

PART 0

RESEARCH FRAMEWORK

1.1 BACKGROUND

In the recent years, a few master thesis in TU Delft and TU Eindhoven have been elaborated analysing the possibilities for multi-storeys additions on top of existing buildings. These works focus exclusively on the structural design from an engineering perspective, resulting in technically and economically efficient solutions. However, they do not provide insights into other architectural qualities, for instance, building expression or functionality.

In the last decade, precedents of multi-storeys building extensions have been constructed, especially in The Netherlands. These projects highlight the potentials of building extensions, by exploring technical complexities in combination with architectural design, and at the same time, achieving financially-feasible results. Nevertheless, up to date, there is still an absence of information concerning structural and architectural principles, for building extensions.

Furthermore, there are new demands for sustainability in construction products (ref), these requirements are especially important for the main structure of the building, because of the large quantities of material needed. It has been documented in the literature (ref), that engineered timber is one the most sustainable construction material given that is renewable, it requires low embodied energy for manufacturing and it can be recycled. At the same time, it can be very suited for structural extensions and other complex structures, given its lightweight and dry construction process (ref). On the other hand, there are also other technical questions, such as durability, absolute strength or fire resistance, that up to date, have restricted the use the material in technically-driven projects. With recent research in engineered timber, and their potential in high-rise structures, many of these issues have been clarified, enabling a new rediscovered use of timber in construction.

In conclusion, we can say that there is need for more research about possibilities for integrated design of building extensions using engineered timber products.

1.2 PROBLEM STATEMENT

Nowadays, there is a growing need for construction methods that are able to cope with urban growth in a sustainable way. Tall Timber buildings can be an interesting alternative, however, in congested city centers they required ample space for the building base and often the demolition of an existing building. Needless to say, this is highly unsustainable from an environmental and cultural perspective. On the other hand, extensions of buildings are often executed in a small scale, with light structural interventions. Tall Timber Extensions, can be a new construction typology that combines the sustainable benefits of timber structures, with the advantages of building high on an existing structure.

1.3 OBJECTIVES

Aim

Understanding possibilities of new construction methods with timber structures, and to what extent can they be utilised for extending existing buildings in dense cities.

Literature and case studies objectives

- Analyse precedents for building extension projects, in order to understand and illustrate "the-state-of-art" of construction and architectural principles.
- Describe lateral stability systems for tall building structures, and suitable principles for engineered timber products.
- Highlight sustainability potentials of using engineered timber structures.

- Describe principles and construction methods for engineered timber structures, and suitable applications in building extensions.

Design outline

Location - Ter Meulen, Rotterdam, The Netherlands

The rationale behind the selection of this building, was derived from the literature study of precedents and state-of-art building extensions. The new building called Karel Doorman, represents the highest precedent of building extensions using extra structural capacity of an existing structure. In the new extension, 16 lightweight extra storeys were added on top. After physical assessments and structural re-calculations of the original structure with new standards, the Ter Meulen existing structure proved to be in good condition and showed a significant undiscovered extra load-bearing capacity (Hermens, Visscher & Kraus, 2014). This will allow the exploration of ambitious structural and architectural designs.

Programme - Residential

The future programme demand of the architectural design were based on current market demands in major dutch city centers.

Boundary conditions

The design case studies will not focus on the technical assessment of the existing structure. It will consider that the existing structure is in the original condition, based on the technical data extracted during the construction of Karel Doorman.

Design objectives

- Understand urban regulations for a tall building in the specific context
- Understand and calculate composite action, fire and acoustic behaviour of CLT timber products, and comparison with conventional construction methods
- Research engineering and architectural integration possibilities in a building extension project
- Extract guidelines for architects and engineers for sustainable integration in a complex building extension

1.4 RESEARCH QUESTIONS

To what extent is a Tall Timber Extension (TTE) technically feasible?

- What is the state-of-the art of tall timber structures?
- What are the main technical considerations for a tall timber structures?
- To what extent is a Tall Extension technically feasible?

To what extent can we build a residential TTE in the intended location?

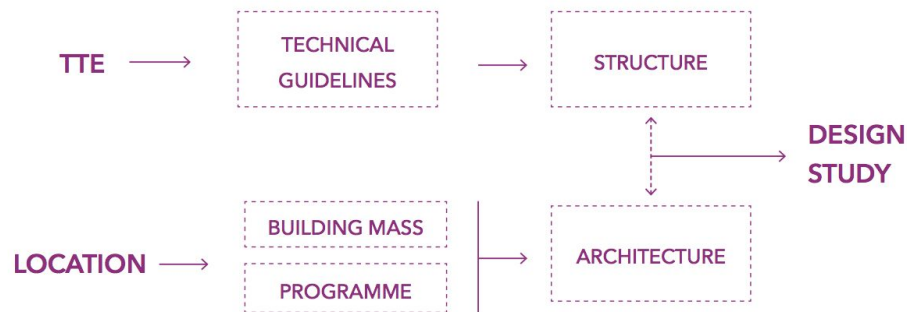
- What is a tall building and how does it apply to TTE and context?
- What is Rotterdam urban policy regarding tall buildings in the intended location?
- What are the current market demands for a tall residential building in Rotterdam?

How can we design an integrated TTE in the intended location?

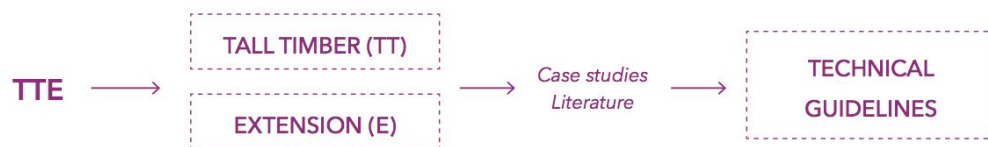
- What is the solar impact of a Tall building in the existing context?
- What are the most important structural design principles for designing timber structures?
- What are the most suitable structural systems for the TTE in the intended location?

1.5 METHODOLOGY

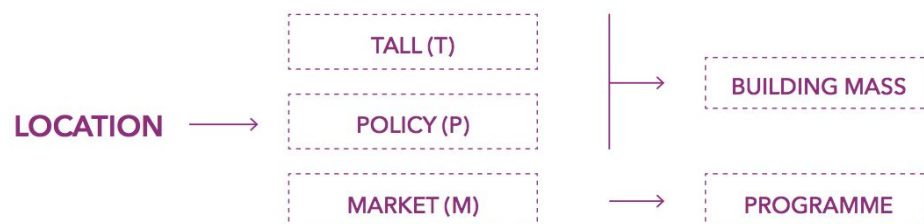
Understanding and designing a building can be a difficult task due to the multiple parameters simultaneously involved, especially if it is considered from a strict research perspective. In that context, an ambitious research framework is proposed with three main parts that try to integrate case studies, literature review and research by design, in three parts.



- Part 1 researches the technical considerations for Tall Timber buildings (TT) and Extensions in existing buildings (E), through an extensive literature review and case studies, in order to understand the state-of-the-art of these construction methods and extract general guidelines for the architectural design.



- Part 2, focuses on the specific urban policy and architectural demands that a tall building in the selected location has to meet. From these considerations a general building mass and programme guidelines can be used in the later architectural design.



- Part 3, intends to apply the obtained research into an specific project with both architectural and structural ambitions.

