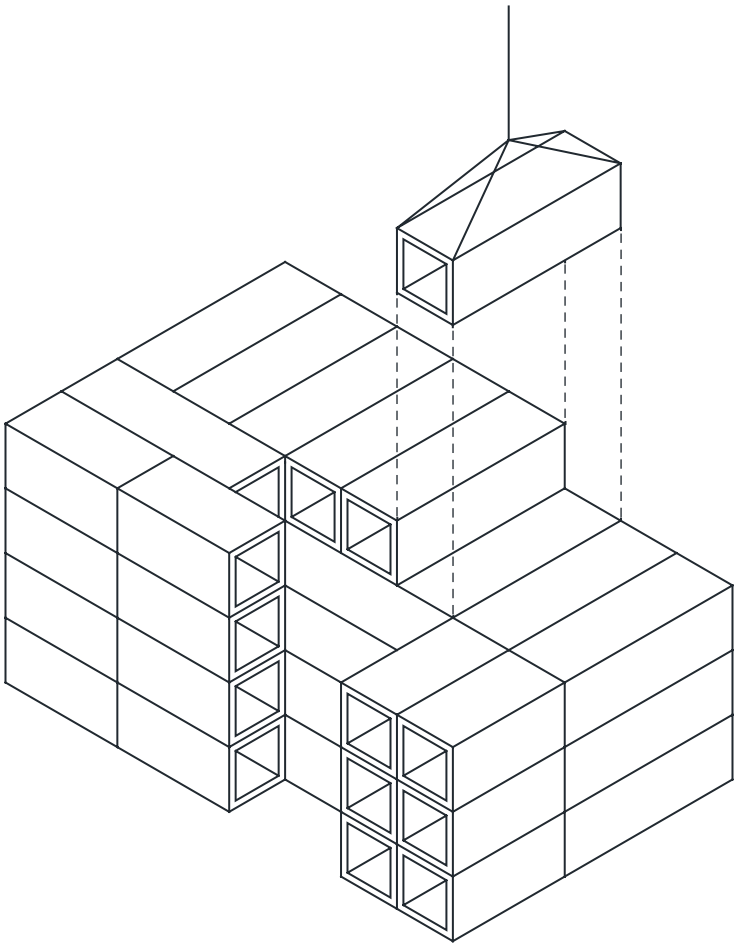


RESEARCH PLAN

MODULE+

TOWARDS AFFORDABLE AND QUALITATIVE STUDENT HOUSING

PAWEL ANDRUSZKIEWICZ
aE STUDIO | 2023

MODULE+

A WAY FOR AFFORDABLE AND QUALITATIVE STUDENT HOUSING

STUDIO

Architectural Engineering Studio
Design tutor: Anne Snijders
Research tutor: Pieter Stoutjesdijk
Argumentations of choice of the studio:

My interests in the field of architecture focus on two main aspects – the social role of architecture, as well as the implementation of new technologies to the design process. Architectural Engineering studio is, as I believe, the perfect place to combine these two areas. It allows taking a closer look into the contemporary social problems through the prism of the technical, engineering area of architecture.

TITLE

Module+
Towards affordable and qualitative student housing

GRADUATION PROJECT

KEYWORDS

Affordability, Computational design, Modular architecture, optimization, algorithm, timber

TABLE OF CONTENT

1. PROBLEM STATEMENT & RELEVANCE

1.1. HOUSING CRISIS

Home is one of the most essential and fundamental aspects of everyone's life. It have a physical, cultural, phenomenological or psychological dimension (Moore, 2000). As Appleyard (1979) claims, a home provides not only psychological comfort, but also social and the most basic physiological needs. On the other hand, Heidegger (1971, as cited in Bonnes & Secchiaroli, 1995), while speaking about dwelling, defines it as the most essential element of being "a human being in the world".

Considering this aspect, the growing housing crisis taking place in the Netherlands seems to be all the more serious. As Boelhouwer (2019) points out, providing enough houses is one of the most significant problems in the current Dutch housing market. According to data from a report by Capital Value (2022), the housing shortage is currently at 331,000 homes, while this number is projected to rise to 415,000 homes by 2024. On the other hand, as the number of available apartments decreases, there is a growing problem with their affordability. According to data provided by Statistica (2021), house prices have been on a steady upward trend since 2013 (Figure 1.). Furthermore, as CBS (2022) points out, house prices in the second quarter of 2022 increased by as much as 18.2% compared to the second quarter of the previous year, placing the Netherlands in the 5th place among the EU countries with the highest increase in housing prices.

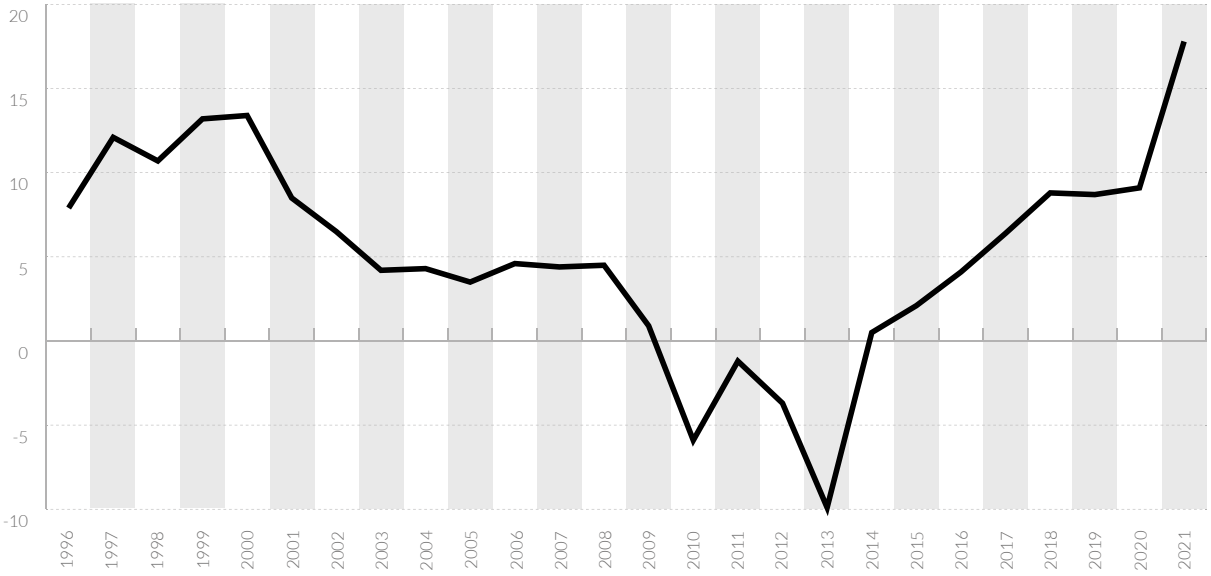


Figure 1. *Percentage change on previous year of housing prices in the Netherlands from January 1996 to August 2021. (CBS, 2022)*

1.2. TU DELFT STUDENTS

One of the group that is most acutely affected by the consequences of housing shortage and the decreasing affordability, are students. It is caused, inter alia, by their limited budgets and the decreasing number of available housing on campuses, resulting from the increased interest in Dutch universities (Savilles, 2021). One of the places facing this issue is TU Delft, which is one of the most popular technical universities in the Netherlands. While in 2019-2020 the student housing shortage in this place was estimated at 9%, it is expected that in 2026-2027 it will be as much as 24%. According to data from the municipality's report, by 2030 the shortage of student rooms in Delft will be between 5,260 and 6,111 units (Rijksoverheid, 2022). The average rent for a student apartment in Delft also has an upward trend. In 2021 it was as much as 15% more than in the previous year (Savilles, 2021). Moreover, according to the Savilles report (2021), a significant drop in the quality of student housing conditions is observed every year as well.

1.3. CONSTRUCTION COSTS & DENSITY

The lack of sufficient and affordable housing have many reasons – starting from political, demographic, economic or sociological variables. However, as the aim of this work is to look at this problem from an architectural perspective, it is crucial to focus on these reasons, which are directly related to the building environment.

According to Lawrence (2021), the most important causes of the affordable housing crisis directly related to the building sector are a significant increase in the prices of building materials and on-site construction works. Wallance (2021), on the other hand, draws attention to the high costs of transporting materials and construction equipment. As a result, the total construction costs in 2022 increased by 8.8% compared to the previous year, with the greatest contribution of building materials costs, which increased by as much as 13.8% (CBS, 2022). The reason why it is so crucial is the fact that the costs of materials, transport and site personnel account for as much as 85% of the total costs of traditional construction (Lawson & Ogden, 2010), which in turn, translates directly into the renting and purchasing price.

Another significant aspect is the dwindling land available for construction, especially in urban areas. It is particularly important in the context of the Netherlands, which has a relatively small area of land available for new investments (Lalor, 2022) and a high proportion of 3-4-story low-density historic dwelling (Centraal Bureau voor de Statistiek, 2022). In this situation, as emphasized by Balaji (2020), in order to meet the growing demand for new apartments, high-density housing seems to be the most promising option. Providing more units per acre, is not only crucial in the context of housing shortage, but also in terms of lowering the average cost for the single unit (California Planning Roundtable and California Department of Housing & Community Development, 2002).

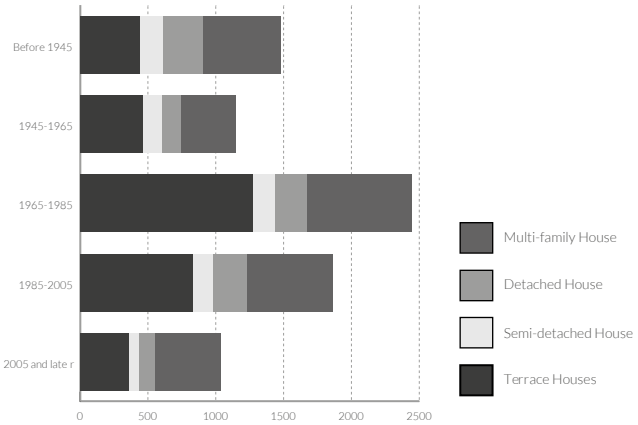


Figure 2. *Number of houses by type and year class. (Central Bureau voor de Statistiek, 2022)*

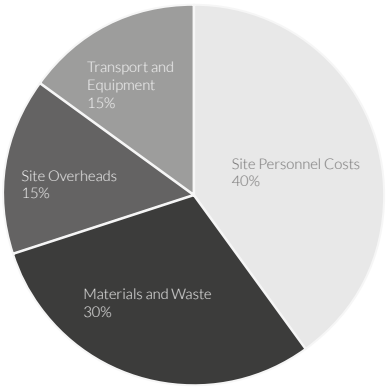


Figure 3. *On-site construction costs. (Lawson & Ogden, 2010)*

1.4. FINDING THE BALANCE

However, an attempt to increase the density of buildings and at the same time reduce construction costs, seems to be contradictory and very often leads to the significant decline in the quality of the living environment. In order to reduce costs and provide as many living units as possible, materials used in the construction are low quality, workmanship is less durable, while the program of such areas consists merely of cramped flats with minimal floor area and insufficient complementary functions (Bashir, 2002). Residential buildings designed this way, as Bashir (2002) emphasizes, have a highly negative impact not only on physical condition - through the use of cheap materials that are harmful to health - but above all, the mental and social well-being of the inhabitants. The general health and well-being is in turn the most fundamental feature, that a dwelling should provide (Molina et al., 2021).

Notwithstanding, the decline in the quality in the case of newly built affordable dwelling is clearly noticeable (Actieagenda Wonen, 2021).

Thus, in order to effectively and reliably approach the problem of the **lack of sufficient affordable and qualitative student housing in the context of TU Delft**, it seems necessary to take such steps, that would find a balance between the reduction of construction costs and creating high-density housing, taking into account the functional specificity of qualitative student housing.

1.5. TIMBER MODULAR ARCHITECTURE

Modular architecture, according to Wallance (2021), has a high potential in terms of reducing costs related to transport, on-site personnel and construction equipment. The use of modules also significantly reduces the construction time, while at the same time provides higher quality and accuracy than in traditional methods (Lawson & Ogden, 2010). Moreover, as Wallance continues, due to the relatively small spans in residential construction, the use of modules appears to be a highly effective structural solution.

In the case of dwelling, the use of timber as the main construction material seems to be particularly promising. Timber not only has a particularly high degree of prefabrication and precision, but also the lowest environmental impact among construction materials and positive impact on the indoor climate (Kaufmann et al., 2018). However, in order to take full advantage of the cost-reducing potential of modular technology, it is necessary to properly select the sufficient amount of material. This is dictated by the aforementioned drastic increase in material prices (CBS, 2022), as well as the costs associated with the necessity to use manufacturing machinery and factory infrastructure (Lalor, 2022). Therefore, the most essential aspect is to carefully and optimally select the material use for a single unit, as well as the entire building, taking into account the area and construction requirements related to the functional program (Kaufmann et al., 2018).

Figure 4. *Modular architecture - assembling the modular unit (Jocher et al., 2018)*

1.6. COMPUTATIONAL DESIGN

Thus, although modular architecture, as a technology in itself, solves the issues of on-site personnel and transport costs, it is still necessary to find a way of reducing material use while ensuring the greatest possible number of housing units, taking into account the qualitative functional program for student housing. In this regard, the use of computational design could be the most relevant.

Computational design is a tool that uses the algorithmic power of computer-through coding in problem solving, by complex geometric calculations, limitless iterations and rationalization (Fathi et al., 2016). Moreover, it allows for the creation of evolutionary multi-objective algorithms, enabling the optimization of the building design based on of specific, pre-defined requirements (Zani et al., 2017). In other words, the use of this particular technology, allows for a relatively quick generation of solutions that meet all the conditions specified by the designer. Therefore, taking into account the problem presented, it is possible to select such conditions that, based on timber modules, can allow to optimize the functional layout of student housing, finding a balance between maximum living units and minimal material use.

2. PROJECT OBJECTIVE

The overall objective of this project is to **provide affordable and qualitative housing for TU Delft students**, by combining computational design and timber modular architecture.

As the work focuses on the case of TU Delft, the campus, and more specifically its main northern part, would be selected as the design context. Enriching the program of this area with housing function could not only contribute to solving the problem of affordable student housing, but may positively influence the identity of the campus. As claimed by sociologists, the identity of a place is strongly correlated with the identities of people who use the space the most often (Dymnicka, 2017; Seamon, 2012). In other words, people treat a place where they live as a part of their own identity. Therefore, it might be a way to bring the TU Delft campus back to life and make it a true "living lab".

Within the overall objective, the research would focus on creating a **computational system based on timber modules, that would optimize the functional layout of the student housing**. The aim of this system would be to find functional solutions for student housing that will **maximize the number of living units while minimizing material consumption**. On the basis of the qualitative student dwelling program defined at the beginning of the research, modular typologies with precise parameters - optimal in terms of the required space and technological possibilities - will be created. Then, specific conditions that have an impact on the maximization of living units as well as the reduction of material will be selected and discussed. Their influence on the arrangement of the functional layout would be determined as well. The final result of the research would be an algorithm that will generate the most optimal functional solutions in the form of modules in terms of the number of available apartments and material consumption in a given location.

After the research phase, two locations within the northern part of the campus will be analysed - the space at the corner of Cornelis Drebbelweg and Leeghwaterstraat, and the parking lot at Van Den Broekweg. Then their site conditions and design capabilities would be determined and included as the parameters in the created algorithm. In consequence, the algorithm would serve as an analytical design tool, examining the potential of plots by generating the most optimal solutions for affordable and qualitative student housing in modular technology.

The generated solutions will constitute a reliable and clear starting point for an individual architectural project for affordable and healthy student housing in one of the areas. The final result of this work would be the design of a **dwelling for TU Delft students with complementary facilities, which is affordable and at the same time possesses features of a qualitative living environment**.

3. OVERALL DESIGN QUESTION

How can the use of computational design in combination with timber modular architecture contribute to the creation of affordable and qualitative dwelling for students on TU Delft Campus?

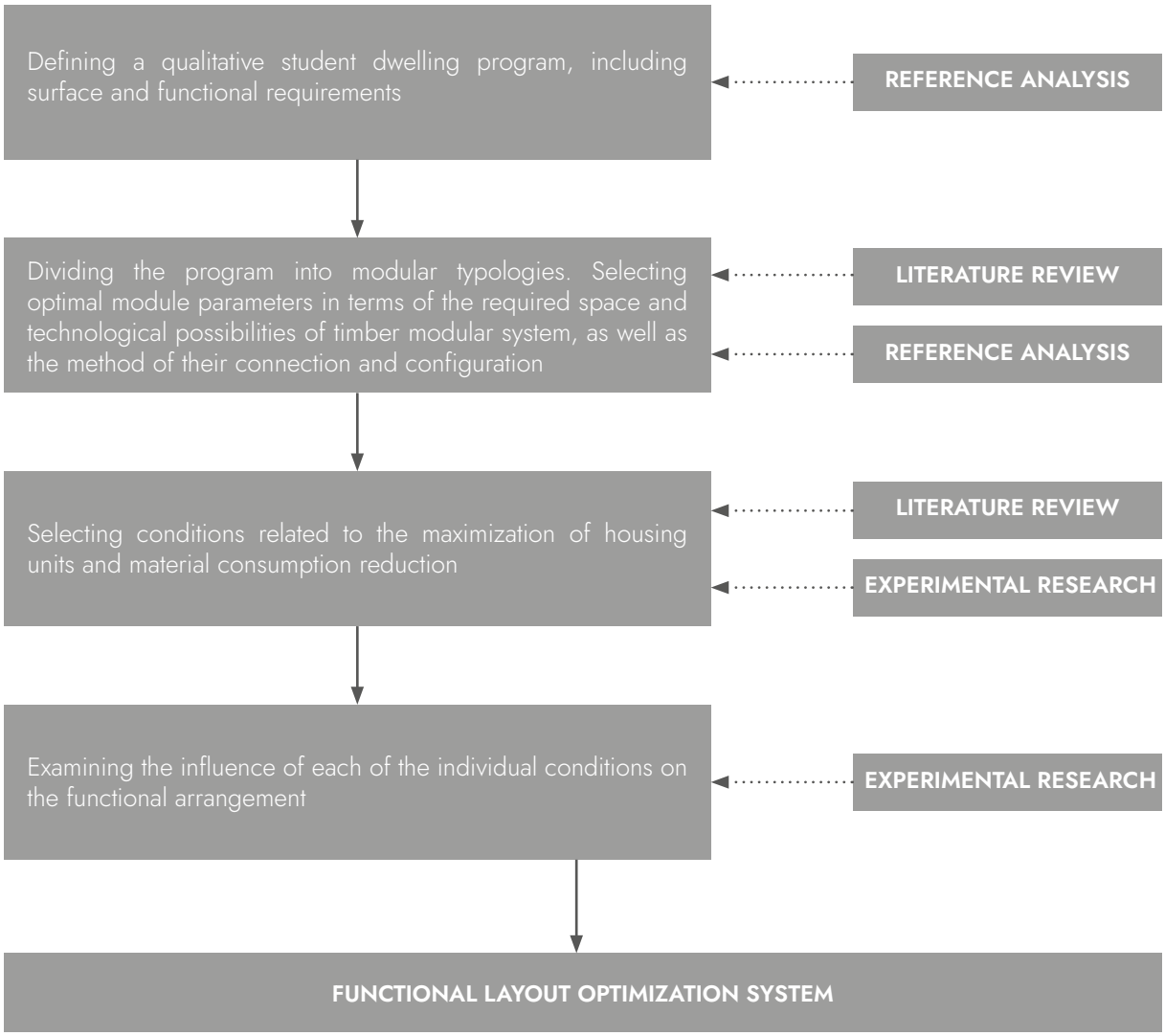
4. THEMATIC RESEARCH QUESTION

How could computational system based on timber modules optimize the functional layout of student housing, by finding the balance between the maximum living units and the minimal material use?

Sub-questions:

1. What does the functional program of student dwelling consist of?
2. What are the most optimal parameters of a timber module for student housing?
3. What conditions should the optimization system be based on?
4. How would each of the individual conditions affect the functional layout of the building?

5. THEMATIC RESEARCH METHODOLOGY



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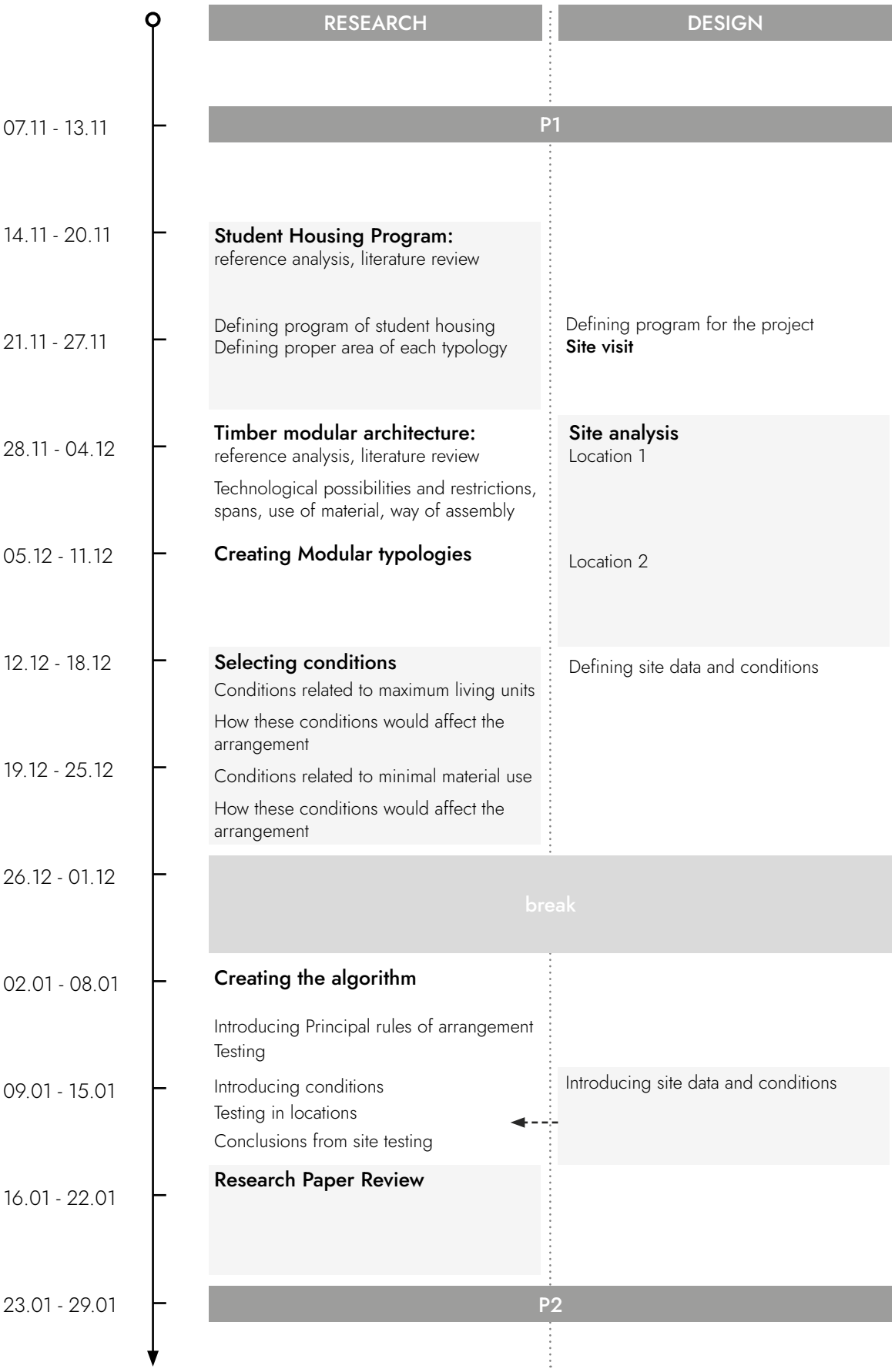
RESEARCH
DESIGN
07.11 - 13.11
P1
14.11 - 20.11
Student Housing Program:
reference analysis, literature review
21.11 - 27.11
Defining program of student housing
Defining proper area of each typology
Defining program for the project
Site visit
28.11 - 04.12
Timber modular architecture:
reference analysis, literature review
Technological possibilities and restrictions, spans, use of material, way of assembly
Site analysis
Location 1
05.12 - 11.12
Creating Modular typologies
Location 2
12.12 - 18.12
Selecting conditions
Conditions related to maximum living units
How these conditions would affect the arrangement
Defining site data and conditions
19.12 - 25.12
Conditions related to minimal material use
How these conditions would affect the arrangement
26.12 - 01.12
break
02.01 - 08.01
Creating the algorithm
Introducing Principal rules of arrangement
Testing
09.01 - 15.01
Introducing conditions
Testing in locations
Conclusions from site testing
Introducing site data and conditions
16.01 - 22.01
Research Paper Review
23.01 - 29.01
P2

BIBLIOGRAPHY

Actieagenda Wonen. (2021). *Samen werken aan goed wonen*. Retrieved October 23, 2022, from https://aedescms.getbynder.com/m/40d9069ce1416bc6/original/Actieagenda-Wonen.pdf

Appleyard, D. (1979). *Home. Architectural Association Quarterly*, 2, 4—20.

Balaji, K. (2020). RE: Habitat -Towards a new paradigm for high-density housing. *ICETDACE 2020,* 215—222.

Bashir, S. A. (2002). Home Is Where the Harm Is: Inadequate Housing as a Public Health Crisis. *American Journal of Public Health*, 92(5), 733—738. https://doi.org/10.2105/ajph.92.5.733

Boelhouwer, P. (2019). The housing market in The Netherlands as a driver for social inequalities: proposals for reform. *International Journal of Housing Policy*, 20(3), 447—456. https://doi.org/10.1080/19491247.2019.1663056

Bonnes, M. & Secchiaroli, G. (1995). *Environmental Psychology: A Psycho-Social Introduction*. London: Sage.

California Planning Roundtable & California Department of Housing and Community Development. (2002). *Myths and Facts About Affordable & High Density Housing*.

Capital Value. (2022). *Housing and residential investment market in the Netherlands 2022*. Retrieved October 10, 2022, from https://www.capitalvalue.nl/research/housing-and-residential-investment-market-in-the-netherlands

CBS. (2022). *Dutch house price increase among EU top five*. CBS. Retrieved October 23, 2022, from https://www.cbs.nl/en-gb/news/2022/41/dutch-house-price-increase-among-eu-top-five

CBC. (2022). *New construction homes*. CBS. Retrieved October 23, 2022, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/80444ned/table?fromstatweb

Centraal Bureau voor de Statistiek. (2022). *42 procent van alle woningen is een rijtjeshuis*. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/nieuws/2022/31/42-procent-van-alle-woningen-is-een-rijtjeshuis

Dymnicka, M. (2017). Tożsamości Miejskie [E-book]. In *Miasto, Przestrzeń, Tożsamość* (pp. 49—80). Wydawnictwo Naukowe SCHOLAR.

Fathi, A., Saleh, A., & Hegazy, M. (2016). Computational Design as an Approach to Sustainable Regional Architecture in the Arab World. *Procedia - Social and Behavioral Sciences*, 225, 180—190. https://doi.org/10.1016/j.sbspro.2016.06.018

Heidegger, M. (1971). *Poetry, Language, Thought*. London: Harper and Row.

Kaufmann, H., Krötsch, S., & Winter, S. (2018). *Manual of Multi-storey Timber Construction*. Reed Business Education.

Kences. (2021). *Grote tekort studentenwoningen afgelopen jaar weer verder toegenomen*. Retrieved October 23, 2022, from https://www.kences.nl/nieuws/grote-tekort-studentenwoningen-afgelopen-jaar-weer-verder-toegenomen

Lalor, A. (2022). *Why is there a housing shortage in the Netherlands? The Dutch housing crisis explained. DutchReview*. Retrieved October 24, 2022, from https://dutchreview.com/expat/housing/why-is-there-a-housing-shortage-in-the-netherlands-the-dutch-housing-crisis-explained/

Lawrence, P. (2022). *Rising Construction, Labor Costs Increase Rents, Contributing to the Affordable Housing Crisis*. Novogradac. Retrieved October 24, 2022, from https://www.novoco.com/notes-from-novogradac/rising-construction-labor-costs-increase-rents-contributing-affordable-housing-crisis

Lawson, R. M., Ogden, R. G. (2010). *Sustainability and Process Benefits of Modular Construction*, CIB TG57 - Ind. Constr., no. 354, pp. 38—51

Maasoumy, M., & Sangiovanni-Vincentelli, A. (2016). Smart Connected Buildings Design Automation: Foundations and Trends. Foundations and Trends®. in *Electronic Design Automation*, 10(1—2), 1—143. https://doi.org/10.1561/1000000043

Molina, G., MacGregor, C., Johnstone, M., & Donn, M. (2021). What is a comfortable home? — a definition developed from homebuyers' perspective. *27th Annual Pacific Rim Real Estate Society Conference*.

Moore, J. (2000). Placing Home in Context. *Journal of Environmental Psychology*, 20(3), 207—217. https://doi.org/10.1006/jevp.2000.0178

Rijksoverheid. (2022). L*andelijk Actieplan Studentenhuisvesting 2022 tot 2030*. https://www.rijksoverheid.nl/documenten/rapporten/2022/09/07/landelijk-actieplan-studentenhuisvesting-2022-2030

Savills. (2021). *Spotlight Student Housing 2021 - Housing Shortages*. Savills. Retrieved October 23, 2022, from https://insight.savills.nl/spotlight-student-housing-2021/housing-shortages/

Seamon, D. (2012). Place, place identity, and phenomenology: A triadic interpretation based on J.G. Bennet's systematics. In *The Role of Place Identity in the Perception, Understanding, and Design of Build Environments*, 3-21. 10.2174/978160805413811201010003

Statistica. (2021). *Percentage change on previous year of housing prices in the Netherlands from January 1996 to August 2021*. https://www.statista.com/statistics/593390/housing-prices-change-in-the-netherlands

Wallance, D. (2021). T*he Future of Modular Architecture* (1st ed.). Routledge.

Zani, A., Andaloro, M., Deblasio, L., Ruttico, P., & Mainini, A. G. (2017). Computational Design and Parametric Optimization Approach with Genetic Algorithms of an Innovative Concrete Shading Device System. *Procedia Engineering*, 180, 1473—1483. https://doi.org/10.1016/j.proeng.2017.04.310

Zawidzki, M., & Szklarski, J. (2020). Multi-objective optimization of the floor plan of a single story family house considering position and orientation. *Advances in Engineering Software*, 141, 102766. https://doi.org/10.1016/j.advengsoft.2019.102766

FIGURES LIST

Figure 1. Image by author. Information: CBC. (2022). *New construction homes*. CBS. Retrieved October 23, 2022, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/80444ned/table?fromstatweb

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Figure 3. Image by autohr. Information: Lawson, R. M., Ogden, R. G. (2010). *Sustainability and Process Benefits of Modular Construction*, CIB TG57 - Ind. Constr., no. 354, pp. 38—51

Figure 4. Jocher, T., Herrmann, E. M., Pawlitschko, R., Steiner, D., Hofmeister, S., & Jain, J. (2018). *Affordable Housing: Cost-effective Models for the Future* (p. 132). (1st ed.). Edition DETAIL.