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**

<table>
<thead>
<tr>
<th>Name</th>
<th>Wouter ter Heijden</th>
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<tbody>
<tr>
<td>Student number</td>
<td>4512596</td>
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<tr>
<td>Telephone number</td>
<td>+31 6 28362819</td>
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<tr>
<td>Private e-mail address</td>
<td><a href="mailto:wouterterheijden@gmail.com">wouterterheijden@gmail.com</a></td>
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**Studio**

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<tr>
<th>Name / Theme</th>
<th>Urban Metabolism</th>
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<tr>
<td>Teachers / tutors</td>
<td>Ulf Hackauf &amp; Henk Jonkers (CITG)</td>
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**Argumentation of choice of the studio**

Using the concept of urban metabolism and material flow analysis for the usage (or disuse) of sand in city construction explores the potential of the material stock in buildings and the possibilities in urban planning, which is currently not well embedded in the urbanism discipline. The crux of this proposal to remove/reduce sand in the construction material flow and functioning of our cities corresponds with the studio group focus of “developing future urban systems that are less damaging to the environment and more resilient to future changes”.

**Graduation project**

| Title of the graduation project | City without Sand: A spatial experiment for the construction sand balance in the Rhine-Meuse estuary |

**Goal**

| Location: | Rijnmond-Drechsteden conurbation in the Rhine-Meuse estuary |

**The posed problem,**

Globally, the construction and demolition sector shares a huge part in the consumption of primary materials and the generation of waste. The sector is also responsible for the materialisation of urbanisation, which is a trend expected to continue. The most important material in the construction sector is sand and gravel as it is fundamental for urban constructions. The consumption of sand and gravel is linear resulting in a constant input of primary material and output which is downcycled.

The Rijnmond-Drechtsedtend (RMDS) region is also expected to continue in urbanisation. With a demand for almost 87,000 dwellings to build and 100,000 to replaced, the construction metabolism of the region will undertake many in- and outflow of primary sand and gravel. This process is still in the business-
as-usual perspective still traditionally and not circular, which is also a missing ambition in the urban design profession for housing development.

| Research questions and design assignment in which these result. | The main research question is: “How can urban design reduce the consumption of primary construction sand and gravel in the construction ecosystem of the Rijnmond-Drechtsteden region?”

The sub-questions are:
1. What is the construction sand and gravel metabolism of RMDS region until 2050?
2. What is the impact of the construction sand metabolism of Rotterdam until 2050?
3. How can urban design improve the materialization consumption and impact of construction sand and gravel?
4. How can the sand and gravel metabolism of RMDS region be improved?

The final product will be a set of urban design which relate to the main research question. These urban designs are supported by sand-sensitive solutions which reduce or alter the construction sand and gravel metabolism by dematerialisation, reusing or alternative materials. Important note is that the impact of the solutions should be taken into account in order to prevent other negative trade-offs. The construction sand and gravel metabolism system is both on urban design scale and regional scale of the RMDS region. In the research part, a scenario of the metabolic system is developed based on expected or projected in- and outflows. The small scale design will alter the in- and outflows in a more circular (less consumption of virgin extracted minerals and waste generation) and improved situation on regional scale. In short, the design results are 3 parts: the sand-sensitive solutions, the metabolic system and the spatial situation both small scale and regional scale.

**Process**

**Method description**
The thesis is a quantitative research with a qualitative outcomes in terms of urban design. The quantitative aspect is typical for studies on urban metabolism. The research follows a systematic approach where first the current situation (scenario) and perspective will be evaluated with a LCA, improvement will be sought on deductive and inductive level which eventually will be applied on the situation (scenario) in concrete solutions (urban design) in order to improve the future perspective environmentally. This approach seems to be a typical engineering method of optimising current systems. However, the measure which need to be taken in order to improve the system are unknown and the objective is not indisputably making it an experiment, which is the core of the design discipline. This makes the research an interdisciplinary project where systematic thinking from civil engineering or industrial ecology (the LCA and MFA) is combined with urban design problems and processes.
The research can be divided in four parts:

A) *Analysing the current situation*
   This part is the research and analysis of the construction metabolism in the region, done by material flow analysis and material intensity model. This analysis is done in three steps; 1. *An analysis of the current material flow of construction sand and gravel (system flows)*, 2. *An analysis of the processes driving the construction and demolition activities and its demands*, 3. *An analysis of the current stocks of sand and gravel in the region*

B) *Life Cycle Assessment*
   The LCA is an evaluation method for the construction metabolism and planning approach in the RMDS region. This evaluation is important in order to improve the current situation.

C) *Material sensitive design approach*
   In order to improve the metabolic system and reduce the sand consumption, new solutions and approach in urban design needs to be found. This is done by developing a catalogue of solutions.

D) *Research by design*
   The solutions will be applied on both regional and urban design scale for the housing development in the region. The result will eventually answer the main research question.

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**Time planning**

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Literature and general practical preference

The problem statement is related to a certain field of study. The hierarchy and structure of the theoretical framework is explained in image below. The background of the research the resource depletion and consumption. The research focus on the consumption of resources in the construction sector, in the context of construction metabolism. Construction metabolism is a concept which explains the construction ecosystems which has certain attributes & processes. These are respectively distinguished in the field of civil engineering and urban design. These two fields are discussed separately but overlap and are closely related to each other.

Key literature and findings

Background: resource management
Current society is dependent on the resources the Earth supplies. The resources can be dived into non-renewable or stock resources and renewable or flow resources, based on how quickly they renew. Sand and gravel renewes over millions of years which means that it is non-renewable and finite. Resources should be consumed efficient in order to prevent scarcity. The current extraction of sand and gravel is also harming related ecosystems.


Context: construction metabolism
Urban metabolism is a concept which describes the consumption of a city by in and outflows. The construction metabolism focuses on the in- and outflows related to construction activity. Sand and gravel are key materials in this metabolic system because of their application, which is explained in the image below.

Attributes: civil engineering
As visualised in the image above is the construction sand and gravel metabolism based on different attributes, also stocks. These attributes can be defined as the urban construction and includes buildings and infrastructure, building site preparation and coastal protection. The materials have a different durability which is based on internal factors (such as degrading material) and external factors (land use change).

Processes: urban design
Material choice is not integrated in the field of urban design. The only notion of materialisation is taking when talking about legibility or identity of the environment. However, urban processes are responsible for in- and outflow of sand and gravel because it defines the urban constructions.

- https://doi.org/10.1162/108819801753358481

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)?

Construction is the key activity which defines the discipline of architecture and urbanism. Architecture and civil engineering are already exploring the circularity of building materials but this is not well exposed within the field of urbanism. Urban Metabolism explores the consumption of cities but currently focus on more ‘fast’ flows of energy or water but not the ‘slow’ construction flow. This construction flow always occur in urbanism when a plan is designed and executed.

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

Scientific relevance
Urban consumption is part of urban design in sense of processes it drives but the notion of consumption and skill to reduce the consumption is missing in the current discipline. Furthermore is the lack of construction metabolism which is currently underexposed in urban metabolism studies. This is notable because the construction sector is the largest consumer.

Social relevance
As mentioned in the introduction, resource reduction is part of a global challenge to become more circular and less dependent on primary resources. The Netherlands is currently aiming for a 100% circular economy in 2050. The construction sector is taking a large share in the consumption but the sector is also extremely conservative (Kibert et al., 2000), which, related to other sectors, means that innovation does not develop quickly due to regulation and liability. In order to meet the circular ambitions, insights in the consumption of sand and gravel and new design solutions will help the society in the achievement of the challenge.

Ethical considerations
In 1987 the Brundtland report ‘Our Common Future’ was published focusing on our current and prospected direction in consumption and development (World Commission on Environment and Development, 1987). They thrive for a sustainable development where sustainability is defined as: “Sustainable development is development that meets the needs
of the present without compromising the ability of future generations to meet their own needs.” The current resource depletion of finite resource, oil, gas but also minerals such as sand and gravel, is disabling the future generations to meet their needs with the same changes and opportunity as we currently do, creating inequality. Although sand and gravel is transformed into durable construction, the ability of reusing the minerals is, with the current technology, unable or difficult after its life-span.