is stored in one of their warehouses. And finally have a company for the 1-on-1 re use of monumental bricks and elements for monumental building in Amsterdam (appendix B5).

As buildings are never torn down at the same time as new materials are required for the same kind of construction. Time management, or rather the management of input and output, is crucial since it is directly related to that. Seasonal variations in the supply and demand curves are rather prevalent in the construction sector. This implies that SCP has disruptions throughout seasons of the year, related to the Christmas and summer vacancies. They face a hurdle in finding the best match for the location's throughput speed (appendix B5). It is comparable to the energy market, although it is much more in its infancy. Rutte Groep expects that they will pay much more for rubble than they do now. But then the market must evolve.

Logistical factors

The location needed to be close to the city of Amsterdam as one of the key factors. With this location within 5 minutes of the A10, it is accessible by the main road network is optimal for SCP to reach the city. Transport by water is cheaper in the volumes earlier mentioned, so it was decided to also sit on the water. Employees at this facility must adhere to Rutte Groep's guideline that requires them to drive fully electric. This is consistent with the holistic view on sustainability. There are also electric boats at the location for ZE last mile delivery to construction sites located on the water. From the emission-free transport by water by Mokum Maritiem to the electric cranes, shovels and vibratory plates that have been deployed on site, nowhere has a drop of fossil fuel been used for SCP's projects. They are the first in the MRA to use that size. The policy agendas of Amsterdam are the source of the investments, and businesses must merely follow that direction. This was a huge investment, because such an electric boat costs around €1.5 million and a diesel alternative costs €300.000, -- (appendix B5).

Technology and knowledge factors

The chaining construction method doesn't radically change the operational processes of SCP. The locations where the most material is released and where the need for material is greatest makes for a more expensive process. This also means that the plan of an Urban Mine is much more complex than a regular recycling location. SCP has used noise barriers to isolate the noise and in addition, intense dust control is used to create as less nuisance as possible (appendix B5). The focus of the hub is the upcycling of concrete, which results in a saving of at least a 60-80% in CO_2 emissions compared to traditional concrete (New Horizon, sd). With the Smart refiner concrete granulate of different sizes can be filtered. The distinction between concrete granulate of 4/22mm, 4/12mm and 0/4mm is made that is used in the circular concrete. Concrete granulate is a composition of at least 90% concrete and bluestone, the grains of which have a dry density of at least 2,100 kg/m3, and a maximum of 10% of

other types of stone, whose grains have a dry density of at least 1,600 kg/m3 (Smart Circular Products, sd).

Social factors

Rutte Groep was the main initiator of the hub. They have had a lot of partners and suppliers for the construction of the facilities at the location. The incentive and the idea to build it up in this way is with Rutte Groep. SCP is experiencing a big demand for circular concrete, but it took four years before the turning point was really reached in the sector. One of the business cases that SCP is working on is renting storage space and ZE logistics to other businesses, making it a white label hub. Interviewee 5 mentioned that the network type of clients and suppliers were important. The process starts with the demolition company that normally earns their money with two things: demolish it as quickly as possible, so the redevelopment can start earlier, and separate the steel from the residual flow as it has a high value. With the introduction of the Smart Liberator, the business model of the demolition company changed. Now it has to demolish following a demolishing protocol that was set up by the Urban Mining Collective (appendix B5). Rutte Groep experienced critique when they initiated this process, but currently the demolishing protocol is taken up in the 'Betonakkoord' (Betonakkoord, sd). The working learning trajectory of Rutte Groep began in infrastructure department. In this, a particular portion of the wage bill was used to pay for workers who were not in the labour market. Then, about 15 years ago, they signed a covenant with the Municipality of Amsterdam, who represented the funding, to pay out the sum all at once and to invest it entirely in an education institute, which has so far guaranteed the hiring a sum of employees.

Governance factors

In the inner city, the municipality of Zaandam is working on reducing environmental impact. In inner-city business parks, they aim for all companies in the long term (2030-2040) to behave as a company in maximum environmental category 3, even if the formal environmental category for that company is higher (Gemeente Zaandam, 2012). Many bridges and quay walls in Amsterdam have reached the end of their life and are in poor condition. To prevent overload and limit further damage, stricter rules apply to heavy vehicles in the centre of Amsterdam. The Zone Heavy Traffic was introduced to protect these overloads in the historic city centre (De Feijter, 2022). This was regulation influenced the daily work of SCP. The collaboration with the Urban Mining Collective and the initiation of Circle of Concrete made it possible to scale up the business. Rutte Groep has received financial support from the Amsterdam Metropolitan Area for the transport branch. This has acted as a catalyst for the development of ZE logistics (appendix B5). Rutte Groep participated in a national pilot project for the application of circular concrete wave breakers near the Afsluitdijk.

> *If you look at the national government, they really push sustainability and circularity requirements into society top down. They give frontrunners like us, who have a number of the market also a huge advantage. So, in the end I find that regional government less convincing.* – ***Interviewee 5***

Summary of factors

In table 13 a summary of the factors for case 4 is presented.

Table 13: Summary of factors of case 4.

	Factors of analysis	
Land Based	Central to demolition and construction projects	Important, close to demolition and construction, at the edge of the city.
	Insights to available materials	Not important.
	Temporary or permanent character	Temporary character
	Use of existing hubs	Not important.
	Space to expand business	Not important, current location does not have additional space for expansion.
Economic	Operational scale	City scale.
	Facilities (R-strategy)	Reduce (R2) and Recycle (R8).
	Business case	Primary circular business case in remanufacturing secondary materials and selling secondary materials.
	Connecting supply and demand	Important, providing temporary space for material storage.
Logistical	Accessibility to main road network	Important, close to main road network.
	Accessibility to water quay for transhipment	Important, for function mix: the transport of bulk materials and ZE logistics with ships.
	Zero emission last mile	Important, moving the decoupling point from the construction site to the hub.
	Logistical information system	Not important.
Technological & knowledge	Changing construction method	Not important.
	Innovation and product development	Important, as SCP is a frontrunner in circular construction and ZE logistics.
	Balanced mix of knowledge and skills	Important, wide range of practical and theoretical employees on the site.
	Resource sharing	Important, sharing space and machines between the companies.
Social	Initiator	Rutte Groep themselves, in collaboration with partners and suppliers
	Public awareness/ societal pressure	Important, as SCP is part of the Urban Mining Collective to promote circular concrete.
	White label hub	White label hub for logistical services.
	Type of clients/ consumers	B2B.
Governance	Environmental zoning category	Zone 4
	Regulation	Zone Heavy Traffic, ZE zone Amsterdam.
	Market	Participating in Urban Mining Collective and Betonakkoord.
	Financial	Private financing but making use of local and national pilot projects.

4.5 Summary of factors

In table 14 a summary of all the factors and cases can be seen that is used for the cross-case analysis in the next part of the thesis.

Table 14: Summary of all factors and cases

	Factors of analysis	Circular Craft Centre	Circular Multimodal BMH	Circular BMH + BMH with urban development	Circular raw BMH
Land Based	Central to demolition and construction projects	Only to demand			
	Insights to available materials				
	Temporary or permanent character	Permanent	Permanent	Permanent	Temporary
	Use of existing hubs				
	Space to expand business				
Economic	Operational scale	Local	Regional	City	City
	Facilities (R-strategy)	R3, R4, R5 and R6	R3 and R8	R2, R3, R6, R7 and R8	R2 and R8
	Business case				
	Connecting supply and demand				
Logistical	Accessibility to main road network				
	Accessibility to water quay for transhipment				
	Zero emission last mile				
	Logistical information system				
Technological & knowledge	Changing construction method				
	Innovation and product development				
	Balanced mix of knowledge and skills				
	Resource sharing				
Social	Initiator	NGO, entrepreneur and recycling centre	Dura Vermeer	VolkerWessels & Bnext	Rutte Groep
	Public awareness/ societal pressure				
	White label hub				
	Type of clients/ consumers	B2B and B2C	B2B and B2C	B2B	B2B
Governance	Environmental zoning category	Zone 3	Zone 4	Zone 4	Zone 4
	Regulation	Certifying waste processes	ZE zones in Rotterdam	ZE zones in Utrecht	ZE zone in Amsterdam and Zone Heavy Traffic
	Market	Local entrepreneurs, recycling centre and NGO	Local government in prescribing efficient construction logistics	Local government in prescribing efficient construction logistics	Urban Mining Collective and Betonakkoord
	Financial	Initial grand from national and local government	Private financing and local subsidies	Private financing and local subsidies	Private financing, local and national subsidies

4.5 Comparative analysis between the case studies

Firstly, an overview of the findings within the analytical framework is represented in table 15. The colour green implicates that all the sub-factors of the main factor were important for the emergence of the building material hub. The yellow colour implicates that only one of the sub-factors in that 'category' was not important for the emergence of the building material hub. The red colour implicates that two or more sub-factors are not important.

Based on the results of the respected analysis of the four cases, the findings from those analysis are compared to identify characteristic similarities and differences between them (table 16).

Table 15: Completed analytical framework

	Circular Craft Centre	Circular Multimodal BMH	Circular BMH + BMH with urban development	Circular raw BMH
Circular functions	Repository and marketplace	Construction logistics, secondary material storage, repository, and marketplace	Construction logistics, repository and marketplace	Construction logistics, secondary material storage
Land Based				
Economic				
Logistical				
Technological & knowledge				
Social				
Governance				

Table 16: Cross-case analysis similarities and differences

	Factors of analysis	Similarities	Differences
Land Based	Central to demolition and construction projects	For the typologies the central location is an important factor	The operational scale in which the hub is central
	Insights to available materials	Insights gained through the focal firms own databases.	The factor was not important for all the
	Temporary or permanent character	The potential growth of the city was considered by two cases	The perception of permanent or temporary differed from case to case.
	Use of existing hubs	Cases make use of other white-label hubs in the Netherlands	One case made the connection with other marketplaces while the other hubs focused more on logistics
	Space to expand business	The locations for the two of the hubs were selected with the space expansion in mind	The quantitative size of the space for expansion differed
Economic	Operational scale	The type of transport modes influenced the operational scale	The materials influencing the operational scale.
	Facilities (R-strategy)	A combination of circular activities take place on the hub	The number of circular activities are different.
	Business case	All the cases have a primary circular business case.	Some cases had the primary focus on selling the materials, while others focused on the logistical business case
	Connecting supply and demand	Using a digital tool to connect to the network and providing storage space	The logistical facilities supporting the supply and demand
Logistical	Accessibility to main road network	Was important for all the cases.	In one case it was important for the suppliers, while for the other cases it was for the consumers
	Accessibility to water quay for transhipment	For all logistical hubs it was an important point that was considered, and it was used for ZE city logistics and supply of bulk materials	Being close to a node in the network
	Zero emission last mile	The hubs were used as decoupling points for sustainable transportation.	Not important for all the cases.
	Logistical information system	Used to calculate efficiency of transport over road and water	Not important for all the cases.
Technological & Knowledge	Changing construction method	Extra space is needed for the temporary storage of the materials	Modular construction is for one case the starting point of the hub, while others see the trend and anticipate
	Innovation and product development	Increasing the efficiency of logistics	Innovation on a product level or innovation in the production process
	Balanced mix of knowledge and skills	Wide range of practical and theoretical employees on the site and incentivising workers with a distance from the labour market	The employees or volunteers work on the site.
	Resource sharing	Sharing space with other companies	In some cases, also the machines were shared with other companies
Social	Initiator	Internal reasons for realising the hub were shared by all the cases	There was a not a combination between public and private parties
	Public awareness/ societal pressure	All hubs promote the CE through means	The initiation of an extra business case where consultant promote the activities of the hub
	White label hub	All the hubs were white label	Only the logistical facilities were white label, while the other typology made all the facilities available to inhabitants.
	Type of clients/ consumers	All the hubs had B2B on the supply and demand site for the building materials	B2C was not shared by all the cases.
Governance	Environmental zoning category	The environmental zoning was 3 or higher.	The activities influencing the categorisation of the zone.
	Regulation	The ZE zones in different cities played a role in the development of the hub	Certifying waste processes was only important for one hub.
	Market	Stimulating the use of sustainable construction logistics through tenders	Collaborating with local authorities
	Financial	Using public funds to stimulate the use of the hubs	Subsidies from local or national governments.

4.6 Reflection on factors

When the comparison between the different factors of the (circular) building material hubs is made, fundamental differences appear. Lastly the factors of analysis are reviewed in their importance in the different cases. This is shown in table 17.

Table 17: Reflection on importance of the factors

	Factors of analysis	Importance of the factors
Land Based	Central to demolition and construction projects	All the building material hub are located central to the demolition and construction projects.
	Insights to available materials	BMH that had logistic facilities as a primary business case and were part of a very large cooperation have insight into the available material for efficient transport, but not for secondary materials.
	Temporary or permanent character	In most of the cases the focal firms had a permanent location on an industrial estate.
	Use of existing hubs	BMH make use of existing (white label) hubs to reduce the upfront investment for developing a new hub and collaborate for efficient logistics.
	Space to expand business	The expansion of space is used for the storage of secondary materials and is common.
Economic	Operational scale	The operational scale for the focal firms ranging from local to regional scale.
	Facilities (R-strategy)	All the circular building hubs facilitated both useful applications for materials and smarter product use.
	Business case	A circular business case is shared by the focal firms.
	Connecting supply and demand	Connecting supply and demand is a key factor that was present in all the cases.
Logistical	Accessibility to main road network	The building material hubs are accessible to the main road network for efficient logistics.
	Accessibility to water quay for transhipment	Generally, accessibility to water quay is used for bulk materials.
	Zero emission last mile	The BMH with a primary logistical function use zero emission last mile logistics.
	Logistical information system	The BMH with a primary logistical function use an information system to calculate the efficiency of logistics.
Technological & knowledge	Changing construction method	BMH are used for efficient transport of modular construction elements.
	Innovation and product development	The BMH that are economically driven actively work on developing and /or adapting innovation.
	Balanced mix of knowledge and skills	In all the focal firms a balanced mix of knowledge and skills is present.
	Resource sharing	In general, a form of resource sharing was present.
Social	Initiator	All the initiators of the hub are still operational active.
	Public awareness/ societal pressure	Raising public awareness is a shared factor by all the building material hubs.
	White label hub	All the building material hubs are characterised as white label hubs.
	Type of clients/ consumers	All the focal firms have other businesses as their clients, selling directly to consumers is also common.
Governance	Environmental zoning category	The environmental zoning ranges from zone 3 to zone 4.
	Regulation	In general, the ZE zones are policy instruments that have an impact on the daily operation.
	Market	In general, the building material hubs collaborate with local public and private parties.
	Financial	In general, private financing with local and national subsidies were used.

5 Discussion

5.1 Validity

Bayman (2012) defines internal validity as: *"[…] whether a finding that incorporates a causal relationship between two or more variables is sound"* (Bryman, 2012, p. 712). In other words, a study's internal validity reveals if the chosen research techniques are appropriate for drawing accurate results. A theoretical framework has been created based on literature research to give an overview of the study's many subjects in order to boost internal validity. Furthermore, the internal validity for the conducted case studies is enhanced by formulating selection criteria in advance that the case study had t' meet. The internal validity for the semi-structured interviews is increased by creating an interview protocol in advance and then choosing respondents based on their involvement and expertise in circular building materialbuilding hubs. Furthermore, to increase the internal validity of the primary data, the interviews were recorded, and transcription was performed word-by-word and validated by each interviewee.

External validity can be defined as *"[…] whether the results of a study can be generalised beyond the specific research context"* (Bryman, 2012, p. 47). The primary issue with case study research, and therefore with this research as well, is that the findings' external validity is frequently in debate (Gummeson 1991). It can be challenging to say that the findings apply to more general situations or even to examples that are similar, especially if only a small number of cases are investigated. This study aims to establish external validity through the comprehensive overview of numerous case studies. Furthermore, hereafter in the discussion the findings of this thesis are related to existing theory in order to increase the external validity.

5.2 Research outcomes

Typologies of (circular) building material hubs

Recent research has been conducted into the concept of building hubs. Kreeft and Vonk (2019) describe a central cluster for a circular construction chain in a study for the additional demand for space in the Amsterdam Metropolitan Region. This cluster is used for the storage and high-quality recycling of building materials where both bulk materials and non-bulk materials come together at one location. This description is very similar to the typology 'circular raw building material hub'. In addition, Kreeft and Vonk (2019) describe regional marketplaces where the building materials are stored and sold, like the typology 'circular building material hub'. According to Van Merriënboer, Bastein, Rondaij and Rabbie (2022) there is little synergy to be achieved in combining the logistics processes for bulk (concrete, asphalt) and non-bulk construction flows (finishing materials, such as doors and frames, but also facade parts and larger prefab building elements). So, combining different typologies of circular hubs for a certain area is therefore also interesting from a spatial and logistical point of view. The various locations could act in a hub and spoke network, based on their function and operational scale to provide the entire area with circular building materials (appendix B6).

Furthermore, Van Merriënboer, Bastein, Rondaij and Rabbie (2022) state that a raw building material hub and a mandatory hub can be upgraded to CBMHs. The different typologies in this study show that transforming current building materials hubs into circular building materials hubs in terms of logistics means adding circular facilities. In addition, this has a direct relationship with the factor 'use of existing building materials hubs', which is regarded as an important factor by all types of hubs. This also became apparent in the second interview (appendix B2), as the building material hub is a location with the most optimal point for the deliveries for a city, so when the return flows of secondary materials are added, the hub van evolve. For the 'upgrade' of the building materials hub to CBMH, significant space

expantion must be considerd for the storage of reusable secondary building materials for a longer period of time.

Territorial factors of the CE

The factors were used as a framework in which the methodical evaluation was given to the current (circular) building material hubs. According to Tapia, Bianchi, Pallaske & Bassi (2020), the economic and land-based factors play a role in determining the framework conditions of circular transformations at the regional and local levels. In general, these statements are confirmed by the findings and from this study. All circular hubs have a circular business case as a starting point through the smarter use of the products and the useful application of the materials (R strategies), whereby the central location makes a connection between the supply and demand of secondary building materials. The operational scale varies from local to regional. The “harder” territorial factors, such as logistical, technological, and knowledge factors, help define the effectiveness of CE strategies, while the “softer” factors, such as social and governance factors, help to speed up the transformation to a CE. This study shows a difference between the 'harder' factors. First, the accessibility of the hub to the main road network, is also a starting point for realizing a CBMH. This difference can be traced back to the difference in research framing. This research specifically looked at 'hubs', originally a logistical concept, in comparison with the CE, which is a model of production and consumption. Secondly, the balanced mix of knowledge and expertise is a basic principle in all researched types of hubs. This comes down to the (digital) sharing of knowledge, so that a mix of expertise is realized within and outside the hub. The 'soft' factors such as the social and governance factors are also broadly in line with the statements of Tapia, Pallaske and Bassi (2020).

What became apparent from the land-based factors is that (additional) space for the realisation of a circular built environment is required. The main problem with the additional space lies in the fact that existing inner-city production areas are being converted into residential and commercial districts using a circular design concept, in part due to urbanization (De Beer, Ekamper, & Van der Graag, 2018). This, however, runs counter to the idea behind a CE that implies that there is circular design and circular functioning. Urban regions lose industrial practices because of these changes, which reduces their circularity because the circular functioning in the areas is no longer there (Van den Berghe & Vos, 2019). Additionally, most types of hubs from the case studies have a permanent character, it could be argued that they also have a temporary character, only over a long period of time. Each square meter is designed for a specific function in the Netherlands and these functions can change with the dynamics of a growing city. This was a starting point for the company from the fourth case (appendix B5). Finally making use of existing hubs generally seen as an important factor. After all, a construction hub is a means and not an end. Perhaps storage, transhipment and processing of materials can also be facilitated via the current chain supply chain.

Several important topics were discussed that make it possible to make a circular building materials hub more financially attractive. In interview C1 it was mentioned several times that changing the tax on materials and labour can have a positive impact on the hubs. The cost of secondary non-bulk materials is relatively high due to the amount of labour and taxes on labour. When the primary building materials will be taxed more heavily or labour is taxed less, this will give the circular building materials hubs a boost (appendix C1). Furthermore, studies that have examined the CE model claim that its expansion will result in several positive outcomes and the development of a new business model that will arguably lead to many job opportunities in the near future (Ghisellini, Cialani, & Ulgiati, 2016). The previous documents discussed the additional space required for the realization of a circular building materials hub. One factor that has not been addressed in this framework is the impact on the labour force in a particular area.

The logistical factors provided the insight that efficiency in accessibility for the hubs is important to prevent ecological, social, and economic nuisance. The interview showed that construction logistics is generally not yet seen across several projects (appendix B3) but is looked at per project. But by planning for a few projects, it is possible to reduce significant emissions, nuisance in the city and costs. This is also confirmed by quantitative data through the multiple studies of TNO (Van Rijn et al., 2020A; Van Rijn, et al., 2020B). In addition, the interviews also make a connection with sectors other than construction for example city logistics (appendix B2; appendix B6), which overlaps with the implementation of the ZE zones from 2025. For the first case ZE was not an important factor as it is located in a smaller town. This is in line with the claims made by Van Luik et al. (2021).

What became apparent from the technological site is that two cases are actively working on logistics and on facilitating modular construction. As stated by (Loef, 2021) (circular) building material hubs can play a role in facilitating this. However, there is a point of discussion, as interview 6 (appendix B6) mentions, the modular elements can only be reused after the elements have fulfilled their use phase. This way the effective transition to a fully circular built environment is still far in the future. The circular raw material hub described in the interview with Rutte Groep (appendix B5) is an illustration of a location where manufacturing operations are evolving due to technological developments to become smaller, quieter, less destructive, and more diffused (Hatuka, Ben-Joseph, & Peterson, 2017).

The social factors showed that all types of circular building materials hubs are a means to actively contribute to more awareness within a circular building sector (appendix B3). This is important factor for the transition to a circular built environment (Borrello, Caracciolo, Lombardi, Pascucci & Cembalo, 2017). The first case showed that the initiators of the hub emphasize the social effects of realizing a hub (appendix B1).

If current laws and policies are to be believed, the transition to a circular built environment should be in full swing. But the policy documents are not always translated into direct action. As indicated in interview 5, there are still evident differences in the departments that set ambitions and the departments that work on the projects (appendix B5). Furthermore, as multiple interviewees (appendix B1; appendix C2) state that the prescription for public and private projects for efficient construction logistic will further enhance the use of building material hubs.

Geopolitical factors

One factor that was not addressed in this thesis are the geopolitical factors. The Dutch economy is heavily reliant on imported raw materials, and since 2010 it has only increased its dependency on the global supply of materials and products (Van Berkel & Schoenmaker, 2020). In a recent study to the impact of supply restrictions on the Dutch economy in an international perspective, Hemmerlé and Van Schaik (2021) showed in that since the beginning of the global economic recovery at the end of 2020, businesses have been confronted with production challenges because of a mismatch between supply and demand. According to survey results from the European Commission, 27% of the Dutch construction industry stated that they lacked the necessary materials to meet demand in October 2021. Ultimately these mismatches in supply and demand had an effected the construction cost in the Netherlands. The construction cost were also affected by the war in Ukraine as on average it increased by 15% in the first quarter of 2022 compared to a year earlier. Products made of wood and metal in particular rose sharply in price. Some of these products come from Russia or Ukraine. For example, there are several large aluminium factories in Ukraine, but they have been shut down because of the war (Smit & Dirkse, 2022). CBMHs can resolve a part of this problem. The supply of secondary materials that come from local demolition project are not dependant on global supply chains and results in a

more predictable supply of secondary materials for building projects in the Netherlands. According to Van Leeuwen, Schwarz, & Endhoven (2020), in the coming decades the demand for building materials in the Netherlands will significantly exceed the supply of secondary materials that will become available through demolition. The sale of materials released from demolition through CBMH are in principle possible because the demand far exceeds the supply. Digital tools can further increase insights into the profitability of circular building material hubs. The 'Bouw-op-de-kaart' initiative from Economisch Bouw Instituut and TNO is an example that is currently under development (Circulaire stad, sd). The tool offers digital insight into the supply and demand of building materials based on projections of infrastructure and residential and non-residential development, demolition, repair, and renovation. This information can be used to forecast which products and materials will be in demand for circular products at various locations and times. Because of this, it is now possible to evaluate how, when, and with what logistics reuse is profitable. Reuse costs, environmental effect, and transportation movements are some of the factors used to calculate the profitability of reuse.

Housing scarcity and CBMH

A point that needs to be addressed regarding the socio-economical context of the Netherlands and in particular the province South Holland is the current housing crisis. To fully absorb household growth in the period 2021-2029 through new housing construction, a total of 961.300 new-build homes must be added to the Dutch housing stock. The total housing task in South Holland amounts to 280.200 (ABF, 2021). Moreover, many municipalities in the Netherlands insist that new dwellings will be built in a circular fashion to meet the 2030 (50%) and 2050 (100%) CE goals (Ramli, 2020). As long as it doesn't slow down the volume and pace of housing construction, the province of South Holland is committed to circular construction (Provincie Zuid Holland, 2019). Construction is when emissions in the industry are most prevalent. Therefore, it is crucial to take action at the construction sites, the source of the problem. We can concentrate on creating a demo site for zero-emission building projects. For diesel generators and polluting cars, substitutes will be employed. Additionally, a pollution-free building site helps inhabitants breathe cleaner air and reduces noise pollution (Provincie Zuid Holland, 2019).
In new construction projects for which no contractual agreements have yet been made, there is currently uncertainty surrounding the development of construction costs and delivery times (Smit & Dirkse, 2022). The development of energy costs, and how these are reflected in material prices, is a major source of uncertainty.

Nitrogen crisis and CBMH

Another challenge in the Netherlands is the current Nitrogen crisis. For organisms to survive, the element nitrogen (N) is essential (Erisman, et al., 2015). Despite the fact that di-nitrogen gas (N_2) makes up the majority of the atmosphere, organisms that need reactive forms of nitrogen (Nr), such as ammonia (NH_3) and nitrogen oxide (NO_x), virtually ever use this form (Erisman et al., 2015). The construction industry contributes to the N-crisis through the production of cement/concrete and construction machinery emitting NO_x (Stokstad, 2019). In total, it contributes 0.6% to the nitrogen emissions in the Netherlands (Stokstad, 2019).
A comprehensive approach should be taken because construction is just a minor contributor to the N-crisis. It is crucial for industries to collaborate and create complete solutions because the agricultural sector accounts for 60% of all nitrogen emissions and future predictions for Nr fixation rates range from slightly lower to twice as high as those in 2000 (Erisman et al., 2015). Increasing the effectiveness of nitrogen use in agriculture (more biological fixation, closing the nutrient cycle, and maximizing productivity), switching to plant-based proteins to reduce food waste, reducing the combustion of fossil fuels, and finally increasing denitrification processes (naturally through wetlands or mechanically in wastewater treatment processes) are all viable options now (Erisman et al., 2015). The building industry and in particular CBMH could offer its knowledge and support for these solutions by making logistics smarter and optimal processing of residual flows for bio-based building materials from agricultural sector. Installing these hubs close to agricultural areas could also aid in encouraging

circular economy concepts, which in turn could aid in reducing the N-crisis that the Netherlands is currently experiencing.

5.3 Discussion on practice

Case study

Selection criteria were first created before a case study was chosen for this study. The criterion boosted the case study's relevance and applicability, which added more valuable information to the research findings. The availability of enough data regarding the case study was another criterion. As a result, potential case studies were first identified, and then a thorough search was made to see what information was available about the case studies in question. Additionally, this earlier study took a lot of time because it was sometimes difficult to find applicable information.

Semi structured interviews

The semi-structured interviews were mostly used to compile more data for the different case studies. The information on various typologies was gathered in large part thanks to the interviews with the 7 respondents. The case study's desk research revealed little about the various factors relating to the typologies, hence the responses of the respondents were valued for this study. An interview protocol was created prior to the interviews. As a result, the same themes of questions were asked to every respondent.

Another topic of discussion was the fact that throughout the interviews, the respondents made statements that might have been opinions rather than facts. Some claims were fact checked, such as environmental zoning for companies, while certain other claims were more challenging to verify. Because of this, none of the arguments were given as unambiguous facts but rather made accurate references to the particular interview in Appendix B and C.

5.4 Limitations

This thesis also included some limitations. The first limitation is the small number of respondents for each case study for primary data. This has possibly reduced the power of the study and has increased the margin of error. However, as the participants had a relevant professional function in the cases, they could answer all the question equally. Furthermore, because these typologies are not described and analysed this way, the findings of this study offer new, potential useful information for future research about (circular) building material hubs.

Second, based on the data from the case studies and interviews of this research, it is not possible to say anything about the difference in importance between the sub-factors. For example, in the interviews, the respondents named one of the sub-factors positively or negatively or did not mention the sub-factor. Therefore, the analytic framework contains only the main factors. By quantitatively assessing the sub-factors it was possible to substantiate the relevance of the main factors.

Thirdly, for the development of the 26 sub-factors, the paper of Tapia, Bianchi, Pallaske & Bassi (2020) was used a reference guide in structuring the subfactors. All the papers relating to one or multiple sub-factors found were relevant for (circular) building material hubs, but some focused more on the CE in general while others focused on the circular built environment or construction logistics. Another point to be made was that the papers were not city or country specific, meaning that developments and perceptions could vary between countries and local regions and could skew to a more optimistic or pessimistic view of the CE, circular built environment, or construction logistics. This was avoided by also researching literature that was specific for The Netherlands.

Finally, because the researcher does not have many years of experience of conducting research and producing academic reports of such a large size individually and due to lack of knowledge on the

subject, the results may be biased. However, the findings for this study are still valid for answering the research questions, since the (circular) building material hubs and factors depicted very general aspects for the relation to a circular built environment.

5.5 Implication of framework and recommendations

As mentioned in previous research, implementing a CBMH could be a logical step when improving the circular activities in an area. The final framework can be considered as a two sited design tool for the realisation of CBMHs. If organizations want to discover whether it is interesting to realize a circular construction hub, they can first investigate whether one type of hub is suitable for the location by looking at the factors already present in the location/area. The organisation needs to decide what the hub will precisely look like. It needs to ask itself an extensive number of questions that are in line with the six main factors. For example, for the land-based factors the organisation can ask themself: What is the operational scale of the hub and size of the hub regarding being central to demolition and construction projects? Has the hub a temporary or permanent character and does it make use of existing hubs? When questions are generated and answered, the organisation can analyse the answers and identify which factors are present. As an example, if three of the four different factors are already present for the realization of a circular craft centre, it is interesting to investigate what is needed to add the last factor, to strengthen circular activity in the area or location.

On the other hand, organizations can also research the addition of circular activity by looking specifically at a certain type of circular construction hub, with added value. This will also make the area or location more circular and broader in scope.

Recommendations for the province of South Holland

For the province of South Holland, it is recommended that if they want to realise a building material hub and improving the functioning of current building material hubs. In table 18 the distinction between the different phases of building projects are presented on the x-axis and the different roles are presented on the y-axis.

Table 18: Recommendations for stakeholders

	Planning and design phase	Tendering & commissioning	Realization phase
Legislator and regulator	• Proactively explore the need for a building materials hub in relation to existing processes and parties that focus on the reuse of materials. • Draft a framework for spatial planning (environmental plan) and mobility. • Introducing ZE zones to sustainable city logistics and consider the charging and filling infrastructure	• Making construction logistics part of the environmental permit. • Coordination between construction projects and the environment is part of the permit process.	• Sanctions for organisations that do not employ sustainable construction logistics.
Contracting authority	• Taking construction logistics into account in design, material and construction process. • Early inclusion of demolition company for expertise.	• Managing construction logistics in tenders via minimum requirements (SoR), award criteria, MEAT requirements. • Managing environmental building impact in tenders via minimum requirements (SoR), award criteria, MEAT requirements.	• Coordination between construction projects and the environment is part of the permit process.

Facilitate and stimulate	• Provide insight into the impact of the construction task on construction logistics. • Temporary locations for storage.	• Proactively participate in pilot projects with market parties.	• Subsidies for sustainable construction logistics. • Facilitate the realisation of a digital marketplace for matching the supply and demand of secondary materials.

Next to the specific recommendations, there are two actions that all stakeholders should employ:

- Provide a clear vision on construction logistics that is widely supported throughout the organization.
- Collaborate, internally and with other organizations.

5.6 Recommendations for future research

Apart from answering the research questions for this thesis, it is interesting to examine future studies. This study identified different building material hubs and the relevant factors, but left out material counting, material costing, distance to source and centre of gravity analysis for possible locations in the Netherland. These typologies of building materials hubs are aimed at the construction sector, but as interviews (appendix B2) also indicate, synergy can be achieved with logistical hubs from other sectors. This leaves room for future inquiries on this topic. A quantitative study is also required to do additional analysis on the framework of the six components to confirm the relative value of each factor. And lastly research about the added value of the different building material hub in different contexts will be useful for policy making.

6 Conclusion

This thesis aimed at answering the research question: “What different building material hubs in relation to a circular built environment exist, and what factors explain their emergence?”. To answer this question, the concepts of a circular built environment, construction logistics and the different building material hubs were studied to get a better understanding of the concept of CBMHs.

Sub-question 1: What is the concept of circular economy?

The concept of CE can be considered as a model of production and consumption that in contrast to the linear economy, which consumes an infinite supply of new resources and produces waste, aims to achieve the decoupling of economic growth from the depletion of natural resources and environmental damage. The concept uses 10 principles as a distinction between various gradations of circularity that have a hierarchy going from lowest to the superior principles: recover (R9), recycle (R8), repurpose (R7), remanufacture (R6), refurbish (R5), repair (R4), re-use (R3), reduce (R2), rethink (R1) and refuse (R0).

Sub-question 2: What is the concept of a circular built environment?

The concept can be defined as a system for closing resource loops at different spatial-temporal levels ranging from a material and component scale, a building scale, a neighbourhood scale, a city scale, and finally a regional scale. The goal of a circular built environment is to maximize the worth and complexity of building materials to conserve the supply of virgin building materials and increase the application of secondary building materials.

Sub-question 3: What is the concept of construction logistics?

Construction logistics were employed to deliver building materials as efficiently as possible. It can be described as a convergent supply chain that directs all supplies to a construction site, where the finished product is assembled from the materials that arrive according to the phase of construction. With a few notable exceptions, it is a transient supply chain that creates unique building projects by routinely restructuring project groups, which results into an instable and fragmentated supply chain.

Sub-question 4: What different building material hubs exist?

There are 12 types of (circular) building material hubs namely, (1) the construction site hub, (2) the suppliers’ building material hub, (3) the floating building material hub, (4) the circular craft centre, (5) the mandatory building material hub, (6) the circular building material hub, (7) the multimodal material hub, (8) the circular multimodal building material hub, (9) the building material hub with urban development, (10) the raw building material hub, (11) the circular raw building material hub and finally (12) the prefabrication building material hub. Furthermore, a distinction can be made between the primary functions of the hubs as there are mostly locations as logistical hubs, locations for storage of secondary building materials and locations for marketplaces and repositories. In practice however, these functions are frequently blended in different configurations.

Sub-question 5: What factors are shaping circular building material hubs?

Based on territorial factors that shape close-loop systems for the CE, this study identify six main factors explaining the emergence of building material hubs. These are (1) land-based factors, (2) economic factors, (3) logistical factors, (4) technological and knowledge factors, (5) social factors and (6) governance factors. Every CBMH starts with a circular business case that establishes the smarter use of products and useful application of the materials. The central site of the building material hub links the supply and demand of building materials, ideally second-hand ones. Accessibility to the main road

network for logistical purposes and a mix of knowledge and expertise are essential factors that shape the building material hubs. Lastly creating public awareness and providing white label facilities by the initiator from the hub were shared factors.

What different building material hubs in relation to a circular built environment exist, and what factors explain their emergence?

There are four different building material hubs that exist in relation to the circular built environment: (1) the circular craft centre, (2) the circular multimodal building material hub, (3) the circular building material hub and (4) the circular raw building material hub.

As the circular craft centre's primary objective is to unite parties and inspire them to close the circular loop as efficiently as possible and as initiators are in the public domain and functions as a circular repository and marketplace, the economic, social and governance factors primarily explain the emergence of the hub. Additionally, to a lesser extend the land-based factors explain the emergence of this building material hub.

The circular multimodal building material hub functions as a location for construction logistics, storage and repository and marketplace for secondary materials. For this building material hub, the land-based, economic, logistical, social, and governance factors primarily shape the emergence. The technological and knowledge factors are less significant for the building material hub.

With the circular building hub and hub with urban development focused on construction logistics and repository and marketplace functions, the economic factors, logistical, technological and knowledge and governance factors primarily shape this type of hubs. The land-based factors and social factors also explain the emergence, but less relevant.

Finally, the circular raw building material is a location that incorporates construction logistics and secondary material storage. For this building material hub, the economic factors, and governance factors were the most important for explaining the emergence. The logistical factors, technological factors and social factors were also important, but less significant.

This study attempted to close the gap between the Netherlands' aspirations for a circular built environment and the function and emergence of building hubs in achieving these aspirations. This study is consistent with the body of research from research organizations on the topic of (circular) building material hubs and its potential, but it emphasizes the development of typologies and their connections to relevant territorial factors that explain their emergence, something that, as far as is known, no other study has done.

For cities and regions that have set the ambitious goal of realizing a circular built environment, the report's findings offer an intriguing parable. It is unknown if the Netherlands will be able to achieve their circular aspirations at the time this thesis is being written. Time will only tell.

This report was done in collaboration with LDE Centre for Sustainability: The Circular Building Hub and the province of South Holland to contribute to the exploration of the relevant factors of building material hubs.

7 Reflection

This research was conducted in the graduation laboratory of the Leiden-Delft- Erasmus Centre for Sustainability 'Circular Building Material and (re)Manufacturing Hub'. As the name suggest the graduation lab had a direct connection with my thesis as they both contained the concepts of circularity and building material hubs. In the thesis lab I collaborated with all the other students to verify the factors of the emergence of the building material hub, however as the circular building was a broad concept, not all the work of the other student were in line with my research. An overview of the different themes that me and the other students worked on can be find in figure 18.

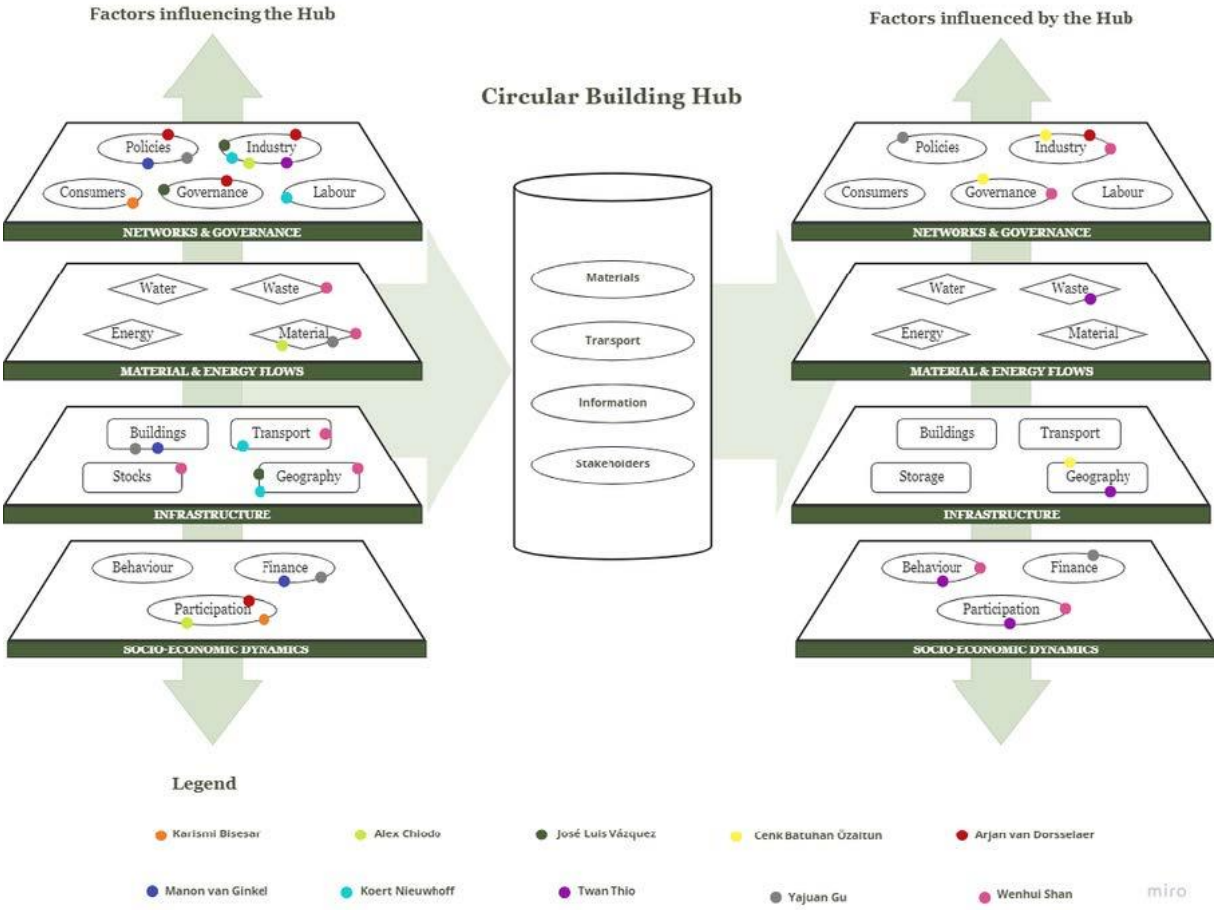


Figure 18: Research themes of graduation laboratory (Chiodo, Van Ginkel, & Thio, 2022)

7.1 Research process

Preparation

In Q4 of the first academic year of the master track I followed the course 'Urban (re)Development Game: Integrating Planning, Design and Property Development' with the role of a CE Manager. As the case was about redeveloping a (former) industrial estate the Binkhorst, I got inspired to investigate the topic of circular business estates. With my background at the HAN University of Applied Sciences, I wanted a very hands-on thesis project. During this course my role mentor was Karel Van den Berghe, and he provided clear feedback and had a pleasant way of communicating. At the end of the course, he told me about the graduation laboratory that he was helping to organise, and it gained my interest.

Towards P1

After the academic summer break, the deadline for the thesis topic was coming closer. I send Karel an email with the first ideas for my graduation topic. We soon had a personal interaction and during this

session, I explained in further detail what I intended to research, and Karel offered hard inquiry alternatives. He agreed to work together on the project, and we moved on to identifying an interesting topic. This was a challenging time, because I had thought that my thesis would give a very practical answer for the requirements of a CBMH. But instead, Karel and I developed the idea to work on the boundaries of a CBMH.

Towards P2

At the beginning of P1 I was still looking for a second tutor. In a personal conversation with Jelle Koolwijk, Jelle gusseted to send a message to Ruben Vrijhoef, as he had worked on 'Living Lab Zero Emission PoRt of Circular Utrecht (ZERO-CU)' that was in line with my topic. In the personal conversation with Ruben, I got positive feedback on the graduation topic, and he immediately started to give suggestions to further specify the steps and goals, which was useful and motivating to hear. At the end of the conversation Ruben agreed to be my second tutor.

In this time, I also applied and got selected to work in the graduation laboratory of the LDE Centre for Sustainability. Though the lab a meeting was set up with two practitioners of the province of South Holland. In this meeting I presented my graduation topic, and they were able to give more feedback that I used when developing my literature study. Overall, I found the graduation process challenging, that was partly due to the Covid-situation that had a mental burden as there was no real perspective on times getting better. Furthermore, not able to concentrate when working from home, resulted in unproductive days. But studying at the faculty or at the public library helped in becoming more productive.

Towards P3

Due in part to holidays and the beginning of the internship period, the research made essentially no progress during the first few weeks of this time. Later, I realized that I ought to have started the research sooner because it had gotten a little behind schedule. And due to the full agenda, it was difficult to really work out the research. This period was full of planning, conducting and transcribing the interviews. Looking back, this took a lot of time and was a demotivating activity, because I have no affinity with this. The graduation lab and the collaboration with the other students gave me energy to do research again. Many ideas came along to complete the analytical framework, it was a period full of experimentation and trying out.

The report was not yet sufficiently developed at my P3 presentation it to be successfully passing the P4. As Karel and Ruben pointed out, it is essential to create the structure and thus the narrative of the research. That is why I have decided to postpone the submission moment of P4 to a later moment. While this eased the pressure to further finish the report, I was hopeful that it would be ready for the P4 after the summer break. My P3 was held two weeks before the presentation of P4, which resulted in the 3 quasi P4 being assessed by my supervisors. This was necessary to feel further pressure to complete the study.

Towards P4

In retrospect this was the most stressful, but productive part of the whole graduation process. This period can be described as a blend of production and thoughtful deliberation about establishing conclusions. The interviews were firstly analysed and included into the research at this time. I finished my internship and other courses, which made more time available for finishing of the thesis. As stated earlier, I only had two weeks between the P3 and P4 presentation and therefore needed to sharply plan my activities that needed to take place. I also needed to make choices for the research, and with the limited time I could not procrastinate the decisions. Earlier in the research I wanted to plan an expert panel to give further feedback on the research findings, however due to the limited time I was

not able to identify experts and plan an expert panel. In retrospect it is a missed opportunity to strengthen the validation of the research. The feedback of both Karel and Ruben were critical for the final product, because I struggled with finding the real underlaying problem of my thesis: making a scientific report with the literature and empirical data. The main reason for this was the structure that the TU prescribes in their guidelines, were not always in line with the most logical structure for my thesis. I leaned that even though the guidelines helped to structure the thesis, it is still a guideline that is not to be strictly followed. I'm writing the thesis for my mentors to grade and therefor their suggestions were more valuable.

Towards P5

The final phase of the thesis process started with incorporating the feedback from the mentors that was given during the P4 presentation. The main points were related to strengthening the discussion, as the implications of the thesis were lacking in relation to the real-life context of the province of South Holland. Since most of the work for the final part was done in the third week of this period, there was sufficient time for finalizing the thesis report. I finalized the abbreviations list and added a summary of the research. As a result, the thesis is complete without any time constrains, which ultimately had a positive contribution to the final product.

7.2 Research methods

Literature study

At the beginning of the literature search, it was challenging to locate any scientific literature on circular construction material hubs because there is still a dearth of information on the topic. For this reason, a lot of literature on the topic of a CE was first read in order to familiarize oneself with its guiding principles before connecting them to the circular built environment and using the body of knowledge on construction logistics to do so. It was difficult selecting the relevant literature regarding this topic, as all the literature was relevant in my eyes. However, with constantly updating the analytical framework and connecting the literature to this framework, this problem was eventually solved. However, towards the end of P3, I needed to review the literature again and to make it more coherent with the narrative in the thesis. I was thus able to organize the literature study so that it could provide as much input as possible for responding to the major and sub-questions of this research thanks to the overview that is provided by the constructed analytical framework.

Interviews

Experts were chosen in advance of the interviews based on their role and background in the field. Ruben provided a shortlist of possible participants, and the specialists were then contacted after, among other things, analysing the accessible LinkedIn profiles of probable responses. In hindsight, the choice of experts has been advantageous because each chosen respondent who was interviewed contributed helpful information to the study. However, doing in-person interviews was not an option because of the coronavirus outbreak and personal preferences of the respondents. There were two issues with the telephone interviews. First, there wasn't a pleasant atmosphere, which made it harder to reach responders for inquiries. Second, these interviews were only conducted for a total of 25 to 30 minutes. However, five respondents were questioned by Microsoft teams. Because the respondents could see me and I could see them, and a more pleasant environment was established. In retrospect the interviews on Microsoft Teams was the best option for the interviews.

Case study

Selection criteria were first created before case studies were actually chosen for this study. The criterion boosted the case study's relevance and applicability, which added more valuable information to the research findings. The availability of enough data regarding the case study was another criterion.

The factors used in the case studies also provided structure for the interviews and trying to connect the different ideas in the research.

Expert panel

As stated earlier, in the P2 Graduation plan I proposed to use an expert panel for verifying the draft result of the thesis. However, due to difficulties finding independent experts it was a challenge to set up the expert panel. Furthermore, with the limited time after the P3 presentation it was not feasible with the amount of work that needed to be done.

7.3 Ethical issues and dilemmas

In the writing of this thesis there was one occasion where a moral issue was involved. This had to do with the fact that one interviewee did not verify the content of the transcript. This could imply that the interviewee was not satisfied with the given answer. However, as I kept the word-by-word transcription of the interview. It was possible to analyse the answer of one of the questions in the whole context of the interview.

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9 Appendix

A. Interview protocol

Goal of the study

This study serves the explorative research into various factors that influence the emergence of a circular building materials and (re)manufacturing hub (CBFH).

Method

This is an in-depth interview. This means that the interview questions later on do not serve as a hard, fixed conversation structure, but mainly as a guideline. The content of the conversation may steer the interview towards new, additional insights. To provide direction, 'probing themes' are also added, which can be used to further deepen the information that emerges from the interview.

Structure guide

This interview protocol offers the interviewers the opportunity to conduct each interview systematically and in the same way. The parts in quotes are script pieces and are read to the participant. The protocol is for the interviewers and is therefore an internal document. The information under 'interview questions' (including the introductory piece of text) is shared with the participant in advance. This interview protocol consists of the following parts:

- Action points prior to interview
- Points of attention at the start of the interview
- Probing Themes
- Start recording
- Interview Questions
- Stop recording
- Closing

Action points prior to the interview:

- Contact the participant by mail or telephone, propose, set the date
- Share informed consent letter, and ask for approval
- Make it clear that the participant can withdraw from the study at any time
- Share interview questions with the participant, no later than two days before the interview.

Points of attention at the start of the interview:

<u>Introduction</u>

"I'm Koert Nieuwhoff, student of Management in the Built Environment at Delft University of Technology. As part of my graduation thesis, I investigate which factors are relevant and influence the emergence of a circular building materials and (re)manufacturing hub.

<u>Purpose of the interview</u>

In order to gain a picture of the relevant factors with regard to the origin of the different types of CBFHs, interviews are conducted with people in the field to examine their personal experience and insights. The interview is mainly intended as an in-depth interview, which means that the structure of the conversation is not completely fixed. The questions I have sent you are primarily intended as a guideline."

- Repeat key points letter informed consent & ask for consent

"As you have read in the letter, you are completely free to answer or not to each question. There are no right or wrong answers, it's mostly about your own experiences and insights. If you change your mind later and prefer not to participate, you can also withdraw your participation at any time.

In order to keep the focus on the conversation during our conversation, and to be able to write it out accurately later, I would like to record the conversation for scientific elaboration, analysis, presentation and possible publication. The information I receive from you, as well as the recording itself, will be treated confidentially, and only shared within the scientific graduation lab. In order to record your consent, I will ask the question again in a moment when the recording started."

Probing Themes

- Definition of a CBFH
- Personal/Professional Role
- Functions of the CBMH (R-ladder)
- Space demand
- Choice location
- Time within CBFH
- Space and material
- Geographical scale: supply, (re)processing and demand of materials
- Financing and business case
- (Multimodal) Logistics
- Social Return
- Administrative constraint/effects

Start recording

"The recording has started. As just discussed prior to the recording, I would like to ask you the following question again: May I record this conversation with you and save it for later elaboration for scientific research?

Interview questions….

Stop recording

Closing interview

B. Semi structured interviews

B1. Interview Gemeente Hoeksche Waard
B2. Interview CityBarge
B3. Interview Dura Vermeer Urban Miner
B4. Interview VolkerWessels M&L (1)
B5. Interview Rutte Groep
B6. Interview Province of South Holland
B7. Interview Vliegende Brigade

C. Public interviews

C1. Interview Bnext

Source: BlueCity (2019).

Welkom bij de BlueCity podcast vanuit de sauna van BlueCity. Hier onderzoeken we de verduurzaming van de Nederlandse economie. We beginnen bij de bouw, want wat vandaag wordt gerbouwd, staat in 2050 nog. Mijn naam is Ties Joosten, en ik wil weten hoe de economie sneller circulair wordt. En deze serie wordt mede mogelijk gemaakt door Duurzaam Gebouwd, Cobouw en Rotterdam circulair. Axel welkom in mijn sauna.

00:00:41 Axel Hendriks

Ja dankjewel.

00:00:42 Ties Joosten

Wat vind je van de sauna?

00:00:44 Axel Hendriks

Ja heel knus.

00:00:45 Ties Joosten

Knus? Geen last van claustrofobie?

00:00:46 Axel Hendriks

Het is goed dat hij uitstaat ook.

00:00:47 Ties Joosten

Misschien is het voor de luisteraars leuk dat je even uitlegt waar je bent terechtgekomen. Wat je ziet.

00:00:53 Axel Hendriks

Je ziet, ja, dus letterlijk een sauna, een oude houten sauna in een verlaten tropicana.

00:01:00 Ties Joosten

We zitten in het voormalige tropicana inderdaad, wat tegenwoordig Blue City heet. We zitten helemaal rechts bovenin als je op de Maas vaart, dan zou je ons in de verte moeten kunnen zien. We hebben net geen uitzicht op de Willemsbrug en de Erasmusbrug, maar het scheelt niet veel. En, we zitten inderdaad in een piepklein oud saunatje, ja, waar vroeger gezweet werd en nu de podcast worden opgenomen. Wat we gaan doen de komende maanden is een vijfdelige podcastserie opnemen waarin we een antwoord proberen te formuleren op de vraag hoe de bouw en de sloop sector sneller kan verduurzamen. Dus circulair kan worden. We beginnen vandaag met het slopen van gebouwen en daarom zit hier Axel Hendriks tegenover mij van Beelen. Nou nogmaals, leuk dat je er bent. Laten we beginnen bij jouw linked in profiel. Je hebt gestudeerd aan de Hogeschool van Rotterdam. Daar heb je een bachelor Real Estate gedaan. En, vervolgens ben jij na je afstuderen naar Triodos gegaan en daar ben je in 2015 in de duurzame vastgoed terecht gekomen.

00:02:06 Axel Hendriks

Ja klopt helemaal.

00:02:07 Ties Joosten

Hoe kom je bij duurzaam vastgoed terecht?

00:02:09 Axel Hendriks

Nouja, vooral met vastgoed heb ik veel. En met bijzonder vastgoed én met de materialen die daarin vast zitten en vooral ook de maatschappelijke impact van vastgoed. Vastgoed is natuurlijk veel meer dan een stapel stenen. Het heeft natuurlijk een enorme impact sowieso op milieu, maar ook op de mensen die erin wonen, die langsfietsen die ernaast wonen. Dus ik vind het concept vastgoed, zeg maar, hoe zich dat verhoudt tot mens, maatschappij en milieu, dat vind ik heel erg interessant.

00:02:35 Ties Joosten

En zo kwam je in september 2018 bij Beelen terecht.

00:02:39 Axel Hendriks

Ja, heel ander bedrijf.

00:02:40 Ties Joosten

Ging je vastgoed slopen.

00:02:43 Axel Hendriks

Ja precies. Ja precies. Nou heel ander bedrijf en in dat opzicht voor sommigen ook wel een opvallende stap. Maar voor mij wel een hele bewuste. Ik raakte op een gegeven moment in gesprek met Beelen. Ze waren bij Beelen op zoek naar iemand die fulltime aan de gang ging met innovatie en innovatie gaat binnen ons bedrijf gewoon heel erg snel over circulariteit, maar ook de maatschappelijke impact van onze projecten. En, het werd mij vrij snel duidelijk dat ik heel veel vrijheid kreeg om te doen, nou ja, welke projecten ik goed achtte. En met name dat sprak mij heel erg aan, dus we zijn gewoon bezig met hele concrete projecten. Vandaag in het nu. En daarin heb ik gewoon heel veel vrijheid gekregen.

00:03:23 Ties Joosten

Nou, ik ben ook hartstikke blij dat je bent willen langskomen, want ik was bijzonder geïnteresseerd, met name in Beelen, omdat ik mijn research aan het doen was. En ik zag op de website van Beelen staan dat zij op dit moment voor 99,45% van de materialen die vrijkomen uit een slooppand dat we 99,45% daarvan een zinvolle nuttige toepassing weer weten te geven. Toen dacht ik nou score, we zijn er. Nog 0,55% te gaan en dan hebben we de circulariteit van de bouw gefikst. Dus ik vroeg me in eerste instantie natuurlijk af, wat was die 0,55%?

00:04:02 Axel Hendriks

Ja, er zijn inderdaad heel veel mooie materialen in gebouwen, maar er zitten helaas ook nog steeds materialen in gebouwen, die we niet willen en of kunnen hergebruiken. Dan moet je met name denken aan asbest en andere verontreiniging delen.

00:04:15 Ties Joosten

Wat gebeurt er met asbest?

00:04:17 Axel Hendriks

Ja, daar heeft de Nederlandse overheid, lees wij, nog niet echt een oplossing voor. Dus dat wordt nu opgeslagen door de Nederlandse overheid. Dus wij leveren dat in eigenlijk bij de bij de overheid, en zij slaan dat op.

00:04:27 Ties Joosten

Dat is een overheidstak? De Nederlandse asbest opslagfabriek?

00:04:34 Axel Hendriks

Bij wijze van. Hoe het precies heet weet ik niet, maar inderdaad, ja. Wij leveren dat in, dat wordt opgeslagen.

00:04:37 Ties Joosten

En, dat wordt niet verbrand? Dat ligt daar te wachten tot we een goed idee hebben?

00:04:41 Axel Hendriks

Een van de eigenschappen van asbest is dat het niet zo goed brandt. Er is ook nog niet echt een andere verwerking voor dus en vooralsnog wordt het inderdaad door de overheid opgeslagen, ja.

00:04:53 Ties Joosten

Nou, dat is 0,55% die we dus sowieso nog moeten oplossen. Maar laten we ons dan vandaag voor de rest focussen op de 99,45% waar wel al dingen mee gebeuren. Zou je die 99,45% voor mij eens kunnen opbreken? Wat voor stromen hebben we het dan grosso modo over?

00:05:11 Axel Hendriks

Nou ja, als je puur kijkt, want die 99,45% is inderdaad op basis van gewicht en het meeste gewicht, wat wij tegenkomen, zal je niet verbazen, is puin en beton puin, maar ook meng puin. En, wij doen ook redelijk wat asfalt en andere puin achtige soorten. Dus dat zit uiteraard in die 99,45%. Maar ook andere stromen die wij gescheiden inzamelen, beetje hout glas. Noem het maar. En er wordt uiteraard heel gewoon gemengd ingezameld nog steeds. Daarvoor hebben wij 2 grote sorteer centra eigenlijk in Houten en Vlaardingen. Je moet dat zien als hele grote machines waar je aan de voorkant gemengd bouw en sloopafval in gooit. En het wordt door die machines gescheiden zoveel mogelijk in schone stromen. Hout, glas, ferro's, non-ferro's, metalen, stenen, gips, noem het maar. En uiteindelijk blijft er dan ook een deel over wat niet sorteerbaar is en of niet recyclebaar en dat wordt gebruikt voor de voor de winning van energie, zoals dat zo mooi heet.

00:06:15 Ties Joosten

Ja, dus dat wordt verbrand dan. Kun je wat zeggen over, wat gebeurt er bijvoorbeeld met de glas stromen? Daar wordt nieuw glas van gemaakt? De hout stromen, wat gebeurt daarmee?

00:06:28 Axel Hendriks

Ja absoluut. Hout heb je in 3 kwaliteiten. Je hebt AB en C hout. En, afhankelijk van de kwaliteit van de type hout, wordt daar een verwerking voor gezocht. Dus een deel van het hout wordt verwerkt in MDF maar ook een deel wordt gebruikt als brandstof ook.

00:06:44 Ties Joosten

Nou ook dus ook dat gaat voor een deel de verbrandingsoven in. En gebruiken jullie ook, zeg maar complete spullen uit huizen? Bijvoorbeeld, ik zeg wat, kabelgoot is volgens een mij bekend voorbeeld uit jullie wereld, maar er zullen meer zijn.

00:07:00 Axel Hendriks

Absoluut, dus voordat wij beginnen met slopen, kijken wij uiteraard heel erg goed van, ja, welke gebouwonderdelen in dit gebouw kunnen nou direct worden hergebruik? En dus we hebben twee demontage teams, die doen heel de dag niets anders dan die spullen demonteren, eventueel bewerken en zorgen dat ze weer ergens een plekje vinden. Dus we hebben daar inmiddels ook een beetje, op zich in die handel in gebruikte bouwmaterialen, die is al zo oud als het slopen zelf. En wat je nu ziet, is dat dat met name door digitalisering gewoon steeds beter een plekje vindt. We hebben bijvoorbeeld nu zelf ook een webshop opgericht voor die gebruikte bouwmaterialen en je ziet ook echt de interesse in die materialen echt wel groeien. Je ziet nu echt architecten zich toeleggen op het ontwerpen met gebruikte bouwmaterialen. Het was op zich een hele interessante beweging.

00:07:44 Ties Joosten

Ik neem aan dat jullie ook waardevolle materialen zoals koper enzo, die zul je ook eerder eruit halen en apart verwerken, omdat het gewoon geld waard is.

00:07:52 Axel Hendriks

Ja, in principe is alles, hoe meer je scheidt, hoe zeg maar rendabeler het is. Koper is uiteraard een voorbeeld wat goed gescheiden wordt, maar verder ook alle metalen en eigenlijk überhaupt, zelf hout is gewoon gescheiden is dat gewoon iets anders waard dan op het moment, dat het allemaal in elkaar zit. Scheiden loont in dat opzicht altijd. Zoveel mogelijk aan de bron wanneer dat gaat, wanneer het niet gaat, dus inderdaad achteraf met ons sorteer centra.

00:08:15 Ties Joosten

En zijn er dan nog materialen die ik over het hoofd zie?

00:08:17 Axel Hendriks

Nouja, we zijn er natuurlijk steeds beter in geworden om allerlei slechte materialen in onze gebouwen te stoppen. Glaswol is daar een heel mooi voorbeeld van. Ik heb collega's die zeggen, zodra wij klaar zijn met het opruimen van asbest, kunnen we beginnen aan glaswol.

00:08:35 Ties Joosten

Ja zo erg?

00:08:38 Axel Hendriks

Ja, absoluut. Er zitten, ja, dan worden we heel technisch, maar er zitten ook hele kleine vezeltjes in. Feitelijk gewoon hele kleine glasvezeltjes, die op het moment dat het vrijkomt gaat het letterlijk in de lucht zitten en die kan je dus ook inademen. Net zoals bijvoorbeeld met asbest.

00:08:51 Ties Joosten

Moeten de mensen thuis zich zorgen maken over het inademen we glaswol in dezelfde maat als ze zich zorgen maken, over het inademen van asbest?

00:08:58 Axel Hendriks

Nee zeker niet in dezelfde mate, denk ik, maar nogmaals ja, weet je het zijn, het is gewoon niet heel lekker spul en zo lang, dat denk ik veilig in je muren zit is er weinig aan de hand. Nou ja nogmaals, ik denk op termijn dat we toe moeten naar andere isolatie, zeker op het moment dat je het hebt over de circulaire economie. En wat is nou goed recyclebaar?

00:09:17 Ties Joosten

Want glaswol is niet goed recyclebaar?

00:09:21 Axel Hendriks

Nee, nee.

00:09:22 Ties Joosten

Je zegt het heel beslist. Je zou dus kunnen voorstellen dat je dit zo uit de muur haalt en zo terug stopt in een andere.

00:09:27 Axel Hendriks

Nee precies dus, maar dat is natuurlijk niet recyclen, maar dat is inderdaad een van de oplossingen. Wat wij nu doen met name met steenwol is dat inderdaad zoveel mogelijk heel uit de muur proberen te halen en weer proberen door te zetten. Voor steenwol heb je ook wel recycle programma's, maar dan nog gaat er een gigantische bak energie in. Want wat je dan feitelijk doet, is dat je de steenwol terugbrengt naar lava en er dan weer nieuwe steenwol van spint noemen ze dat ik. Nou ja, dat kost gewoon heel veel energie. Dus inderdaad, die isolatiematerialen, waar mogelijk halen wij die gewoon 'as is' uit en proberen we die op die manier weer naar een andere projecten toe te brengen.

00:10:03 Ties Joosten

Maar goed, de grootste bulk in ieder geval naar gewicht, dat is puin, dat is beton puin, baksteen puin. Wat gebeurt daarmee?

00:10:14 Axel Hendriks

Je hebt mengpuin, dat is inderdaad gemengd puin, dus dat komt bijvoorbeeld van bakstenen, maar ook van beton wat gemengd is met bakstenen, letterlijk mengpuin. Dat gaat eigenlijk heel erg vaak naar de weg en wegen industrie. Dus dat verdwijnt letterlijk als fundering onder nieuwe wegen. Betonpuin is een iets ander verhaal. Op het moment dat je echt mooi schoon betonpuin hebt, en je bent in staat om daar betongranulaat van te maken, dan kan het betongranulaat weer dienen als grindvervanger in nieuw beton.

00:10:44 Ties Joosten

Hoeveel energie kost dat? Dat beton, neem ik aan, dat moet je dan breken. Dat moet je dan kapot maken tot granulaat, tot kleine stukjes.

00:10:54 Axel Hendriks

Exact. Dus er zit op de op de sloop zelf een stukje voorzichtigheid, zou ik bijna zeggen, want op het moment dat het betongranulaat moet worden, dan moet het dus ook echt heel schoon beton zijn. Dus daar mag niks anders of nauwelijks iets anders doorheen zitten, dus dat vraagt vaak net even op voorzichtige manier van slopen. En inderdaad, daarna moet het gebroken worden tot een bepaalde korrelgrootte, gezeefd, soms zelfs gewassen, dus daar zitten nog best wel wat stappen achter.

00:11:20 Ties Joosten

Kun je daar wat van zeggen, hoeveel energie kost dit? Zijn we heel veel energie kwijt aan het granulaat maken, aan het maken van fundering voor onder onze wegen?

00:11:30 Axel Hendriks

Nou dat is wel wat anders, hè, dus dat zijn twee verschillende dingen. Dus normaal menggranulaat, dat mag relatief, dus daar mag baksteen tussen zitten en dat mag, dat moet uiteraard wel gebroken worden, maar dat hoeft bijvoorbeeld niet of nauwelijks gezeefd te worden. Dat hoeft ook niet gewassen te worden, dus dat kost qua energie, valt dat nog mee. Maar op het moment dat je echt gaat naar het betongranulaat voor de betonindustrie, nou, dat vraagt dan echt een andere kwaliteit, dus dat vraagt aanzienlijk meer bewerking. Dus dat kost zeker energie geld, ja.

00:11:59 Ties Joosten

Wat levert 1 ton granulaat op?

00:12:03 Axel Hendriks

1 t menggranulaat nu ongeveer 3 a € 4 de ton.

00:12:08 Ties Joosten

3 a € 4 per ton? En dat is dat je alle bewerkingen hebt gedaan.

00:12:13 Axel Hendriks

En al die bewerkingen, kijk wat wij proberen is om die bewerking ook op de sloopplaats te doen, dus je bent een gebouw aan het afbreken aan de ene kant. Daarna gooi je het letterlijk, ter plekke, het puin door de breker heen, waardoor er ter plekke grondstof voor de wegenbouw ontstaan, zodat ook direct van de sloopplaats door kan naar de plek waar ze nou in dit geval een weg aan het bouwen zijn, zodat je in ieder geval de stap overslaat dat het naar één van onze vestigingen moet. Dus daar probeer je dan een efficiency slag te halen, want op 3 € 4 de ton, als je dan een paar kilometers kan besparen, dan is dat natuurlijk al snel beter.

00:12:50 Ties Joosten

Ja de marges moeten gestoord laag zijn.

00:12:52 Axel Hendriks

Ja klopt, ja, het is echt volumehandel.

00:12:54 Ties Joosten

Volumehandel, ja, gewoon ja en dus inderdaad, als je gewoon granulaat naar Groningen moet brengen vanuit die Rotterdam, dan verdwijnt je marge alweer.

00:13:04 Axel Hendriks

Maar dat doet dus niemand.

00:13:04 Ties Joosten

Dat doet dus niemand? Dus het granulaat onder de wegen in Rotterdam komt waarschijnlijk uit gesloopte huizen uit Rotterdam?

00:13:12 Axel Hendriks

Nou ja, misschien dat de cirkel iets groter is, want je zit natuurlijk met je beschikbaarheid. Maar inderdaad, die cirkel, die is zo klein mogelijk. Dus wij kijken daar ook heel bewust naar, deels vanuit CO2 en andere overlast, maar zeker ook vanuit kostprijs.

00:13:24 Ties Joosten

Betekent dat dan als er in Rotterdam ambities om heel veel nieuwe wegen te leggen, dat hier dan een tekort ontstaat aan granulaat of dat het heel veel het kost, omdat het uit Groningen gehaald moet worden?

00:13:37 Axel Hendriks

Ja je ziet in heel Nederland zijn wij op dit moment zoveel wegen aan het bouwen dat er eigenlijk op de markt een krapte is aan menggranulaat.

00:13:45 Ties Joosten

Dus die 3 a € 4 is zelfs een resultaat van krapte, schaarste?

00:13:51 Axel Hendriks

Ja. Ik vroeg aan een collega toevallig eergister en die zei dat toen hij begon in 2014/2015 was het 1 a € 2. Rond de euro zei hij zelfs.

00:14:06 Ties Joosten

Maar ik snap niet hoe je daar een vrachtwagen voor kan laten rijden of is dat gewoon, omdat je er toch op een of andere manier van af moet? Je moet het natuurlijk ergens kwijt, dus dan maar onder een weg.

00:14:15 Axel Hendriks

Ja tuurlijk, ja, dat is ook zo.

00:14:18 Ties Joosten

Nou fascinerend. Nu zijn er natuurlijk partijen die langzamerhand nadenken over cement terugwinnen uit granulaat of uit betonpuin. Maar als ik jou luister, dan is dat misschien niet eens heel zinvol, omdat er nu al sprake is van krapte? Dus ja, hoe minder granulaat er overblijft, hoe krapper die markt wordt.

00:14:45 Axel Hendriks

Ja, nou ja, je ziet daar verschillende ontwikkelingen in. Inderdaad menggranulaat is prima in dat opzicht voor de wegenbouw, want in de wegenbouw is gewoon die grondstof nodig. Je ziet voor de betonindustrie, daar kan je dus betongranulaat inderdaad prima gebruiken als grindvervanger, mits op de goede grootte gezeefd, gewassen enzovoort. Maar je ziet inderdaad dat die vraag kant, aan de zeg maar, de wegenbouw kant, die is nu zo groot dat er soms een spanning ontstaat tussen, ja, ik heb prima het granulaat, maar werk ik dat op tot een grondstof voor de betonindustrie of, nou ja, stuur ik het letterlijk naar de wegenbouw. Dat spanningsveld, dat ontstaat inderdaad door die grote vragen aan de kant van de wegenbouw. En vervolgens zie je natuurlijk een beweging, want betongranulaat verwerken in beton als grindvervanger is op zich een hele mooie oplossing. Tegelijkertijd is de meest vervuilende component van beton cement. Ik geloof dat cement wereldwijd verantwoordelijk is voor 8% van de CO2 uitstoot en daarvoor moet je natuurlijk naar andere oplossingen gaan kijken, dus dan is inderdaad het proberen van het terugbrengen van beton tot grind, zand en cement is inderdaad

een hele mooie oplossing. Er wordt nu door verschillende partijen kleine, maar toch wel steeds groter wordende schaal mee geëxperimenteerd.

00:16:04 Ties Joosten

Dus aan die kant kan het een aanzienlijke CO2 besparing realiseren aan de cement kant. Maar voor het funderen van onze wegen, zullen we dan iets anders moeten verzinnen?

00:16:13 Axel Hendriks

We zijn nu bijvoorbeeld in Terneuzen zijn wij bezig met het opwerken van AEC granulaat. Afval-energiecentrale, dus letterlijk de bodemassen die als restmateriaal uit de energiecentrales komen, die kan je bewerken en wassen tot eigenlijk een vrij toepasbare bouwstof en dan vervolgens bijvoorbeeld in plaats van betongranulaat als bouwstof in de wegenbouw gebruiken.

00:16:43 Ties Joosten

Misschien is het dan leuk om door te gaan naar Beelen Next, want dat is eigenlijk jouw passie, jouw werk. Misschien moet je dan eerst even uitleggen, wat Beelen Next precies is.

00:16:53 Axel Hendriks

Beelen had eigenlijk 4 bestaande bedrijfsonderdelen: sloopwerken, recycling, bedrijfsafval en een festival reiniging. We hebben daar een nieuwe bedrijfstak naast gezet, inderdaad Beelen Next en wat Next doet is alle innovaties die binnen de groep spelen en samenbrengen, verder brengen en dan eigenlijk weer teruggeven aan de werkmaatschappij. Dus wat doen we dan concreet?

00:17:19 Ties Joosten

Ja dat wilde ik net vragen.

00:17:21 Axel Hendriks

Hoe we dat concreet doen, is eigenlijk op twee sporen. Enerzijds zoeken wij pilotprojecten, dus wij hebben, heel veel opdrachtgevers, die hebben nou normale ambities. We hebben ook een aantal opdrachtgevers, die hebben echt hele hoge circulaire ambities. Samen met die opdrachtgevers gaan we echt op project schaal kijken van wat kan er nou binnen dit project, wat bijzonder is, wat anders is, wat meer circulair is dan regulier.

00:17:44 Ties Joosten

Kan je dit illustreren met een voorbeeld?

00:17:46 Axel Hendriks

Zeker. We zijn in Leiden bezig, daar zijn we nu bijna klaar. We zijn bezig met de sloop van een gebouw op de campus. Het is een relatief simpel gebouw, stalen constructie betonnen vloer met een glazen gevel eromheen. Normaal gesproken zou zo'n gebouw, nou ja, worden fijn geknepen eigenlijk en teruggebracht tot de 3 materialen die ik net noemde, glas, metaal en betongranulaat en in ieder geval bracht de opdrachtgever ons eigenlijk in contact met een consortium op 500 m verderop een nieuwbouw gebouw aan het bouwen is.

00:18:17 Ties Joosten

Voor de universiteit ook?

00:18:19 Axel Hendriks

Voor Biopartner, dus dat is op zich een partij die ook wel op het universiteitsterrein zit. En die hadden eigenlijk wel interesse in materialen die uit ons gebouw kwamen. Maar ja. Al sprekend kwamen we eigenlijk op de stalen constructie en dat heeft in dit geval geleid tot het soort van omgekeerde bouwtekening van het gebouw wat we aan het slopen zijn. We hebben samen met IMD ingenieurs bureau gekeken van hoe kunnen we dat gebouw nou zo opzagen dat letterlijk die stalen elementen, dus die balken en die T-stuts, dat die 500 m verderop weer kunnen worden toegepast in de nieuwbouw. Dus je slaat daarmee eigenlijk de hele stap van de hoogoven sla je eigenlijk over, want je zaagt letterlijk die element los en je schroeft ze 500 m verderop weer in elkaar. Zo klinkt het heel simpel. In de praktijk is het wel redelijk ingewikkeld.

00:18:59 Ties Joosten

Maar dat betekent ook dat jullie niet met jullie knijper dat gebouw uit elkaar konden halen?

00:19:11 Axel Hendriks

Inderdaad, het betekent ook heel veel voor onze operatie en de jongens die daar aan het werk zijn.

00:19:16 Ties Joosten

Hoe reageren ze hierop? Allemaal extra werk, toch?

00:19:20 Axel Hendriks

Ja, het is extra werk en tegelijkertijd zien zij ook wel, weet je, dat het heel bijzonder is en dat het heel tof is. Het is ook voor hun soms even kijken van ja, wat vinden we hiervan? Ook omdat er anderzijds altijd nog wel een soort van tijdsdruk is. Een project moet ook gewoon af. Er staan grote kranen, er staan grote machines te werken, en ook mensen. We hebben van deze opdrachtgever wel alle tijd gekregen voor dit. Of niet alle tijd, maar in ieder geval iets meer tijd gekregen om het project.

00:19:47 Ties Joosten

Definieer eens iets meer.

00:19:48 Axel Hendriks

Nou ja, ik geloof dat wij eigenlijk rond de bouwvak klaar hadden moeten zijn, en we ronden nu ongeveer af, dus dan heb je het toch al snel over 1,5 maand.

00:19:56 Ties Joosten

En die, heb je extra gekregen om dit op deze manier te doen. Wat kost het nou extra? Dit kost extra als je hier de business case van zou uitrekenen, toch?

00:20:09 Axel Hendriks

Ja dit kost extra, maar je bent inderdaad op een andere manier, je bent dingen los aan het zagen inderdaad, in plaats van aan het knijpen én tegelijkertijd levert ook heel veel op. Want de prijs die wij normaal zouden krijgen voor dit metaal, nou ja, dat ligt dan op een bepaald niveau,€ 450 de ton, en wij hebben diezelfde prijs dus doorbelast aan dat consortium, een op een, heel transparant. En, ik geloof dat normaal staal kost, zeg maar even wat, stel dat het €1000 de ton kost.

00:20:39 Ties Joosten

Als ze het als balken hadden besteld?

00:20:41 Axel Hendriks

Exact, als ze dat gewoon nieuw hadden besteld bij de staalfabriek.

00:20:46 Ties Joosten

Zij besparen € 550 per ton.

00:20:48 Axel Hendriks

Exact, in dit geval ik weet ik de precieze prijzen niet. En dat bedrag, dan kan je natuurlijk gebruiken voor enerzijds een stukje extra werk aan onze kant en anderzijds natuurlijk een stukje werk aan hun kant, want er moet aan hun kant dus echt een staalwerker die hele constructie in elkaar zetten.

00:21:05 Ties Joosten

Ja, dat had hij toch al moeten doen?

00:21:07 Axel Hendriks

Als het allemaal kant en klaar aan komt rijden op vrachtwagens is het alleen maar in elkaar te schroeven, bij wijze van, dan kost het wel minder tijd dan wanneer je daar een stukje aan moet lassen en daar nog iets van af moet halen. Dus het kost wel aanzienlijk meer tijd. Dus ik geloof dat ze overall op dezelfde prijs uitkomen als, zeg maar, nieuw staal.

00:21:24 Ties Joosten

Maar dat is wel een hoopvol bericht, dus we hebben gewoon het staal van de buren gebruikt en na alle extra werk die erbij komt kijken, was dat aan het einde van de rit even duur en ook jullie extra werk zat daarin meegerekend. Dit kost jullie ook meer werk. Zo een grote knijper is minder werk dan alles één voor één uit elkaar schroeven.

00:21:46 Axel Hendriks

Ja, in dat opzicht, dit project zouden wij al Japans gaan slopen. Ik wil niet heel erg in details gaan, maar ik ga het nu toch doen.

00:21:53 Ties Joosten

Je hebt Japans slopen gezegd, nu ben ik benieuwd.

00:21:58 Axel Hendriks

Japans slopen is dat je eigenlijk letterlijk het gebouw stukje voor stukje opzaagt en dan aftakelt en dat doe je met name in omgevingen die heel erg gevoelig zijn voor overlast. Je zit hier letterlijk op een universiteitscampus. Nou ja, dan wil je niet met een hoop herrie en hoop trillingen overlast veroorzaken. Dus wij hadden hier eigenlijk al het plan om inderdaad dit gebouw op te zagen. Dus het belangrijkste wat wij zijn gaan doen is anders zagen en veel voorzichtiger zagen. Je gaat bijvoorbeeld die betonvloer, die zaag je normaal gesproken op in stroken en dan takel je hem strook voor strook af, maar op het moment dat je die stroken beton doorzaagt, dan raak je altijd de constructie die eronder ligt. Normaal is dat niet erg.

00:22:40 Ties Joosten

Maar als je die constructie wil gebruiken, niet handig.

00:22:42 Axel Hendriks

Exact, dus je gaat wel veel voorzichtiger werken. Je gaat net even wat anders zagen. Maar het was in dit geval, omdat we dus al Japans zouden slopen, waren die kosten redelijk overzichtelijk.

00:22:57 Ties Joosten

Dus omdat jullie al Japans zouden slopen, had het al meer werk gekost dan de ouderwetse sloopkogel, heel simpel te zeggen, en nu kost het nog wel weer extra wat tijd. Ten opzichte van dat concept, ja, kwam het gewoon uit eigenlijk?

00:23:10 Axel Hendriks

Ja, zeker ja.

00:23:12 Ties Joosten

Hoopvol verhaal joh, het kan gewoon zo eigenlijk al.

00:23:14 Axel Hendriks

Ja precies en het grappige is dat we nu relatief toevallig deze andere partij tegenkwamen, deze andere consortium. Ja, we moeten natuurlijk toe en we werken natuurlijk hard aan een model waarbij dat geen toevalligheid meer is, maar dat wij precies weten van ja, wij gaan in periode x gaan wij dit afbreken en in diezelfde periode wordt er ergens iets gebouwd, wacht eventjes, wat kunnen we op elkaar afstemmen?

00:23:38 Ties Joosten

Je noemde al, dat je wel heel graag wil dat het geen toevalligheid meer is. Dat je eigenlijk automatisch weet dat iemand op hetzelfde moment bezig is met het bouwen van een gebouw en daarbij materialen zou kunnen gebruiken die jij in de aanbieding hebt als sloper. Hoe is dat beter te organiseren?

00:23:58 Axel Hendriks

Ja digitalisering en je moet het zo zien, de handel in gebruikte bouwmaterialen, zoals ik het dan maar even zo noem, hing vroeger, zo tot een half jaar geleden, aan elkaar van netwerk, dus van mensen die wij kenden, mensen die we aan de telefoon hadden. We wisten als we deuren hadden, moesten we die bellen. Als we sanitair hadden moesten we die bellen enzovoort. We hebben nu met een webshop denk ik de eerste stap gezet. Dus we zijn begonnen met het online zetten van alle materialen die wij in voorraad hebben en wat wij nu aan het doen zijn, is het online zetten van materialen die nu nog in gebouwen zitten, maar die over een maand of twee maanden beschikbaar komen. En dat maakt natuurlijk ook dat je transport bespaart dat je handeling bespaard, want dan ga je dus niet eerst naar de opslag brengen, maar dan kan je dus direct van het oude project eigenlijk naar het nieuw project. De volgende stap is natuurlijk dat je niet één of twee maanden vooruit kan kijken, maar één of twee of 3 jaar. Weet je, dan kunnen ontwerpers ook beter gaan ontwerpen met materialen die beschikbaar komen. Kijk wat nu nog vaak gebeurt is dat een ontwerper of een architect iets ontwerpt. Daarna gaat hij de materialen erbij zoeken, terwijl idealiter gaat hij natuurlijk ontwerpen met de materialen die beschikbaar zijn. En daarvoor moet je langer dan één of twee maanden vooruit kunnen kijken.

00:25:13 Ties Joosten

Precies, dus eigenlijk zou je dan willen dat iemand zegt, ik ga hier een nieuw gebouw neerzetten. Beelen, wat heb je zodra de bouw begint over 3 jaar? Wat heb je in voorraad dan? Dat zou natuurlijk betekenen dat jullie ofwel altijd precies op het juiste moment beginnen met slopen. Ofwel dat je op een of andere manier zorgt dat de materialen die vrijkomen dat je jaren bewaard totdat die bouwers het nodig hebben.

00:25:36 Axel Hendriks

En dat laatste is dus een klein beetje wat er nu gebeurt maar je ziet wel dat het kosten toevoegt.

00:25:39 Ties Joosten

Want je moet een gebouw bouwen om al die stalen balken neer te leggen.

00:25:44 Axel Hendriks

Exact. Ja, letterlijk. Dat is natuurlijk zonde, want je concurreert eigenlijk altijd nog steeds met nieuw en nieuw is natuurlijk eigenlijk veel te goedkoop, dus op het moment dat je dingen op moet gaan slaan, ja, voegt dat kosten toe en wordt dus je business case nog ingewikkelder.

00:25:58 Ties Joosten

Je zegt nieuwe grondstoffen zijn eigenlijk te goedkoop, kan je dat toelichten?

00:26:04 Axel Hendriks

Wat wij natuurlijk zien, is dat wij op het moment dat wij bouwmaterialen willen hergebruiken, moeten we voorzichtig demonteren. We moeten er een keer een doekje overheen halen, een keertje wat repareren, een keer een kleine bewerking. En vervolgens inderdaad, nou ja, op transport richting onze opslag en daar dan in dit geval dus tijdelijk opslaan. En dat zijn natuurlijk allemaal kosten. En met name arbeid is natuurlijk gewoon duur, dus relatief veel arbeid. En nieuw is gewoon relatief goedkoop. Als je naar de gamma gaat of naar een andere bouw zaak, dan kan je voor een hele lage prijs, kan je een deur of wat dan ook kopen. Op het moment dat wij moeten gaan sleutelen of voorzichtig om moeten gaan met die bestaande deur, nou ja, dan is dat een interessante concurrentiestrijd inderdaad.

00:26:48 Ties Joosten

Beelen zou eigenlijk de gamma van de van de grote mensen bouwwereld moeten worden?

00:26:54 Axel Hendriks

Ja, ja, dat worden wij denk ik ook steeds meer. Of wij dan zelf, zeg maar al die scharniertjes moeten leveren of dat wij dat via onze partners doen, maar je ziet natuurlijk dat steeds meer materialen die vrijkomen bij onze panden ook gewoon weer een tweede leven krijgen. Nogmaals deels gaat dat via onze webshop een op een maar we zijn nu in Amsterdam deze maand gestart met een zagerij. Daar brengen wij hout naartoe dat wij uit sloopprojecten vrij krijgen. Dat wordt daar verzaagd tot nieuwe houten producten. Nou ja, een deel van die houten producten zullen wij zelf verkopen, maar de grote stroom gaat via Pontmeyer zo meteen.

00:27:27 Ties Joosten

En die verkopen we het gewoon weer binnen hun winkel?

00:27:30 Axel Hendriks

Ja.

00:27:32 Ties Joosten

Ja, hoe wordt hier nu tegenaan gekeken door, nou laten we eens beginnen, binnen Beelen?

00:27:39 Axel Hendriks

Wat ik heel erg merk is dat eigenlijk al mijn collega's zonder uitzondering zeggen van, joh, dat we dat materiaal, als dat weggegooid moet worden, dat is zonde. En dat vindt heel veel weerklank. Dat vinden mensen allemaal, al mijn collega's vinden dat op het moment dat iets moois weggegooid wordt, dat vinden ze allemaal zonde, dus ik wordt om de haverklap gebeld van Axel, ik loop hier nu om een project, weet je, als we dit op de reguliere manier gaan doen, dan weet ik niet precies wat er gebeurd, dus zorg alsjeblieft dat je hier komt, want hier zitten hele mooie materialen. En dat moet niet weg want dat is zonde.

00:28:11 Ties Joosten

Wat is het soort materiaal waar zo'n collega dan warm van wordt?

00:28:17 Axel Hendriks

Ja, vanuit die tak die bedrijfsafval en festival afval doet, zijn wij nu de RAI aan het doen. De RAI vinden hele grote beurzen plaats en die beurzen, die worden natuurlijk vol gezet met mooie stands en die stands, die moeten mooi aangekleed worden. Een heel deel van die mooie aankleding, van die mooie materialen, die worden daar achtergelaten. Die worden letterlijk weggegooid, dus ik wordt dan gebeld door collega's van Axel, er ligt hier een hele mooie partij tegels, van die mooie hardstenen tegels. Die hebben op een stand gelegen. De stand bouwer wilde ze niet mee terug nemen dus wij moeten ze nu in de gemengd bouw en sloopafval bak gooien. Dat willen we eigenlijk niet. Kan je ze niet eens op komen halen en op de website zetten, want dan kunnen ze een tweede leven krijgen. Ja dus letterlijk, ik word dagelijks gebeld op die manier.

00:29:02 Ties Joosten

Ja dus hier ligt een mooie partij tegels, hier ligt een stukje marmer, weet ik veel, maar iets prachtig moois wat doodzonde is om weg te gooien, anders moet het in mengafval ook nog eens en dus gewoon de verbrandingsoven in eigenlijk.

00:29:21 Axel Hendriks

Nou ja, dus dit zou dan specifieke puin zijn. Maar, inderdaad ja.

00:29:23 Ties Joosten

En jouw overtuiging is dat binnen de, zeg maar, sloop wereld vindt men dit allemaal zonde.

00:29:32 Axel Hendriks

Nou ja, kijk de een zal er meer mee hebben dan de andere. En eerlijk is eerlijk, op het moment dat ik daadwerkelijk aan iemands proces kom, dus weet je zoals in Leiden en weet je, daar ga ik natuurlijk een beetje door het reguliere proces heen fietsen. En natuurlijk zeggen mensen dan wel eens van, ja, maar Axel, dat kost veel tijd en hartstikke veel extra werk. Wat doe je moeilijk? En dat is ook prima, weet je, het mag ook een beetje schuren. Het mag af en toe ook wel een beetje op die manier. Nou ja, in ieder geval onderwerp van gesprek zijn. Ik denk dat het een heel goed gesprek is om te voeren, want op het moment dat je inderdaad veel te veel tijd gaat steken in het demonteren van een

bepaald materiaal, ja ja, dan komt er ook een moment dat je het gewoon niet meer moet doen. Zeker gezien, nogmaals, de prijzen die voor nieuw gevraagd worden. Ja dan is het ook gewoon een bedrijfseconomisch kantelpunt, waar het gewoon niet meer interessant is om iets te demonteren.

00:30:18 Ties Joosten

Laten we daar nog eens naar toe gaan. Als jij echt aan de knoppen zou zitten. Gewoon de baas zou zijn van het Journaal en de koning was van Nederland. Wat zou je dan nu veranderen om te zorgen dat we minder van die waardevolle materialen waar je collega's mee komen, dat we die weggooien?

00:30:41 Axel Hendriks

Ik denk twee elementen. Wat ik net al even zei, arbeid is vergeleken met grondstoffen heel erg duur, dus dat brengt de meest bizarre situaties met zich mee. Maar inderdaad bijvoorbeeld dat hergebruikte materialen, als je het helemaal doorrekend, vaak duurder zijn dan nieuwe materialen die uit China komen en daar en-mass geproduceerd worden.

00:30:56 Ties Joosten

Ik vind dat zo. Ik heb het wel vaker gehoord natuurlijk. Dit is binnen de duurzame wereld best een algemene klacht, maar ik blijf dat zo bizar vinden. Ik kan die waarheid, mijn hoofd kan die waarheid niet aan, dat het gewoon vaak duurder is om een materiaal hier uit een gebouw in Rotterdam eruit te halen, schoon te maken en opnieuw te gebruiken. Dat is duurder dan het halen uit China en het gloednieuw in te laten vliegen en te gebruiken, toch? Dat is allemaal arbeidskosten? De voorname reden daar is arbeid? Maar ja, ik denk dat je ook niet echt de handen op elkaar krijgt als je zegt dat je collega's minder moeten gaan verdienen.

00:31:42 Axel Hendriks

Nee, dat lijkt me ook zeker niet de incentives. Nou ja, kijk dat arbeid zo duur is heeft natuurlijk te maken met ons belastingstelsel en dat virgin materiaal zo goedkoop zijn, heeft natuurlijk te maken met het feit dat CO2 niet beprijst wordt om maar een middel te noemen. Dat zijn denk ik, dat zijn hele grote knoppen dat realiseer ik me, maar dat zijn, denk ik wel knoppen waaraan gedraaid zou kunnen worden. Weet je anderzijds, denk ik dat het loont de milieu impact van gebouwen ook toetsen en dat ook echt een onderdeel te maken van bijvoorbeeld een bouwvergunning aanvraag. Wat je bijvoorbeeld hebt gezien met de EPC, de energieprestatie coëfficient, dus hoe energie zuinig is dit gebouw, daarvoor staan harde eisen in het bouwbesluit. Als je iets nieuws gaat bouwen, moet je aan een bepaalde norm voldoen. Het moet X energiezuinig zijn. En die X is die is in de loop van de jaren afgebouwd, dus is die steeds lager gebracht, dus als je 20 jaar geleden een huis bouwde, moest die redelijk zuinig zijn en nu moet hij bijna energieneutraal zijn. De EPC voor woning is nu bijvoorbeeld 0,4. Die was twee jaar geleden als die 0,6, daarvoor was die 0,8.

00:32:50 Ties Joosten

Ja ja ja.

00:32:56 Axel Hendriks

En zo een zelfde mechanisme zou je kunnen invoeren voor de milieu impact van gebouwen.

00:33:06 Ties Joosten

Ik ben bewust van het feit dat er een energienorm bestaan dat als je een gloednieuw huis koopt, dan heb je in principe kun je wel zeggen dat je een nul op de meter woningen krijgt, bijna. Maar dat

betekent dat je heel weinig energie van buiten nog nodig hebt om gewoon te kunnen leven. En Ik ben ook bewust dat dat het gevolg is van normen die gesteld worden. Maar vertel je me nu dat voor het gebruik van de materialen die gebruikt worden in gebouwen, dat zo een norm überhaupt niet bestaat?

00:33:37 Axel Hendriks

Nou ja, er wordt heel voorzichtig mee geëxperimenteerd. Je hebt de MPG heet dat volgens mij, milieuprestatie gebouwen. Volgens mij, en die is er nu wel, maar hij wordt niet gehandhaafd.

00:33:53 Ties Joosten

Even, je lacht erbij, maar ik zou daar toch een beetje cynisch van worden als ik jouw ambitie om de bouw en sloop circulair te maken hoor. Waarom wordt het niet gehandhaafd, leg eens uit?

00:34:02 Axel Hendriks

Omdat het eigenlijk heel ingewikkeld is om het te meten en dat is waar ze nog heel erg mee worstelen. Dus er is wel een soort van norm. Maar bijvoorbeeld hergebruik zit daar nog niet fatsoenlijk in. Die energiezuinigheid is al complex om te meten. Maar de milieu impact van een gebouw en van alle materialen die erin zitten, de schaduw kosten eigenlijk die daarmee gemoeid zijn, ja, dat is gewoon enorm ingewikkeld en enorm complex. Dat maakt dat daar nog wel weerstand is tegen het echt hard invoeren en handhaven van die norm, want als een norm handhaven wordt, ja, dan moet ook wel goed duidelijk zijn. Hoe meet je nou zoiets? Klopt dat ook allemaal?

00:34:42 Ties Joosten

Maar dit vind ik dan toch fascinerend, omdat we toch ook met elkaar hebben besloten dat we in 2050 na een volledig circulaire economie gaan.

00:34:54 Axel Hendriks

En er wordt ook absoluut naar gekeken, er wordt heel hard gewerkt aan een uniforme norm om zo meteen de milieu impact van een gebouw te meten en welke dat dan uiteindelijk word, ik weet het nog niet, maar er wordt wel heel erg hard aan gewerkt door verschillende partijen op verschillende niveaus. En, ik denk wel dat dat een hele belangrijke oplossing is, want dan kan je die norm inderdaad op een gegeven moment vaststellen en daarna beginnen met de afbouwen. Dat je letterlijk, net zoals de energiezuinigheid van huizen, op een gegeven moment stappen kunt gaan maken en dan ga je ook sturen op een ander model dan alleen kosten. Een super energiezuinig huis is duurder om te bouwen dan niet energiezuinig huis. En toch worden alle huizen nu heel energiezuinig gebouwd én hetzelfde kan je natuurlijk zeggen over de milieu impact van een gebouw. Op het moment dat iets gewoon lage milieu impact moet hebben, dus je moet gebruikte bouwmaterialen gebruiken, anders krijgen je geen vergunning en dan ga je dus sturen op andere punten.

00:35:47 Ties Joosten

Dus ik ben een beetje bewust van de moeite die het gaat kosten om een CO2 belasting in te voeren, omdat we dat als Nederland nooit in ons eentje gaan doen, dus dat moet dan weer Europees, dus langzaam.

00:35:55 Axel Hendriks

Ja.

00:35:56 Ties Joosten

Dit onderdeel, dus zeg maar meer de stok, dus anders krijg je gewoon geen vergunning, dat lijkt me iets wat Nederland wat autonomer zou kunnen invoeren.

00:36:09 Axel Hendriks

Ja, mits ze dus inderdaad overeenstemming komt over een goede manier om het te meten.

00:36:14 Ties Joosten

Maar wie moet dat doen?

00:36:15 Axel Hendriks

Ja dan toch de overheid denk ik.

00:36:15 Ties Joosten

En wie binnen de overheid? Is er een instituut, wat deze norm moet gaan uitrekenen en vaststellen?

00:36:25 Axel Hendriks

Dat weet ik niet.

00:36:26 Ties Joosten

Nou, dan gaan we daarmee door de volgende keer. Axel Hendriks van Beelen Next, hartelijk bedankt voor dit gesprek. Deze Blue City Podcast is mede mogelijk gemaakt door Duurzaam Gebouwd, Cobouw en Rotterdam circulair. De volgende maand bouwen we vanuit deze schitterende sauna verder aan de circulaire economie. Tot dan.

C2. Interview VolkerWessels M&L (2)

Source: MoVe-RDH (sd A)

“Bij bouwen in de binnenstad komt heel wat kijken. Het is niet meer zoals vroeger”, stelt Ron Frazer van Volker Wessel bouwmaterieel. Hij was betrokken bij de bouwhub in Nieuwegein. We hebben hem als ervaringsdeskundige bevraagd over zijn ervaringen met de bouwhub, waarom het voor interessant is om te werken met een regionale bouwhub.

“We zagen een tegenstrijdigheid”, vertelt Ron, “we gaan steeds meer bouwen in de binnenstad terwijl de steden steeds meer op slot gaan. Lokale overheden stellen meer eisen als het gaat om logistiek in de binnensteden: het moet minder, schoner, stiller en veiliger. Eigenlijk liever helemaal geen bouwverkeer … “

“In 2014 vroeg een van onze grote klanten om hierover mee te denken. Als eerste hebben we met elkaar onderzocht wat de urgentie was, ” vervolgt hij zijn verhaal. “Bouwers rijden jaarlijks heel veel kilometers. In totaal 9 miljard kilometer, waarvan zo’n 1,2 miljard kilometer in de binnenstad. In de toekomst zal een groot gedeelte van de bouwopgave in de binnenstad plaatsvinden. Met al dat bouwverkeer loopt de binnenstad vast en daar wordt niemand blij van. Een ander punt dat we ontdekt hadden, is dat de beladingsgraad slechts 40% bedraagt, dat is heel inefficiënt. Van oudsher plaatste een bouwer ergens een hek en daarbinnen verrijst een gebouw. Hoe de spullen er komen, daar wordt traditioneel gezien nauwelijks naar gekeken. Er is geen enkele partij die de gehele logistieke keten coördineert, laat staan dat dit voor meerdere projecten in dezelfde omgeving tegelijkertijd gebeurt. Iedereen rijdt de binnenstad in met maar halve vrachten. Als er nou een partij zou zijn die de logistieke keten zou monitoren, zouden we slimmer en efficiënter rijden was de conclusie.”

“We hebben ons laten inspireren door Londen waar ze ten tijde van de Olympische spelen een bouwhub hebben gefaciliteerd om de bouw van het Olympische dorp in goede banen te leiden. Dat hele proces hebben ze gemeten en de resultaten waren ontzettend goed. Die pilot gedachte hebben we als uitgangspunt genomen toen we op zoek gingen naar zo’n plek aan de rand van Utrecht.

We zijn in 2014 een proefproject gestart en daarbij hebben we samengewerkt met diverse kennisinstellingen waaronder TNO, een aantal Universiteiten en Hogescholen. Zij hebben ons geholpen data te verzamelen en de effecten van deze nieuwe manier van werken te kwantificeren.”

“Zolang de urgentie voor verandering niet hoog genoeg is, gebeurt er niets.”

“Wij hebben een plan geschreven waarbij wij de ideale bouwvolgorde hebben vertaald naar een logistieke planning over de ketenpartijen heen. Zo is de BouwHub ontstaan.”

“Hoe werkt nu zo’n BouwHub?” vroegen wij Ron. “De BouwHub is een plek aan de rand van de stad van waaruit de bouwlogistieke stromen, van de ruwbouw tot en met de afbouw, worden gecoördineerd en gemonitord”, legt hij uit. “Toeleveranciers leveren hier hun volle vracht af, zonder te hoeven wachten. Op de BouwHub worden alle bouwmaterialen gebundeld tot werkpakketten voor de dagelijkse werkproductie en vervolgens op een efficiënte manier naar de bouwplaats vervoerd en op de juiste plek neergezet. Afval wordt weer mee teruggenomen. Werknemers maken ook gebruik van de BouwHub. Zij parkeren daar en worden met pendelbusjes naar de bouwplaats gebracht.”

Werken met de BouwHub scheelt enorm veel bouwverkeer en daarmee overlast voor de omgeving. Uit metingen van TNO blijkt dat het aantal vrachtbewegingen met gemiddeld 70 procent afneemt. Bovendien stijgt de gemiddelde beladingsgraad naar 90 procent en bespaart een toeleverancier gemiddeld 85 minuten op een rit naar de bouwplaats. Hierdoor kan er op de bouwplaats sneller en veiliger worden gewerkt, doordat materialen op de juiste plekken staan, precies op het moment dat ze nodig zijn in de productie. Uit onderzoek blijkt dat de arbeidsproductiviteit hierdoor tussen de 20 en 40 procent stijgt.

“Met deze uitkomsten is er besloten om vanuit deze pilot ons concept door te ontwikkelen,” vervolgt Ron. “Zo monitoren we sinds 2016 vanuit Utrecht (Lage Weide) een groot aantal projecten in Utrecht. Dit doen we vanuit een White label gedachte waarbij we ook andere bouwers dan VolkerWessels bedienen. De dagproductiepakketten op de hub worden gemaakt door voormalig bouwplaatsmedewerkers die door fysieke omstandigheden niet meer op de bouwplaats kunnen werken. Het is mooi om te zien dat de kennis waarover zij beschikken zo niet verloren gaat. Daarnaast prefabriceren zij allerlei zaken waar op de bouwplaats geen tijd of ruimte voor is.”

“Omdat wij over de projecten heen kunnen kijken, zijn wij bijvoorbeeld in staat geweest om voor vier grote projecten rondom Hoog Catharijne het aantal vrachtbewegingen met 75 procent terug te dringen ten opzichte van de traditionele situatie. Ook hebben we materialen, zoals bijvoorbeeld isolatie dat bij het ene project overbleef weer ingezet voor andere projecten. Dit scheelt een hoop verspilling in de keten.”

“Op elk project verzamelen wij nog steeds data om inzicht te krijgen in het verbeterpotentieel maar ook om het nieuwe economische ketenmodel verder vorm te geven. Ook kunnen wij deze kennis gebruiken om de keten slimmer met elkaar te laten samenwerken.”

“Wij zijn ook bezig om ons logistieke concept te verrijken met deelconcepten, waaronder circulariteit, social return en mobiliteit. Voor wat betreft circulariteit wordt de BouwHub een fysieke marktplaats voor her te gebruiken materialen. Dat kan je heel goed faciliteren via onze BouwHub.”

“En de arbeidsproductiviteit is met 40 procent omhoog gegaan, alleen maar door de spullen op de juiste plek te zetten!“

“Ook bij de gemeente zijn de positieve effecten van de BouwHub opgevallen. Een aantal grote steden zijn bij ons op de Bouwhub in Utrecht wezen kijken. Ook zitten we zelf proactief bij grote gemeentes aan tafel om te praten over toekomstige stadslogistiek. Deze gesprekken beschouwen wij als erg waardevol, omdat zij juist zien dat de BouwHub een grote bijdrage kan leveren aan het verduurzamen van de bouwsector. Behalve duurzamer maakt dit de binnenstad ook veiliger. TNO heeft becijferd dat door te werken met een BouwHub de uitstoot van CO2 met 40 tot 87 procent en de uitstoot van stikstof met 40 tot 68 procent gereduceerd kan worden. Wanneer we de last-mile ook nog eens elektrisch of op waterstof gaan rijden, worden de resultaten nog beter.”

“Grote besparingen zijn dus te behalen op het gebied van duurzaamheid, arbeidsproductiviteit, het aantal vrachtbewegingen, beladingsgraad en wachttijden door de inzet van de BouwHub. Ook doen we mee met andere pilots zoals opslag waterstof en kijken we naar andere modaliteiten. Hoe kom je per schip naar de BouwHub? Bij de grote steden zitten we al aan tafel en onlangs hebben we het convenant Zero Emissie Stadslogistiek (ZES) getekend. Dit is een gezamenlijke opgave van de Gemeente Rotterdam en de logistieke sector. Hier zijn de bouwplannen heel concreet. We nemen de leerpunten natuurlijk mee: het moet een behoorlijke ontwikkeling zijn, dus alle grote projecten aan laten sluiten en zorgen voor synergie in de hele keten. Als je van alle projecten de planning kent, dan

kun je efficiënter zijn en de faalkosten worden lager. Ketensamenwerking is belangrijk, hoe minder overlast we de binnenstad bezorgen en hoe schoner en slimmer we kunnen bouwen. Voor iedereen een win/win situatie. Hoe mooi wil je het hebben!"

"Het is onze ambitie om de BouwHubs uit te rollen in alle stedelijke gebieden waar een positieve business case bestaat."

C3. Interview Municipality Delft

Source: MoVe-RDH (sd B)

"Onze grote bouwlocatie van circa 6.000 woningen in Delft ligt aan de Kruithuisweg (N470) en dus dicht bij een afslag van de N470. Het vrachtverkeer kan direct van de weg de bouwlocatie op rijden en dan heeft een bouwhub niet zoveel zin. Voor het bouwen in de binnenstad, waar de ruimte heel schaars is, dan is een bouwhub wel heel handig. Maar heeft Delft wel voldoende projecten om een bouwhub te kunnen vullen? We zien dat de grote steden als Den Haag en Rotterdam wel de schaal, de massa en de schaarste hebben, zodat een bouwhub kan werken. Maar kleinere steden zoals Delft hebben die schaal niet en zullen moeten meeliften."

Bouwhub: meeliften voor je binnenstadlocatie waar ruimte echt schaars is en het financieel zin heeft.

Jan maakt onderscheid in locaties:

- Moeilijke locaties: kan niet op klassieke manier, maatregelen voorschrijven zodat we op bouwhub uitkomen;
- Locaties waar het efficiënter is en meerwaarde heeft om elders te verzamelen en door te bundelen kleinere eenheden naar de bouwplaat in de stad te brengen;
- Locaties waar het niet uit maakt of je het wel via bouwhub doet.
- Locaties waar het efficiënter is om het op de locatie zelf te regelen.

Jan: "De meeste grote verstedelijkingslocaties hebben best veel bouwruimte. Als je 5.000 woningen gaat bouwen, betekent dat er ook veel ruimte is. Pas bij de bouw van de laatste woningen wordt de ruimte schaars. Bij kleinere bouwprojecten is het snel al krap.

"Als gemeente kijken we vooral naar zaken zoals verkeersafwikkeling, veiligheid en hinder, duurzaamheid en communicatie. We kunnen niet bepalen hoe de woningen worden gebouwd, dat laten we over aan de bouwers en de projectontwikkelaars. Om de secundaire doelstelling te bewerkstelligen, kunnen we wel voorwaarden bij de gebiedsontwikkelingen voorschrijven zoals milieueisen, demontabel en circulaire bouwen enz. De bouwer zal uiteindelijk zijn eigen conclusies trekken. "

"Belangrijk is dat in de regio de grote spelers een bouwhub starten, dat maakt het gemakkelijke voor de kleine projecten om erbij aan te sluiten. Je zou kunnen beredeneren dat een grote bouwlocatie als Schieoevers zelf als bouwhub kan dienen voor de rest. Zoiets komt van de grond zodra de voordelen duidelijk zijn voor zowel stad en als bouwer(s). Je kan maatregelen niet moet pushen, maar je stuurt wel op de effecten die je voor ogen hebt. Zo zullen de meeste gemeentes erin staan."

"Als gemeente zijn de juridische kanten van concurrentie en aanbesteding best wel ingewikkeld en daar gaat de energie in zitten. Uiteindelijk is het aan de bouwer om het te regelen. Je kan bijvoorbeeld wel vragen om hun bouwplaats of hub open te stellen voor derden," is Jan van mening.

“De eventuele extra kosten betaalt de gemeente zelf omdat het meerwaarde heeft. Zeker als het voor andere bouwers efficiënter is en enorme besparing geeft. “En soms spelen de meerkosten van een bouwhub geen rol, vervolgt Jan, “als er midden in de historische binnenstad gebouwd moet worden, kunnen we niet anders.”

“En dan moet je samen met de buurgemeentes moet je kijken wat de bouwopgave in de regio is om eventueel samen te bepalen of en waar een bouwhub handig is. Vervolgens moet je kijken wie is de eigenaar van de grond voor zijn of haar medewerking en gesprekken voeren met de bouwers. Wordt het eigendom van een bouwerbedrijf of wordt het een onafhankelijk platform waar iedereen gebruik van kan maken? Dit zijn voor een deel dezelfde gesprekken die we voeren bij de stedelijke distributie. Daar weten we van dat er veel organisatorische vragen zijn waar goed van tevoren over na gedacht moet worden.”

“Hoe je het in de markt probeert te zetten, daar kunnen we nog veel van leren. Mijn ervaring is dat als je begint met een maatregel in te stellen het veel moeilijker is om iets voor elkaar te krijgen. Het is effectiever om het gesprek te beginnen met welke doelen je samen wilt bereiken. Is eenmaal goed scherp wat de doelen zijn, dan volgen de maatregelen vanzelf. Je ziet heel veel initiatieven en innovaties ontstaan en toch kost het moeite om het voor elkaar te krijgen. Misschien moeten wij ook middelen inzetten om het van de grond te krijgen, bijvoorbeeld startkapitaal aan bieden. Zo geven we duidelijkheid en dan volgen de marktpartijen vanzelf. Wel achteraf evalueren of het eenmalig was of het een vervolg krijgt. “Kijk wat er is gebeurd bij de woningbouwimpuls,” geeft Jan als voorbeeld, “alle gemeentes hadden tekorten, maar het ministerie van Binennlandse Zaken heeft gedurende vier jaar geld vrijgemaakt zodat iedereen toch projecten kon ontwikkelen. Dat was net het zetje wat nodig was.”

C4. Interview Vlasman Betonbewerkings

C5. Interview New Horizon (1)

Source: New Horizon (2020)

00:00:15 Fabienne de Vries

Hartelijk welkom bij bouw en vastgoed vandaag met vandaag te gast in de studio Michel Baars van New Horizon. Hij gaat ons straks alles vertellen over urban mining, gebouwen niet alleen slopen, maar vooral kijken wat je kunt hergebruiken. Nou, dit zien we strakjes, hij staat al naast me, maar eerst even het nieuwsoverzicht. Dat maken we in samenwerking met het vastgoedjournaal. Wat is er allemaal gebeurd in, de wereld van bouw en vastgoed? Het kabinet heeft geleerd van de vorige crisis en investeert vors in bouwprojecten. Minister Kajsa Ollongren neemt voor 2020 kortetermijnmaatregelen, zodat de bouw niet stilvalt als gevolg van de crisis. Vooral het aantal woningen moet verder omhoog. Het kabinet doet dit door zelf te investeren en verduurzaming te stimuleren. Volgens makelaarsvereniging NVM heeft de huizenmarkt nog weinig last van de coronacrisis. Sinds half maart zijn er iedere week tussen de 2,5 en 3000 huizen verkocht via nvm makelaars. Ongeveer net zoveel als voor de coronacrisis. En dan een opvallende trend. De tiny houses nemen in populariteit toe. Één op de 5 Nederlanders geeft aan graag in zo'n klein huisje te willen wonen. De interesse is het grootst bij twee groepen, de zogenaamde empty nesters waar de kinderen net het huis uit zijn, en je raadt het misschien al, die andere doelgroep zijn die jongeren die net het ouderlijk huis hebben verlaten. En dan de ontwikkeling van het stationsgebied in de stad Utrecht gaat een nieuwe fase in. De bouw van de eerste 122 woningen is van start gegaan. Ook tekende NS en de gemeente Utrecht voor de ontwikkeling van de volgende 3 fasen en daarin staan de plannen voor de bouw van ruim 1000 woningen, recreatie en horeca. En dan gaan we nu naar de gast van vandaag. Michel Baars en die spreekt dus niet van slopen van gebouwen, maar het oogsten van gebouwen. Ja jij spreekt dus niet van het slopen van gebouwen, maar het oogsten van gebouwen. Leg uit.

00:02:09 Michel Baars

Ja een gebouw is eigenlijk gewoon een verzameling van hele goed bruikbare materialen en grondstoffen.

00:02:14 Fabienne de Vries

Is het zo dat het na dan de sloop dat dat dan nog steeds zo waardevol.

00:02:18 Michel Baars

Zeker. Ja, daarvoor moet je de sloop proces wel iets aanpassen en dat begint natuurlijk met het inzicht hebben; wat zit er nu daadwerkelijk in dat gebouw? Maar als je dat eenmaal doorhebt en je past de sloop proces daarop aan, dat noemen ze eigenlijk urban mining, dus je gaat op een andere manier de ontmanteling van het gebouw vormgeven, dan komen daar inderdaad hele waardevolle materialen uit.

00:02:35 Fabienne de Vries

Wat wil je daarmee bereiken?

00:02:37 Michel Baars

Ja, wat we er vooral mee willen bereiken is het tot stand brengen van een circulaire bouw en vastgoed economie op zijn minst in Nederland, zeg ik dan maar even bescheiden. Dat reduceert een enorme milieulast. Dus het is goed voor onze CO2-emissie, die reduceren we daar enorm mee. We

voorkomen dat schaarse materialen nog schaarser worden, maar vooral ook, als je kijkt nu naar de huidige omstandigheden, we voorkomen dat we last krijgen van allerlei handelsbeperkingen, CO2 inprijzingsmodellen, het is onze voorraad. Die hebben we al letterlijk in huis, dus laten we die vooral gebruiken.

00:03:07 Fabienne de Vries

En is het dan zo dat dat materiaal wat daar dan weer uitkomt, dat dat net zo stevig was als de eerste keer dat het gebruikt is.

00:03:15 Michel Baars

Voor sommige materialen geldt dat je ze één op één opnieuw kunt toepassen. Een scharnier is een scharnier, een kabelgoot is een kabelgoot. Voor andere materialen zul je er iets aan moeten doen om weer een nieuw bruikbaar, gecertificeerd én gegarandeerd product van te maken. Een houten kozijn wat je uit een oud gebouw haalt, mag je volgens huidige bouwbesluit niet meer in een nieuw gebouw plaatsen, want het is niet hoog genoeg. Dus dat moet je eerst aanpassen. In de laatste categorie moet je terugbrengen naar grondstoffen niveau om er iets nieuws van te kunnen produceren.

00:03:39 Fabienne de Vries

Ja, wat was het eerste moment, kan je dan nog herinneren, dat jij dacht hebben zoveel goud eigenlijk in huis? Wat doen we nou moeilijk met al dat overseas?

00:03:47 Michel Baars

Ik ben ervan overtuigd dat iedereen een hekel heeft aan verspilling, alleen dat we niet altijd doorhebben hoeveel acties wij nemen, hoeveel besluiten wij nemen waardoor we verspilling tot stand brengen. Als je voor het eerst naar het sloopwerk gaat kijken en je ziet wat daar in een bak geprakt wordt, dat was wel het eerste moment waarop ik dacht, dit moet anders kunnen.

00:04:02 Fabienne de Vries

Nou, en dat doen jullie. Jullie zijn op dit moment een gebouw in Amsterdam aan het slopen. Laten we maar even kijken hoe dat gebeurt.

00:04:21 Erik Koremans

Mensen die naar een bebouwde omgeving kijken, die zien een gebouw dat normaal gesloopt moet worden en wij zien een gebouw vol potentie met grondstoffen en materialen die nog prima kunnen worden ingezet in toekomstige nieuwbouw. Ons schoon geoogste beton uit onze ontmanteling leveren wij aan bij de betoncentrale in Zaandam. Eenmaal hier, gaat ons betonpuin door de machine die wij noemen, de smart liberator en de smart liberator is in staat om de oorspronkelijke bestanddelen van waaruit beton is gemaakt, zand, grind en cement om die weer zuiver terug te herwinnen. Eenmaal zuiver terug herwonnen zand, grind en cement zetten wij weer in om nieuwe betonproducten van te maken. Wij leveren stortbeton voor muren, voor funderingen voor vloeren. Ons beton heeft aantoonbaar lage milieukosten, aantoonbaar lage CO2 uitstoot en bouwen met bouwmaterialen die het milieu nauwelijks belasten, dat is waar het in deze tijd om gaat.

00:05:48 Fabienne de Vries

Nou, dat ziet er super gaaf uit. Wat een mooi, mooi goede machine. Beton, daar zijn jullie dus hartstikke blij mee. Wat voor een grondstoffen wordt je nog meer blij?

00:05:58 Michel Baars

Van worden van heel veel grondstoffen blij, maar dit is wel de grootste impact hoor. Daar moet ik wel eerlijk in zijn. Beton is in de wereld verantwoordelijk voor 9% van de CO2-emissie. Dat is evenveel als alle mobiliteit in de wereld bij elkaar opgeteld. Dus hier is wel, dit is wel waar we begonnen zijn met een patent van koos schenk, samen met Rutte Groep dit goed doen. Maar dan komt er nog heel veel meer vrij, wij worden heel blij van hout. Daar kunnen we echt ontzettend veel mee. Dat willen we zeker niet de biomassa installatie in hebben voor een beetje energie. Dat kun je super hergebruiken in allerlei verschillende verschijningsvormen.

00:06:26 Fabienne de Vries

Ontstaat er dan al een soort gevecht over wie dan hout houdt?

00:06:26 Michel Baars

Zeker ja, sterker nog, er is een grote gesubsidieerde stroom waar wij eigenlijk tegen moeten concurreren, omdat mensen op zoek zijn naar duurzame energie, en kolencentrales groene stroom kunnen maken als ze een beetje biomassa bijvoegen. Ja, wij willen gewoon het hout hebben om het hout te kunnen laten blijven. Ja, dus daar moeten we tegen concurreren. We maken gevelstenen, dus nieuwe bakstenen van keramisch afval. Daar bak je eigenlijk gewoon weer nieuwe gevelstenen die exact hetzelfde eruit zien, dezelfde certificaten hebben. Bitumen van bitumen. Dus ja, we zijn verliefd op donor gebouwen, ja.

00:06:59 Fabienne de Vries

Precies en eigenlijk wordt het dus een soort van warenhuis van grondstoffen. Zie je het zelf ook zo?

00:07:03 Michel Baars

Ja, ik zou heel graag het magazijn van Nederland wat meer inzichtelijk maken. Wij doen dat natuurlijk op microniveau als MKB bedrijfje gebouw voor gebouw en inmiddels zijn wij wel zo ver dat we een volume hebben waarmee we een behoorlijk proces verandering in gang kunnen zetten, maar het liefst zou ik natuurlijk gewoon de portefeuilles van woningcorporaties en beleggers in kaart brengen om duidelijk te maken wat die urban mining potentie is, want die is niet alleen in milieu impact enorm, maar ook gewoon financieel een enorme voorraad, eigenlijk het magazijn van Nederland.

00:07:31 Fabienne de Vries

Dit valt natuurlijk heel goed in het concept van Real Estate Future Proof, waar jullie ook eind van de maand of eind volgende maand staan. Wat gaan jullie daar precies doen?

00:07:40 Michel Baars

Ja, we gaan een aantal dingen doen, maar we gaan natuurlijk het raakvlak tussen digitalisering en circulariteit benoemen. Het zijn natuurlijk twee ontwikkelingen die op zichzelf exponentieel gaan, maar elkaar ook enorm versterken. Juist door data analyses kunnen we de urban mining potentie bepalen en daarmee het inzicht geven wat nodig is om beleggers andere keuzes te laten maken, en investeringen op te halen om die innovatie tot stand te brengen. Cruciaal voor ons is voorspelbaar volume, dat geldt voor iedere innovatie en dat kunnen we met data technologie heel goed in kaart brengen.

00:08:08 Fabienne de Vries

Ja, ja, en eigenlijk past dit in een in een plan voor een veel groter beeld, hè? Dus niet alleen Nederland maar wereldwijd. Laten we eens kijken hoe New Horizon daar in staat.

00:08:21 New Horizon promo video

De bouwsector staat voor een kolossaal karwei, 75.000 woningen per jaar bouwen, 10 jaar lang. Ook de vraag naar zorgvastgoed, eigen productiefaciliteiten en opslag neemt alleen maar toe. Een opgave die om enorm veel materiaal vraagt en een groot milieu impact heeft. Maar grondstoffen worden schaarser en dus duurder. Huidige handelsbeperkingen en crisis maken internationaal transport van materiaal moeilijk. Hoog tijd voor verandering om radicaal anders te denken over grondstoffen. Wij maakten van urban mining ons vak, wij slopen niet wij oogsten. Maak samen met ons uw voorraad inzichtelijk, dan benutten we het magazijn van Nederland voor altijd optimaal. Laten we samen de cirkel rond maken. New Horizon.

00:09:18 Fabienne de Vries

Jij staat er volgens mij ook als rasondernemer, heel gepassioneerd in en denk je ook inmiddels al lang voorbij Nederland, klopt dat?

00:09:26 Michel Baars

Nou, het is wel zo dat je voor dit soort ontwikkelingen schaal moet hebben, maar we zijn in Nederland ook nog lang niet zo ver, dus ik ben er wel van overtuigd dat we technologiën, zoals je net met beton zag, maar nog wel met andere processen waar we leiding aan geven heel goed kunt exporteren of in ieder geval die kennis kunt delen naar andere landen en misschien zijn er ook nog landen te bedenken waar het veel sneller opschaalbaar is. We zijn nu zelf in Duitsland met de eerste twee projecten bezig. Ja, daar zie je bijvoorbeeld wat hier in Nederland mijn grootste project is, is daar echt het kleinste project bij wijze van spreken in de regio Berlijn. Ja, dat gaat over een omvang die echt aanzienlijk is.

00:09:58 Fabienne de Vries

Is daar wordt je als ondernemer natuurlijk super gretig van. Wat is daarin het gevaar?

00:10:03 Michel Baars

Nou, mijn grootste gevaar is, dat circulaire economie geframed wordt als de volgende duurzaamheid hype en ik zie circulaire economie echt als een nieuw economisch model. En dat is ook waarom ik denk dat ondernemers de circulaire economie moeten maken en niet de activisten. Dus ik wil laten zien dat je door business te doen en door te sturen op impact, uiteindelijk gezonde bedrijven krijgt die in een kringloop samenwerken. Dus het grootste risico is dat ik gedrukt wordt in de groene hoek, want dat is niet waar mijn klanten zitten, mijn klanten zijn gewoon mensen die op geld tijd én risico beslissingen nemen, en ik ontwerp circulaire principes die daar kunnen concurreren met lineair.

00:10:36 Fabienne de Vries

Ja, want dat levert gezonde gebouwen op en wat nog meer?

00:10:38 Michel Baars

Ja, dat levert vooral onafhankelijkheid op op grondstoffen die wij niet als Nederland hebben, en nu uit alle landen moeten importeren. Nou een stukje onafhankelijkheid erin is denk ik heel belangrijk, dat merken we ook op andere vlakken. Dat levert een betere economie op en vooral ook heel veel meer sociaal maatschappelijke positieve effecten, hè? Onze manier van werken vraagt gewoon om meer arbeid, en wij kunnen heel veel mensen die nu misschien met een afstand naar de arbeidsmarkt kijken, betrekken bij dit proces.

00:11:02 Fabienne de Vries

En, waar zie je jezelf over 10 jaar in dit hele proces?

00:11:06 Michel Baars

Hopelijk zoals ik 5 jaar ook begon. Vissend in de Biesbosch denkend over mijn volgende bedrijf.

00:11:12 Fabienne de Vries

Dan moet dit staan.

00:11:13 Michel Baars

Ja, ik wil het graag voor doen. Ik wil het graag met iedereen doen en daarna wil ik graag dat iedereen het doet. Ik vind het de verantwoordelijkheid van de koploper om het peloton harder te laten fietsen en niet om de wedstrijd te winnen.

00:11:22 Fabienne de Vries

Nee, heel goed. En dank je wel ook voor je komst naar de studio. Tot zover deze uitzending van bouw en vastgoed vandaag. Wekelijks op maandag om kwart voor 12 zijn wij te bekijken via onder andere LinkedIn live via Wouter Trevino. En, wil je niets missen van het nieuws uit de bouw en vastgoed sector? Zorg dan dat je die pagina volgt. Over twee weken is er weer een live uitzending en dan hebben we Ron Sesing van Zig Real Estate te gast, ik zie je graag dan. Dag.

C6. Interview New Horizon (2)

Source: Finance Ideas Talks (2019)

00:00:06 Wouter Geerlings

Bij mij staat Michel Baars van New Horizon. Michel, je hebt net voor 150 mensen voornamelijk uit de zorg en woningcorporatie een verhaal gehouden. Wat neem jij mee uit deze zaal?

00:00:16 Michel Baars

Nou, ik hoop letterlijk heel veel grondstoffen, dus ik hoop dat ze me weten te vinden met gebouwen die ze gaan ontmantelen of willen ontmantelen. Wat ik indrukwekkend vond, is de betrokkenheid van deze groep die op zoek gaat blijkbaar naar innovatieve partijen, naar visies die hun wereld wel eens helemaal kunnen veranderen. En dat vind ik wel bijzonder, dat mensen actief op zoek gaan naar iets wat misschien wel een fundamentele verandering van hun eigen huidige bestaansrecht kan inhouden. Dat maak ik niet zo vaak mee.

00:00:45 Wouter Geerlings

Je ligt net een klein tipje op van de sluier. Ik merk dat heel veel financiële mensen, maar ook bestuurders toch vaak op zoek zijn naar: “hoe betaal ik dat nou?”, die vaak vanuit het heden denken, hoe ga ik nu mijn huidige problemen oplossen? Jij lichte een klein tipje van de sluier op. Kun je die nog toelichten?

00:01:02 Michel Baars

Nou ja, wat je ziet is dat heel veel van de waarde, die opgesloten zit in ons huidige manier van werken en ik in mijn geval gaat het dan om de bebouwde omgeving, heel veel van die waarden wordt onvoldoende onderkend. Dus ik denk dat heel veel zorg instellingen en corporaties op de balans wel zeg maar vastgoed waren hebben staan, maar helemaal niet nadenken over het feit dat dat vastgoed ook een grondstof waarde in zich heeft. En nou, het is aan mij voorlopig om ervoor te zorgen dat die waarde ook daadwerkelijk gerealiseerd kan worden door ervoor te zorgen dat die grondstoffen kunnen worden omgezet in nieuwe producten in plaats van in afval. Maar het besef dat dat er aan komt en voor een groot deel ook nu zelfs al is. Ja, dat is wel een belangrijke nieuwe dimensie, denk ik die misschien ook wel andere dingen mogelijk maakt.

00:01:47 Wouter Geerlings

Wat zou het dan mogelijk kunnen maken?

00:01:50 Michel Baars

Nou ja je ziet dat, denk ik nu sloopkosten op een bepaalde manier drukken op project initiatieven. En denken, ja, luister, we moeten, een, afwaarderen, en twee, moeten we eerst nog kosten maken voordat we überhaupt iets nieuws kunnen doen, maar naar de toekomst toe zou je ook nog kunnen nadenken. Ja, het bouwen van iets nieuws hoeft in de toekomst niet in te houden dat je ook eigenaar wordt van al die spullen. Dus ja, als dat niet meer hoeft en dan zijn andere mensen die die beleggingswaarde van die grondstoffen inzien, ja, dan kun je dus een zorginstelling gratis bouwen.

00:02:25 Wouter Geerlings

Maar dan raak ik in de war. Ik ben eigenaar van vastgoed maar je zegt eigenlijk, in de toekomst ben ik geen eigenaar van vastgoed meer. Vastgoed wordt van iemand anders.

00:02:34 Michel Baars

Ja, je bent denk ik eigenaar van een fantastische plek of je bent faciliteert een bepaald proces en dat doe je natuurlijk op, hè, binnen jouw vak op de meest slimme manier. Maar ja, andersom bedacht, nergens staat in de statuten van een woningcorporatie dat zij eigenaar moeten zijn van grondstoffen. Ze moeten sociale huisvesting faciliteren en als ze dat kunnen doen op een manier, sober en doelmatig, die beter is dan het huidige model, ja, dan mag dat ook zonder grondstoffen op de balans.

00:03:00 Wouter Geerlings

Als ik nu kijk naar corporaties, afhankelijk van hoe je het vastgoed waardeert, maar twee-driehonderd miljard wordt nu gewaardeerd in de balans. Hoe zou jij dat vastgoed waarderen? Hoe waardeer jij de grondstoffen die daarin zitten?

00:03:12 Michel Baars

Ja waarderen is altijd, dat is een beetje ingewikkeld. In Nederland hebben we daar niet goed een onderscheid in woordkeuze, maar in het Engels heb je value en je hebt worth. En value is iets wat zich bewezen heeft, waar je validatie op kunt doen. En worth is, nou ja, minder gevalideerd en wat je hoopt dat het misschien gaat zijn. Ik kan op grondstof niveau nog niet tot een value komen, want we hebben gewoon simpelweg geen track record. Dit is ook waar het vastloopt in het huidige lineaire model van kijken naar financieringen, maar we zijn nu gestart met Jones Lang LaSalle om in de commerciële taxaties, dus in de valuation van onroerend goed grondstof waarden op te nemen en daarmee eigenlijk de worth van die grondstof positie alvast te gaan benoemen in de hoop dat hij zich de komende jaren gaat ontwikkelen en ik een markt kan aantonen waarmee we uiteindelijk die worth kunnen omzetten in een value. Ja, dan komt die, dan komen die honderden miljarden er ook in een heel ander perspectief te staan.

00:04:07 Wouter Geerlings

Want jij bent nu slechts 2,5 jaar bezig met je onderneming, met een hele track record natuurlijk. Waar staan we over 5 of 10 jaar, heb je daar enig beeld van al, hoop en ambitie?

00:04:16 Michel Baars

We zijn denk ik niet heel ver weg van het moment waarop een ieder geval het ontmantelen van gebouwen in Nederland gratis is. Dan kost het nog steeds wel geld om het te doen, maar dan is de waarde die je eruit haalt minimaal voldoende om de kosten te dekken. Ik denk dat we binnen 2,5 jaar vanaf nu grondstof fondsen hebben, waarin mensen gaan beleggen, waarin we positie houden en waar vanuit ook, zeg maar, allerlei eisen komen aan de bouw over hoe dan met die grondstoffen die het eigendom zijn van mensen met spaargeld toegepast mogen worden. En ja dan ga je losmaakbaarheid in gebouwen creëren en dat zal de grootste driver zijn voor een circulair economisch model.

00:04:53 Wouter Geerlings

Ik heb een keer een andere ondernemer horen zeggen: “Only if I own it.” Als we nou met zijn allen eigenaren van de grondstoffen gaan worden, gaan we dan niet echt betrokken worden en gaan we met zijn allen de passie voor circulariteit vinden?

00:05:04 Michel Baars

Al is het wel zo dat we denk ik, hè, de waarde van bezit ook een beetje op losse schroeven staat. Het is een functionaliteit die je wilt bezitten, maar misschien een mooie emotie is nog wel trots. We hebben allemaal een hekel aan verspilling. Als we kijken wat we verspillen nu van grondstoffen, dan

zou dat eigenlijk tegen onze natuur zijn. Maar we zien afval als iets waar het ook niet nodig voor is om trots op te zijn. Als we wat meer gaan zien als iets wat waarde heeft, welke waarde dat dan ook is of dat dan sociaal maatschappelijk is of betrokkenheid of geld, maar dat we wat trotser worden op wat we hebben. Nou, dan zul je wel verspilling willen tegengaan.

00:05:39 Wouter Geerlings

Mooi gezegd. Laatste vraag, mensen kijken over een maand nog terug op waar ze vanmiddag geweest zijn. Wat hebben ze dan meegenomen en wat zijn ze dan aan het doen?

00:05:48 Michel Baars

Nou, dan hoop ik dat ze deze dimensie in hun besluitvorming hebben opgenomen, dat ze begrijpen dat ze nu al keuzes kunnen maken die niet per se duurder zijn of langer duren. Dat er al heel veel mogelijk is binnen de kaders, die er nu al zijn. Daar hoef je geen nieuw beleid voor te maken. Maar misschien heb ik een zaadje geplant om dat beleid op dat de toekomst, toch nog wat meer te richten op circulaire economie.

00:06:05 Wouter Geerlings

Ik weet het wel zeker. Michel, dankjewel.

D. Data gathering in the typologies and cases

The primary data gathered in the cases had been retrieved directly from the cases. Secondary data were publicly available. The data have been made anonymous in the table 19 below.

Table 19: Data gathered for each case

Cases	Primary data	Secondary data
Circular Craft Centre – Hoeksche Waard	• Interview B1	• Covenant • Paper articles • Company websites • Magazine articles
Circular Multimodal BMH – 's Gravendeel	• Interview B2 • Interview B3	• Company websites • Magazine articles • External presentation
Circular BMH & BMH with urban development – Utrecht	• Interview B4	• Interview C1 • Interview C2 • Interview C3 • Paper articles • Company websites • Magazine articles
Circular raw BMH – Zaandam	• Interview B5 • Interview B6 • Interview B7	• Interview C4 • Interview C5 • Interview C6 • Covenant • Policy documents • Company websites • External presentation

E. Glossary of abbreviations and Terms

BMH: *Building Material Hub* is a location that are used to better organize building material flows between parties. This leads to fewer transport movements and therefore less congestion and better air quality in the city or region. Materials come together here, are checked and temporarily stored to then be transported bundled to the construction site.

CBE: *Circular Built Environment is* a system designed for closing resource loops at different spatial-temporal levels by transitioning cultural, environmental, economic & social values towards a sustainable way of living (thus enabling society to live within the planetary boundaries).

CBMH: *Circular building material hub* is a BMH where the collection, sorting and processing of non-bulk construction and demolition waste into secondary materials also takes place.

CE: *Circular Economy* is a model of production and consumption, which involves employing different strategies to extant the life cycle of products as long as possible.

Cross-docking: is a practice in logistics of unloading materials from a manufacturer or mode of transportation directly to the customer or another mode of transportation, with little or no storage in between.

Control tower: is a logistical concept in which transport data from different companies is exchanged and centrally managed.

HEC: *High Environmental Category*, industrial estates park with industrial activities from category 4 and higher.

Industrial metabolism: is a concept to describe the material and energy turnover of industrial systems.

Logistical hubs: linking points – infrastructure facilities and nodal points – in logistics networks. They serve primarily as transhipment points for flows of goods. Accordingly, there is not only storage activity but also processes of ordering, bundling, and unbundling.

Multimodal hub: A location that is connected to multiple modes of infrastructure, like the national road network, regional waterways international railways.

Primary materials: Raw material produced by the earth and used by humans to manufacture materials and products.

Secondary materials: Secondary raw materials are recovered, reusable raw materials; substances obtained from previously used raw materials. They have been collected, separated, sorted, prepared, or processed and finally processed.

White label: Originally hailing from the music industry, is used to refer to generic products or services created by manufacturers for sale by other retailers.

SME: *Small and medium-sized enterprises* are non-subsidiary, independent firms which employ fewer than 250 employees AND with an annual turnover equal to or less than €40M OR with a total value of assets on balance sheet equal to or less than €20M.

ZE-zones: *Zero Emission zones* is an area where only zero-emission vehicles (ZEVs), pedestrians, and cyclists are granted unrestricted access.

F. List of figures

G. List of tables