

Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



Graduation Plan: Architectural Engineering

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Studio	
Name / Theme	Architectural Engineering Intecture
Teachers / tutors	Mo Smit, Engbert van der Zaag & Pieter Stoutjesdijk.
Argumentation of choice of the studio	<p>A lot of big and famous architectural offices design mostly for the wealthy part of the population, like companies or governments. But according to the UN-Habitat (2013) approximately a quarter of the world's urban population lives in slums. In the rapidly urbanising world, informal settlements have become an integral part of the urban scene in many developing countries where there is no provision of affordable low-income housing. There is a growing international recognition of the potential role that informal settlements could play in the search for solutions to the critical housing shortage in cities. I am interested in what role an architect can have in this upgrading and improvement of informal and self-built settlements by including and educating the local population in the upgrading- and building process. If through education and inclusion of locals off the grid settlements can be developed in off the grid sustainable housing, the world is a big step closer to their sustainability goals. Therefore, I want to work with the current sustainability goals like circular and energy efficient housing in mind. As I believe that a contemporary architect is not only a designer of spaces, but also an engineer searching for new (technical) solutions, this studio (AE) is in my opinion the right graduation studio for me.</p>

Graduation project	
Title of the graduation project	REINVENTING THE CRAFTSMANSHIP – transformation of the building practice in Indonesia towards a sustainable and circular economy
Goal	
Location:	Cigondewah, Bandung, Indonesia
The Problem Statement	
<p>Since 2014 more than half of the worldwide population lives in cities, and this is expected to increase up to 66% in 2050. During the next two decades, the urban population of the world's poorest regions - including South Asia - is expected to double.</p>	

The huge increase in urban populations amounts to a crisis of unprecedented magnitude in urban shelter provision. All those people need to be provided with shelter, employment and urban services. The stretched capacity of most urban economies in developing countries is unable to meet more than a fraction of these needs, so that the informal sector is providing most of the new employment and housing in environments that have come to be known as informal settlements or slums. Approximately a quarter of the worldwide urban population is living in slums or informal settlements and that percentage will increase in the coming years. In Asia even 30% of the urban population resides in slums. Also Indonesia struggles with enormous amounts of people coming to the cities in search for a better life. Over the last few decades, Indonesia has been experiencing high economic growth and people left the countryside in search for work in factories. Country wide there is already a backlog of 11.4 million houses in 2015 and the need for living spaces increases rapidly with a need of 800,000 new houses annually.

Cigondewah, the research location in Bandung, Indonesia, is an informal settlement, called a kampung. Although from a historic point of view the Indonesian kampungs cannot be compared to slums, there are similarities. The UN-HABITAT defines a slum household as a group of individuals living under the same roof in an urban area who lack one or more of the following: access to improved water, access to improved sanitation facilities, sufficient living area, structural quality/durability of dwellings and security of tenure. These conditions are referred to as *the Five Deprivations* negatively affecting the lives of slum dwellers.

According to UN Habitat the percentage of people living in slums in Bandung is 23 percent. Since the industrialisation of the textile industry in the area, the from origin rural kampung of Cigondewah developed into an urban, industrial kampung. Lots of people were attracted to the area by the work provided by the textile industries, flocking the Kampung and resulting in a crowded, unsustainable living area. The Kampung could no longer provide itself with food, resources and water and the textile industries are polluting the area. As Smit at al. witnessed in their case-study: "the industrial kampungs of Cigondewah have to deal with big spatial and environmental challenges like inadequate (worker) housing, extreme water pollution, over exploitation of groundwater resources, land subsidence and flooding, lack of garbage collection services, degenerated agricultural land and outdated energy systems."

Since the factory owners are not providing their workers with housing, they find themselves housing in the surrounding kampungs. A lot of kampung families have changed their job from the agricultural sector towards a providing service related to the textile industry, either renting out rooms for the factory workers or sorting textile waste. This interwoven system makes the whole kampung, both the factory workers as well as the local community, interdependent of the textile and garment industry. However: "Despite its environmental problems and lack of adequate housing, public facilities and services, the industrial kampung environment is home to a socially and economically tight knit community. People are used to take care of themselves and each other."

Although the most houses in the kampung are from durable materials like steel, concrete and stone, the building quality is poor and buildings have to be changed, repaired and rebuild often. In Indonesia the demand for building materials is higher than the country can provide, meaning they have to import raw materials from abroad. Estimated about half of the material flows are

associated with the building industry. Besides that, about one third of all the negative environmental effects are caused by the building industry. Also, the Indonesian urban areas produce 364 million tonnes of construction and demolition waste every year. Current waste is dealt with in a linear way. The building industry thereby accounts for 50 percent of landfill waste.

With the backlog of houses and the waste produced by the building industry in mind, and a further increase in the population of Bandung in the coming years, the problems in Bandung are not only a quantitative and spatial challenge, but also a challenge in terms of building materials and the environment. It requires further densification, yet existing structures are already weak and not suitable for further extension. Besides, ground space and raw materials are limited within the city, over time become more and more rare goods.

The socially and economically tight knit community in Cigondewah can provide a good starting point for improvement of the Kampung. In my graduation project, I want to provide the local community with an example of how to build in a more sustainable way with natural and bio-based materials, designing a building with adequate housing for the factory workers who flocked the neighbourhood, as well as a community centre and workshop space where information on building methods can be shared. The building industry that might develop out of this example building, based on recyclable and bio-based materials in upgradable wall- and floor panels, can provide the Kampung with more work for its inhabitants. Besides, this work is not dependant on the textile industry, creating a healthier economic environment in the kampung.

Objective

It is the declared intent of the project to develop a suitable building system that opts for the use of alternative building materials in support of better structures, less construction and demolition waste production and a healthier living environment. It is not a measure to solve the construction and demolition waste problem in its core essence, but merely a method to motivate the local people to care more about their environment and introduce a different approach to materials and waste in a day to day living. It's way of experimenting with new or less respected materials within a strong framework and showcases the potentials of the materials in the specific environment, possibly taking away a share of the normally used bricks, concrete and steel.

The building system will form the basis for a business model for housing in Cigondewah focussing on the above mentioned replacing of current common building materials and techniques. With a smaller start investment a strong structure with cheaper infill panels can be built. Once the tenant saved more money, the infill panels can be replaced with a more durable and high end material. Required for this is the first infill panel is degradable, not producing any waste. For this purpose potential materials need to consider cost implications as well as fulfil spatial and environmental needs.

Overall Design Question

The overall design question of this graduation is: "How to transform Cigondewah's building material flows into locally managed circular material flows, showcased in a building and taking

into account the (housing) needs of Cigondewah in an appropriate and sustainable way to the context?"

For the **Context**, Cigondewah, I want to research the history and development of the location as well as the culture (community bond), the current housing situation, the current way of building, the materials used in the building process and the material life cycle.

The **Program** is a combination of a building product factory to develop and promote the new materials and a worker's housing complex as a prototype to showcase the building system. Worker's housing is often in a bad state and as the workers often don't know if their housing will be permanent or temporary, they accept more. I will research the current housing situation of factory workers and I will look into their needs.

The **Thematic focus** is a building system that promotes a circular economy, as it is using circular materials. The current building industry is very much polluting, both direct and indirect and the quality of building needs improvement in order to build higher structures. For the thematic focus I will research:

- Alternative building materials for current building materials (availability on Java, properties, strength, life span: What bio-based materials are available on Java? What bio-based materials are suitable for different building components (structure, foundation, walls, floors, windows, doors, roofs) ? What is the life span of the materials?
- Life Cycle Assessment: How can a circularity of the materials be created?
- Business plan : What is the potential of the application of bio-based materials in a circular building system consisting out of wall- and floor elements?

The result should be a low-tech, easy to build system from renewable building materials which I use in my design project of a factory worker's housing project.

Thematic Research Questions

The graduation project is divided in three research parts, part III, part IV and part V, resulting in the design brief.

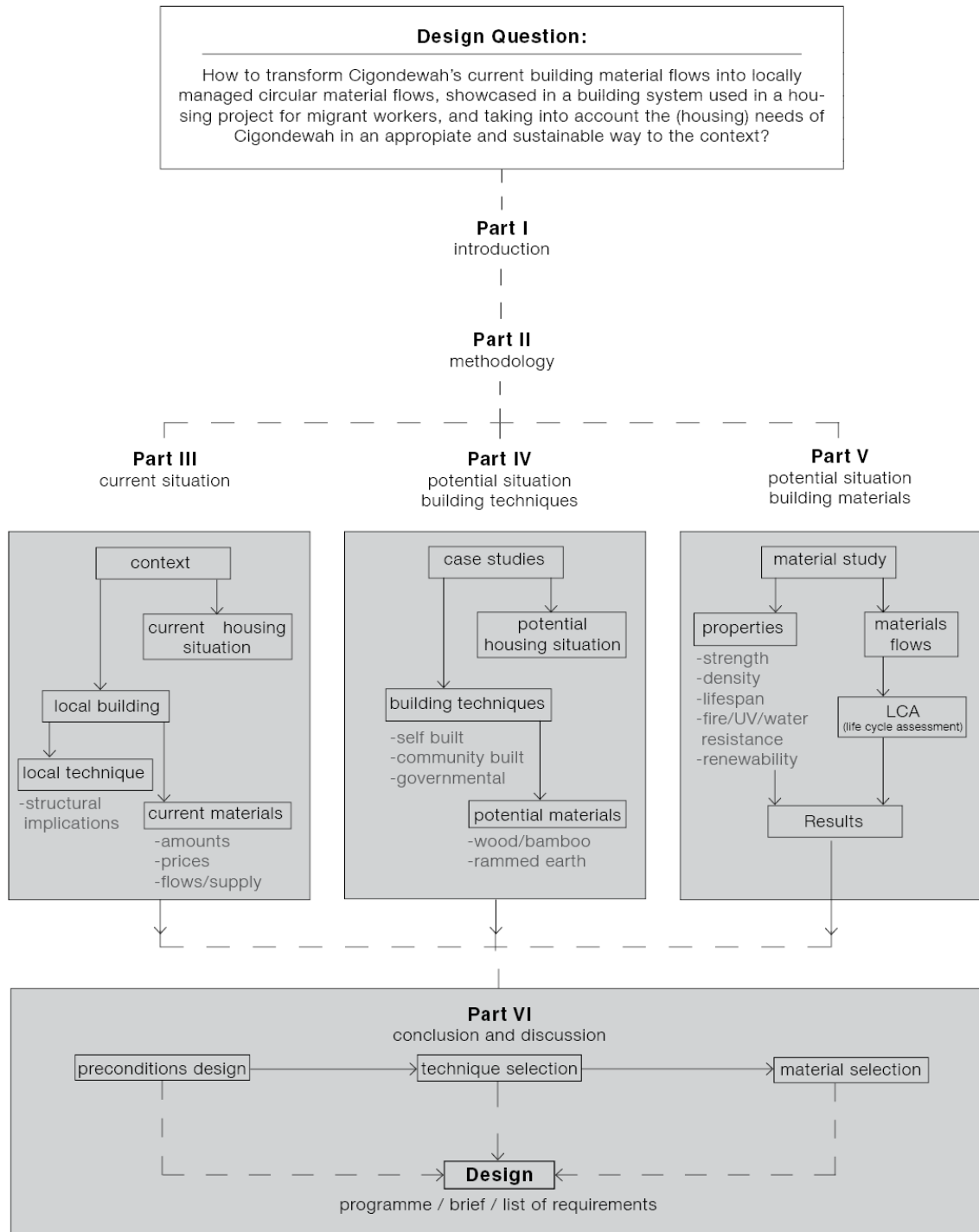
Part III focusses on the current situation in Cigondewah, trying to answer the question "What is Cigondewah's current housing situation and what building techniques and -materials are predominantly used?" To answer this question, this part investigates the current housing situation as well as the local building economy, including the local techniques and the used materials.

Part IV studies several case studies in order to investigate potential building techniques. The question that is asked in this part is: "How are kampungs and slums elsewhere successfully improved and what building techniques and materials were used?" The case studies are selected on several possible interesting factors, like kampung improvement, slum upgrading and community involvement.

Part V includes the thematic focus of the graduation project; materialization. The question researched in this part is: "What are potential sustainable, circular building materials, suitable for the application in a tropical climate and appropriate for the context?" Several materials are

researched, resulting in a list of materials, with their properties, life cycle and environmental costs, providing insight in the potential use of the materials and their sustainability.

The scheme below provides an overview of the relation between the overall design question, the different research parts and the draft design.



Design Assignment

The traditional rural kampungs, like kampung Naga, exist out self-built houses made from locally available materials out of the surrounding nature. With the urbanisation of the kampungs, the bio-based materials became less available and eventually disappeared together with the knowledge of how to build with it. In urban kampungs, the building materials like stone, concrete and steel are provided by the material shops and the building quality decreased as structural knowledge got lost.

The investment to build a house is for most kampung families a big investment, so most inhabitants of the Kampungs decide for the most durable materials like stone and concrete. Besides, as the demand for this materials is high, they are widely available and cheap. However, this way of building is very unsustainable and producing a lot of waste in the whole process. Therefore, I want to develop a more sustainable, circular alternative building method to build dwellings in the kampungs. To show the kampung inhabitants that this method works and to provide the kampung Chigondewah with a new (building) industry, I will design a building product factory and worker's housing complex implementing the system. The goal is to create a successful business plan for a circular economy of bio-based, sustainable and recyclable building materials within the (direct surroundings of the) kampung Cigondewah, trying to implement the traditional and new building materials and techniques within the city and besides increasing the availability of alternative building materials and making it more popular to use them.

Process

Method description

This researches are making use of the observations and information gained during a two week long field trip and exchange with the Department of Architecture of the Institut Teknologi Bandung, as well as interviews with several residents of the Kampung and of Kampung Naga. Beside I make use of interviews and research results by previous graduation student groups of the TU Delft architectural engineering studio. The investigation into materialisation in particular is based on literature and a self-performed life cycle assessment which helps to define the sustainability of each material and the material flows related to the building industry.

While part V of the report is currently solely based on literature research, the subsequent stages of the exploration will focus on research by design with this performed research as its foundation.

The method of life cycle assessment has long been available as a means of evaluating energy and material flows and the effects on the environment. Its further development and in particular the availability of the necessary data are now leading to the introduction of life cycle assessment into design, construction and management processes. It is quite likely that in the future the use of life cycle assessment will become a part of the design and management of every building and will be oriented towards the entire life cycle of a building – from cradle to grave, from new building through maintenance to dismantling and recycling and reuse.

Life Cycle Assessment (LCA) describes a systematic analysis of the resources drawn from nature and the environmental effects of a product over its entire life cycle. As this research focusses on the life cycle of building materials, the Use phase will be neglected. In this research I will use the concept of eco-costs, which is a measure to express the amount of environmental burden a product on the basis of prevention of that burden. It are the costs which should be made to reduce the environmental pollution and material depletion in our world to a level which is in line with the carrying capacity of the earth. Eco-costs are virtual costs, since they are not (yet) integrated in the real life costs of a material. The total eco-costs can be regarded as a robust indicator for cradle-to-cradle calculations in LCA for products in the theory of the circular economy.

Literature and general practical preference

The literature I used focusses on the themes:

- Slum development
- Self-built housing
- Participatory building process
- Traditional / vernacular building techniques and principles
- Affordable housing
- Collective housing, micro dwellings and extension of dwellings
- Materials; current used, traditional and alternative -
- Local renewable resources
- Waste in Indonesia
- Life Cycle Assessment
- Circularity in the building industry

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Reflection

Relevance

Although this graduation project focusses on a solution for Cigondewah, the problems of a big amount of construction and demolition waste and inadequate low-income housing are known worldwide.

The nowadays most commonly used building materials in Cigondewah are concrete, bricks and steels. The production of these materials does not only demand a high amount of energy, but also a high amount of limited resources. The use of these materials is common all over the world, in both industrial and developing countries. As the worldwide population is growing

rapidly, the consumption of these materials will grow even further in the future, resulting in an over-exploitation of our environment and the exhaustion of certain resources.

The proposed circular building system would be a solution not only to stop the exploitation of limited resources and to decrease environmental pollution, but also assure affordable housing for everyone, as prices of limited resources will eventually rise. Renewable resources gained locally are often inexpensive and non-polluting. The materials investigated in the research part V can also be found and applied in similar contexts elsewhere as long as the primary resources are available.

Furthermore, the proposed building system has a simple building method and is designed for a low-income population, making it widely available. A simple building method implies that the building process can be taught easily to a community who build together. With more people participating in the building process, the construction time could be reduced. Creating and spreading building knowledge and skills to construct safe housing might contribute to the lack of affordable housing in developing countries, eventually overcoming this problem.

Time planning

The scheme on the following page provides an overview of the division of the workload in the 42-weeks long graduation year. Besides the graduation project, also other courses that I intend to do are included in the schedule (in blue). The schedule is showing the deadlines and exams of all the courses throughout the graduation year for as far as they are known to me.

