

Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Yuan Jia
Student number	5093260

Studio		
Name / Theme	Management in the built environment / Design and construction management	
Main mentor	Catherine de Wolf	Design and construction management
Second mentor	Tuuli Jylhä	Real estate management
Argumentation of choice of the studio	The built environment is complex due to the multifaceted fields and rapidly changing trends. From my previous study and work in architecture design, I realized a professional in the built environment should hold the awareness of not only technology but also finance, regulation, management and be able to coordinate multi disciplines. That's why I chose MBE to continue my study and do my thesis. In previous experience, I was mainly involved in design but also touched the communication with clients and suppliers. As kind of an extension of my previous work, I chose the field design and construction management in the thesis as it focuses mainly on the building scale.	

Graduation project	
Title of the graduation project	Digital Twin as enabler in circular lifecycle management
Goal	
Location:	A comparative study between China and the Netherlands
The posed problem,	Despite the benefits of applying DT-based CC in the built environment, it was still at the very beginning stage and was mainly applied in representative projects. Little research has been done so far concerning the value of DT in circularity. As the trends of digitalization and circularity continue to grow in the market, there are some gaps needing to be filled. Firstly, it is important to integrate the circular principles and DT concepts throughout the project life cycle.

	However, insufficient awareness and capital lead to the limited and fragmented application. The disconnection between DT at urban and building levels also impedes the information exchange and collaboration. Secondly, the most mentioned barrier and enabler of DT and circularity are regarding financing, whereas it's not yet emphasized in the research and practices (Adames et al., 2017; Rizos et al., 2016). Last but not least, the traditional linear model is not applicable in the CC (Benachio et al., 2019). A circular business model to guide the collaboration and communication in DT-based CC is required (ARUP, 2019; Eadie et al., 2013). Therefore, the research's challenge is to understand the role of DT-based CC and investigate how DT can be applied in assisting CC across the life cycle stages while considering LCC. In order to put this research in a global context, a comparative study of a case study in the Netherlands with one in China will be conducted, as many applications of DT exist in the Chinese context, and many initiatives for applying CC principles exist in the Netherlands.
research questions and	"How can the use of Digital Twins (DT) improve circular construction management while reducing life cycle cost?" 1. What is the current role of DT application and circular construction(CC) in the built environment? 2. To what extent is DT used to make construction circular in China and in the Netherlands and why is it different/similar? 3. How can the benefits of using DT (a) improve circular construction management and (b) reduce life cycle cost?
design assignment in which these result.	This research analyses DT and CC, and to perceive the desirability of LCC reduction and a new business model concept as a possible consequence of the DT-based CC. The deliverables include three parts: 1. A scheme that allows the examination of DT-based CC applications; 2. Differences and similarities between the two comparative cases and the reason behind that; 3. An innovative circular business model.
Process	
Method description	
This study is based on a qualitative research method, which emphasizes an inductive approach to the relationship between theory and research and aims to gain an understanding of the social world through an examination of the interpretation from its participants (Bryman, 2016). Based on the pre-defined problem from the preliminary	

literature study, the research is further divided into three stages, namely theoretical, empirical, and operational phases.

The methods and data collection approaches applied is summarized in figure 1. At the beginning of the study, a preliminary literature study was conducted to understand the context and define the problem and the research questions. Then three stages of research are designed to answer the main question step by step.

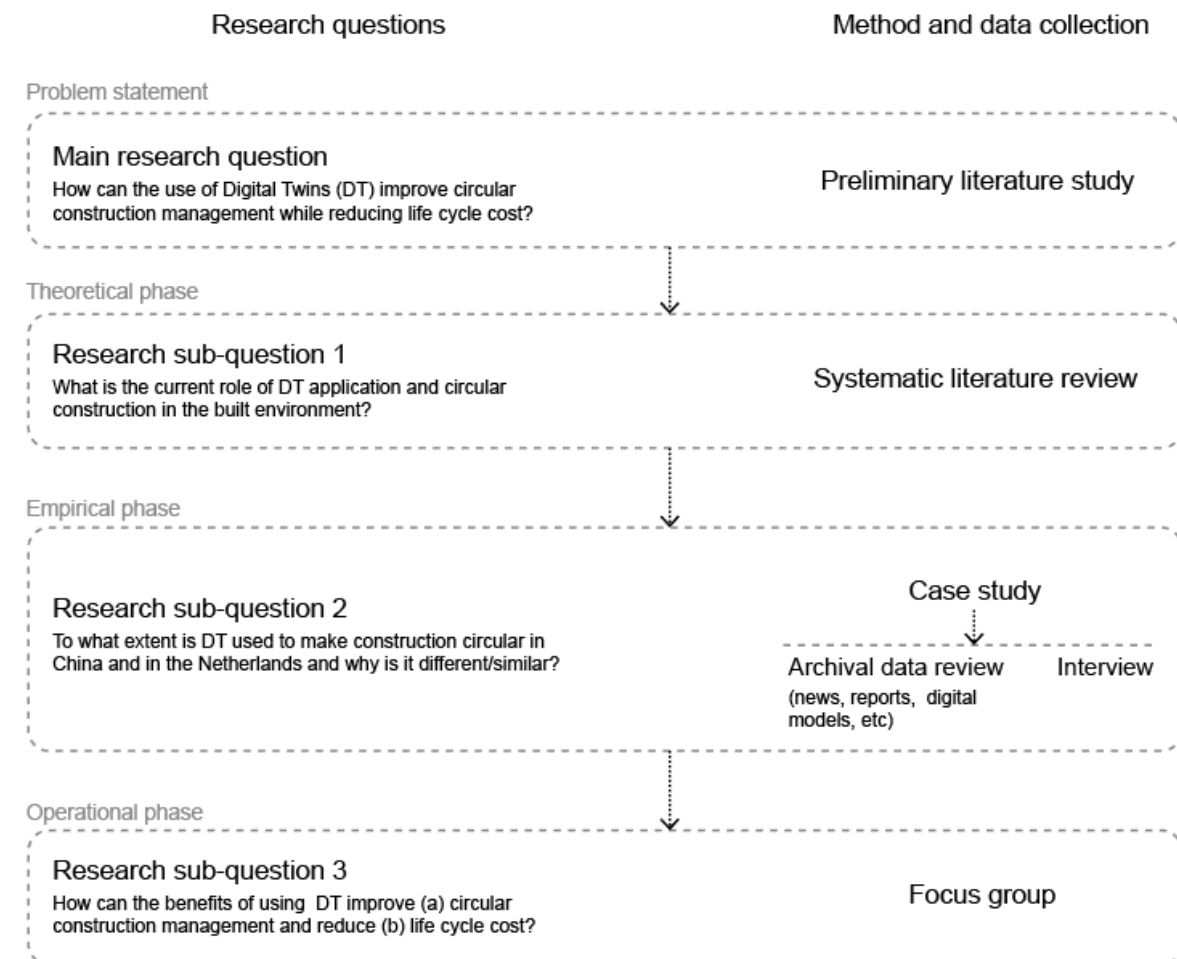


Figure 1: Research sub-questions and corresponding research method (own figure)

Literature and general practical preference

The objective of the first phase of the research is to address research sub-question 1. In order to do this, a systematic literature review, which is normally used to generate unbiased and comprehensive accounts of the literature, of journals, books and reports (Bryman, 2016), is conducted for the following concepts: 1) CC principles across the project life cycle, 2) DT application in the built environment, 3) impact on LCC of DT and CC application, 4) assessment criteria of DT and circularity and 5) current circular business model. The structure of the literature review is shown in figure 2.

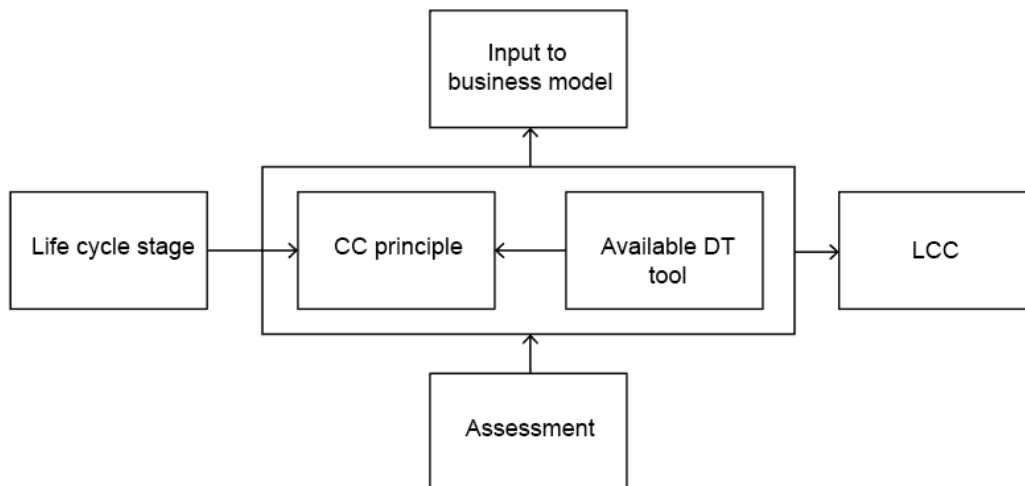


Figure 2: Structure of the systematic literature review

Some of the main authors that were studied per theme are:

CC: Kirchherr et al. (2017); Chi et al. (2019); Adams et al. (2017); Benachio et al. (2019); Lu et al. (2020); Ghisellini et al. (2018); etc

DT: ARUP (2019); Rocca et al. (2020); Benachio et al. (2019); Eadie et al. (2013); Patterson and Ruh (2019); Kyrö et al. (2019); Akanbi et al. (2019); Antikainen et al. (2018); Botton et al. (2013); etc

Assessment criteria: Akanbi et al. (2019); Kirchherr et al. (2017); Antikainen et al. (2018); Wang et al. (2018); Favi & Germani (2014); Britannica (2020); etc

LCC: Khajavi et al. (2019); Boje et al. (2020); Autodesk (2018); ARUP (2019); Mellado & Lou. (2020); Eadie et al. (2013); etc

Business model: Pekuri. (2015); Evans and Bocken (2013); EMF (2012); Lacy et al. (2013); Bakke et al. (2019); Planing (2015); etc

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?
Design and construction management(DCM) as well as real estate management(REM) are two fields embedded in MBE that I am working on in my thesis. My graduation topic focuses on circular construction and LCC reduction as

a goal and Digital Twin as a tool. It needs to be discussed in the life cycle stages, which aligns with the scope of DCM. Some concepts, such as maintenance and operation stages and business model design, are also strongly related to REM. All the concepts mentioned in the thesis focus on the collaboration and communication of multi disciplines across the project life cycle. The business model developed in the thesis is expected to work as a toolbox for decision-makers to customize their own suitable business model. The emphasis on balancing the interests of diverse stakeholders and considering the consequence of one change to all other stages in the project life cycle are related to what I learned in all the courses of MBE track.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

The research is intended to make both scientific and societal contributions. Circularity in the built environment has been researched in the past two decades but the practices in the real projects are still at the very beginning stage. DT is still a rather novel topic in the field of construction, let alone its application in CC. Luckily there is already a lot of research regarding DT-based CC, however, most of them focused on separate technology of DT, such as BIM, instead of the whole DT concept. On the other hand, the related cases didn't cover all the CC principles, which leads to the absence of knowledge from practice. Therefore, this research can hopefully contribute to gathering problems and experiences from the cases and reflect them on the existing theory. The research on LCC and business models can help with building a realistic and financially feasible business model for the DT-based CC application. Furthermore, the research is valuable for both researchers and stakeholders in the construction sectors under the trends of circularity and digitalization.

3. Research Planning

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	P1			P2				P4	
research question & concept									
		Finalize theoretical part							
		Methodology							
		Finalize research design							
				Carry out empirical part					
					Carry out operation part				
						Analyzing findings			

The above figure presents the timeline of the graduation plan from P1 until P4. Main tasks that need to be completed according to the methodology and the estimated time period are also listed.

There are three main deliverables, literature examination report, comparative study report and business model proposal. Literature examination was already included in this P2 report. Case study will start after the P2 is approved and will last for around 2 months. The business model design is expected to start right after the finalization of the empirical phase. However, due to the uncertainty of the schedule of the interviewees, it is hard to pre-decide the exact time of interviews and focus group and there may be some overlap between empirical and operational phases. A final discussion and conclusion based on all the findings is expected to be completed in P4.
