RESEARCH PLAN

PERSONAL INFORMATION

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STUDIO

Name of studio: Architectural engineering

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Argumentations of choice of the studio:

TRANSFORMED INTO TRANSFORMABLE

TRANSFORMING INDUSTRIAL STRUCTURES INTO TRANSFORMABLE HOUSING SOLUTIONS

Keywords

Adaptability, Disassembly, Industrial, Transformation, Flexible, Housing, Temporary, Computational, Parametric design

GLOSSARY

This research plan and the following research contain numerous terms, the definitions of which may vary based on the source. To mitigate confusion and the need for repetitive explanation, a glossary has been provided. This glossary defines the terms according to the researcher's understanding and can be referenced at any point during the reading process.:

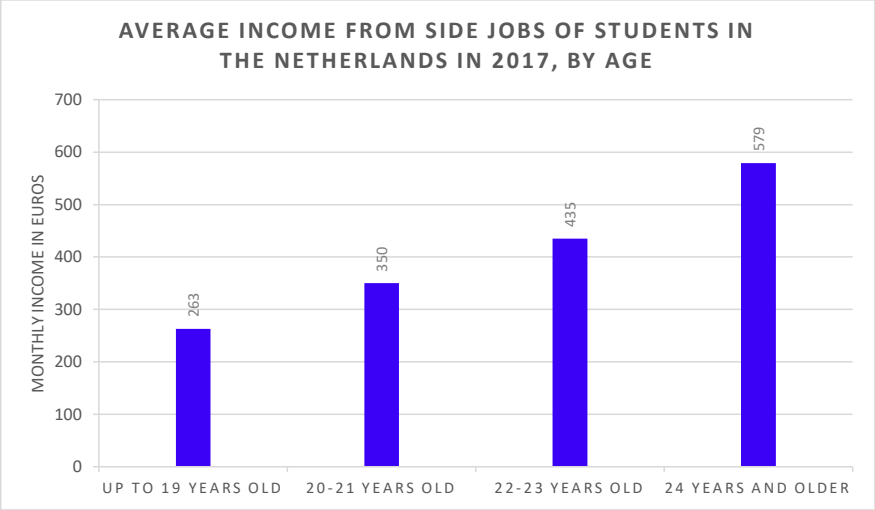
- **Flexibility** – quality of architecture to be capable of different uses without altering the building fabric. That means the interior or exterior space can be altered in response to external or internal stimuli without construction.
- **Transformability** – quality of architecture to be capable of different structural arrangements. Transformability accommodates changing functions through a certain amount of construction. It reduces construction cost and time by anticipating the potential future needs. Changes to the built environment that occur under transformability responded to larger time and spatial scales, yet remain modifiable in the future
- **Adaptability** – includes both flexibility and transformability and therefore reflects the capability of architecture to adapt to major and minor alternations reflecting changing societal, technological and environmental needs
- **Original structure** – unaltered exiting (industrial) building before any changes have been made
- Intervention – all parts of the new transformation design, including adjustments and permanent and temporary elements
- **Pre-transformation preparation** – major and minor alternations to the architectural quality of the building, resulting in the enhanced adaptability of the existing structure, but not including the new elements of the design
- **Hardware** – permanent part of intervention that enhances the building's structural potential for future adaptability
- **Software** – temporary/interchangeable parts of the intervention that allow for alternation/replacement based on the changing needs

GENERAL PROBLEM STATEMENT

HOUSING SHORTAGE

Currently Netherlands is facing a housing shortage leaving numerous demographic groups struggling to find affordable housing. The primary cause of this issue lies in the inability to provide an adequate housing supply, a problem originating from the 2008 economic crisis and the subsequent housing market reaction in 2013. This crisis is evident in the significant drop in housing availability. The situation has been further exacerbated by the rising number of new households due to immigration, intensifying the problem and causing a 3.2% increase in housing shortages in 2018. (Boelhouwer, 2020)

The problem of housing shortage is particularly acute among vulnerable demographic groups, including those without a stable income and lacking sufficient financial support, such as students. As of 2017, the average income of student with a side job was less than 600 euros, which is not enough to cover expenses and rent.(*Studentenonderzoek 2017*, n.d.) In 2022, house prices in the Netherlands surged by 18.5% compared to the previous year, placing the country among the top 5 in Europe with the highest increase in house prices. (CBS, n.d.)



TU Delft is a renowned university with a global reputation. Every year, thousands of students from around the world choose to pursue their education at TU Delft, in addition to the Dutch students studying here A spokesperson from the Universities of The Netherlands umbrella organisation recently said in the AD newspaper (in Dutch): “We are a very attractive country for international students because of the high quality of the universities. But the disadvantage is that the current high flow in some places is affecting the quality of the education and housing is highly problematic.”(de Bruijn, n.d.). The international influx however is not the only reason for the issue. Delft city is currently experiencing a deficit of 1,100 to 1,500 student rooms, a number predicted to rise to 3,600 by 2028, according to municipal projections. This shortage is not only unique to Delft; other large and medium-sized student

Met opmerkingen [AS1]: Add campus for companies not students
add municipality vision

Met opmerkingen [AS2R1]: Add rotterdam. Why there and not in delft

Met opmerkingen [AS3R1]: Add data on student housing in rdam

towns are also struggling with the housing.(de Bruijn, n.d.) These would include Haarlem, Leiden, Maastricht, Nijmegen and Utrecht.(*Housing Shortage Continues to Rise, Dutch Cabinet Launches Action Plan - Erasmus Magazine*, n.d.) Research conducted by Delta reveals a significant decline in the construction of student accommodations, especially in the past five years. Several factors contribute to this decline, including the high cost and limited availability of land, objections from local residents, and existing building commitments by cities, such as subsidized housing initiatives(de Bruijn, n.d.). The lack of affordable adequate accommodation in Delft forces students to look for options in the neighbouring cities, such as Rotterdam or Hague.

Additionally, on July 11, 2023, the executive board announced changes to Contours2030, the university's expansion vision. At least two new Bachelor and Master degree programs, namely Future of Health and Climate & Energy Systems Engineering, as well as Resilient Living Environment, are in development. The goal is to launch these programs in 2026. Moreover, TU Delft's ambitions extend beyond education; they will also focus on research and innovation. However, Delft cannot handle the pressure of these expansions alone. Therefore, a new campus will be established in Rotterdam to accommodate these developments.(*Contours2030 Update | TU Delft Student News*, n.d.). Expansion to Rotterdam means there will be an expectation to accommodate new students within the proximity of their educational facilities meaning that developing a student housing strategy for these students will soon become a priority.

INDUSTRIAL AREAS IN NEED OF REVITALIZATION

Adaptive reuse, the transformation of existing buildings, stands as a sustainable method for urban rejuvenation, prolonging buildings' lives, reducing demolition waste, promoting the reuse of embodied energy, and offering substantial social and economic advantages to society (Tam & Hao, 2019). The PBL has investigated the possibilities for housing construction within the city, compared to the regional housing needs between now and 2050. The study shows that there is still plenty of room for housing in the existing city, in currently vacant buildings and in underused areas. Assuming a high growth scenario (1.600.000 extra dwellings by 2050), almost 35% of the need for additional housing can be realized in vacant buildings and un(der)used sites in the existing city. In a low growth scenario, this is 75% (300.000 extra dwellings) of the total housing need. (Lianne Van Duinen et al., 2016)

Simultaneously, numerous buildings remain abandoned or underutilized, particularly in industrial areas. Initially located on the outskirts of major cities, these industrial areas have become central due to urbanization, necessitating strategic revitalization. The International Committee for the Conservation of the Industrial Heritage defines industrial heritage as the remains of industrial culture with historical, technological, social, architectural, or scientific value. These remnants encompass various structures such as buildings, machinery, workshops, mines, and social facilities related to industry (The Nizhny Tagil Charter for the Industrial Heritage, 2003). Many of these industrial buildings possess tangible and intangible values, qualifying them as industrial heritage(Arbab & Alborzi, 2022).

However, if these heritage buildings aren't adapted to current needs, they risk becoming vacant and deteriorating, endangering their historical value. Industrial areas possess the potential to transform into new cultural hubs, fostering cultural and social sustainability. Several examples in the Netherlands, like Strijp-S in Eindhoven and Amsterdam Noord, illustrate this potential. For cities like Rotterdam, industrial activity played a pivotal role in their development, imbuing them with significant identity

value(Nientied, 2018). Unfortunately, this identity is at risk due to underused industrial structures facing threats from profit-driven developments, neglecting the preservation of heritage and circular economy principles.(McCarthy, 1998)

SHIFT TOWARDS TRANSFORMABLE BUILDING DESIGN

In 1943, Winston Churchill made a profound observation in the Commons: "We shape our buildings, thereafter they shape us." This statement emphasizes the reciprocal relationship between architecture and society, highlighting how our designed environment influences our behaviour, attitudes, and overall well-being. As our society goes through changes and therefore the buildings that people occupy need to adapt to the changing needs of the society. This is referring not only to the general function of the building but also to the way we utilize the most basic function of architecture – housing.

In 2022, there were 198 million households in the EU, with an average of 2.2 members per household. The trend from 2009 to 2022 showed a decrease in the average number of individuals per household in 24 out of the 27 EU Member States. Estonia witnessed the most significant reduction, with a decrease of 0.5 members since 2009, followed by Malta, Romania, Latvia, and Lithuania, where the average household size decreased by 0.4 members. In the Netherlands, these numbers are equal to 2.2 in 2009 and 2.0 in 2022. Despite an overall increase of 10.3% in the total number of households in the EU from 2009 to 2022, single adult households (comprising only one adult, with or without children) experienced a much faster growth, rising by 29.6% during the same period. This growth was even more pronounced in single adult households without children, which increased by 30.7%.(Eurostat, n.d.).

The decrease in household size has a direct impact on the housing market economy. Single adult households, especially those without children, often necessitate more compact designs with fewer bedrooms. As the number of smaller households increases, so does the demand for smaller dwellings in the housing market. While there are logical explanations for the shrinking household sizes, mainly rooted in economic factors, it's important to note that this trend might change in the future, as the future remains unpredictable. And as such, forecasting the changing demands of the society is a complex task, forcing us to stay flexible and anticipatory. This unpredictability has been witnessed during the unforeseen pandemic that struck the world in 2020. While the immediate measures implemented during the pandemic have largely subsided, the lasting effects of COVID-19 on society and its relationship with work and home cannot be ignored. The shift towards remote work, coupled with the ever-deepening integration of technology into the daily lives, is undeniably transforming people’s perception of home and the dynamics within it.

Kronenburg defines adaptability as following: “Architecture that is designed for adaptation recognizes that the future is not finite, that change is inevitable, but that the framework is an important element in allowing the change to happen. Adaptable buildings are intended to respond to readily to different functions, patterns of use and specific users requirements” As such adaptability refers to the inherent capacity of a structure to flexibly respond to change. It involves accommodating diverse uses, facilitating various spatial and functional arrangements, and integrating new technologies and doing so efficiently and without causing substantial disturbance.(Kronenburg, 2007)

Jeremy Till and Tatjana Schneider define flexible housing as “housing that can adjust to changing needs and patterns, both social and technological. These changing needs may be personal (say an expanding

family), practical (i.e. the onset of old age) or technological (i.e. the updating of old services). The changing patterns might be demographic (say the rise of the single person household), economic (i.e. the rise of the rental market) or environmental (i.e. the need to update housing to respond to climate change)" (Till & Schneider, 2016)

Architects and designers must embrace adaptability and flexibility, concepts defined by Kronenburg and supported by Till and Schneider. Currently, architectural designs primarily cater to immediate demands, striving to fulfil them promptly. However, the built environment should strive for adaptability, being proactive in anticipating and responding to change. To achieve this, architecture must embrace adaptability, and housing should maintain its flexibility, ensuring effectiveness in evolving scenarios.

LIMITED APPLICABILITY OF PARAMETRIC DESIGN IN TRANSFORMATION PROJECTS

Architecture discipline has been evolving from its early age and with the arrival of computers, the discipline had to keep up. CAD became the first step to digitalisation of the practice. And while CAD empowered designers to ensure overall consistency by incorporating digital symbols or geometric primitives onto a digital canvas and managing CAD layers, it still was relying on solely architects judgment as the input to generate the output. (Tedeschi & Andreani, 2014)

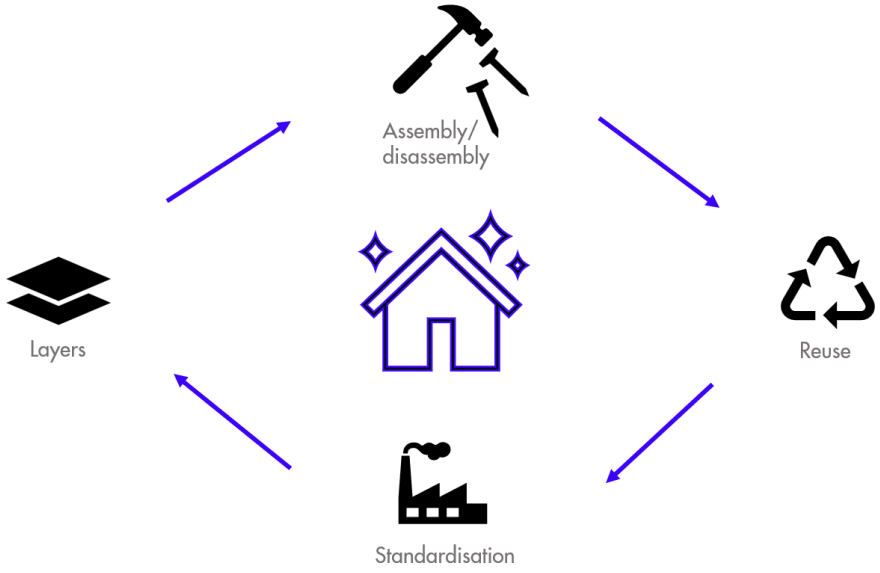
However, the architectural field continues to romanticize traditional design approaches, relying on intuitive thinking, drawing, and freehand modelling. This preference persists despite the vast computational capabilities available today, which could enable data-driven design within predefined constraints, guiding the parameters of new designs. Some argue that the parametrization process restricts the freedom of art of architects. Paradoxically, these constraints often result in designs that harmonize seamlessly with their context. Moreover, data-driven design optimizes resources and labour, enhancing workflow efficiency. If used wisely, it can streamline creativity and design exploration, given the generative power of the computers is much higher that of the human brain. Not only is this approach more practical on its own, but the resulting designs also become more feasible and relevant. Designs rooted in extensive data not only justify specific design choices but also allow for effective modifications if the input data changes. It is essential to recognize that parametrization is not the end result but rather a tool, ensuring designs align with actual conditions as reflected by the input data. The use of parametric design in transformation projects, particularly in crafting adaptable structures, remains largely unexplored.

OVERALL DESIGN OBJECTIVE [± 300 WORDS]

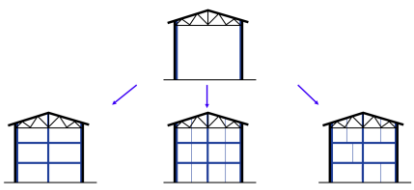
In this graduation project, the primary objective is to address the pressing issue of housing shortage in Delft and create innovative solutions for affordable and adaptable housing. The project's target area is Rotterdam, aligning with TU Delft's expansion vision, which involves establishing a new campus in Rotterdam. The focus is on transforming existing industrial structures, foreseeing the changing societal needs of the location.

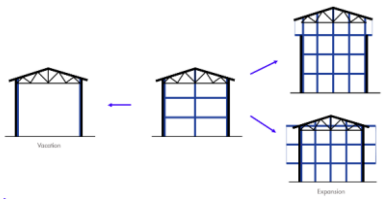
In the context of this project, adaptability, flexibility and transformability are the central themes. The project anticipates shifts in societal and environmental needs, influencing the way the architecture is being utilised. Despite the attempts to forecast the future, its uncertainty necessitates designs that allow seamless and efficient adaptation. Therefore – the key aspect of the project is to ensure the adaptability of the designed intervention on both macro and micro scales. This means considering significant architectural alterations at a broader level, while also foreseeing the necessity for flexibility at the individual user level.

An important attribute of the project involves developing an efficient solution to the housing shortage dilemma. This solution aims to offer immediate relief while more permanent housing options are being developed. The Dutch government's Flexwonen strategy serves as an inspiration, with its goal to establish 37,500 homes in temporary locations by 2024. (*Versnellen Tijdelijke Huisvesting | Home | Volkshuisvesting Nederland*, n.d.) This ambitious plan involves the creation of temporary housing systems and the transformation of existing buildings into residences. To this end, the investigated within this research strategies for adaptable architectural design advocate for streamlined production, layered design rapid assembly and disassembly, and the reuse of components. These practices underscore the undeniable feasibility and environmental advantages associated with temporary constructions. Extensive research will be conducted on the principles of flexible housing, ensuring that housing typologies can seamlessly adjust to the changing requirements of their inhabitants immediately and across generations.



Furthermore, the project emphasizes the untapped potential of existing structures. Instead of opting for demolition, these structures can be effectively transformed, especially in industrial areas where efficient building systems are often present. The key lies in designing these interventions to be highly adaptable, considering the inevitable changes in function and design. An important consideration is the extent to which the integrity of the existing construction is preserved and the footprint that the designed intervention will leave behind. Considering that the project foresees changes in the building's use, it becomes essential to address not only the possible expansion and contraction of the intervention but also the possibility of completely vacating the new structure from the original building. Depending on the pre-transformation preparation that will be required – the structural system of the original building would potentially have to be redesigned leaving a permanent imprint on the original building. The guiding principle in this decision-making process is twofold: to conserve the inherent value of the original structure while simultaneously enhancing it, thereby increasing its transformability and potential for future use.





OVERALL DESIGN QUESTION / DESIGN HYPOTHESIS:

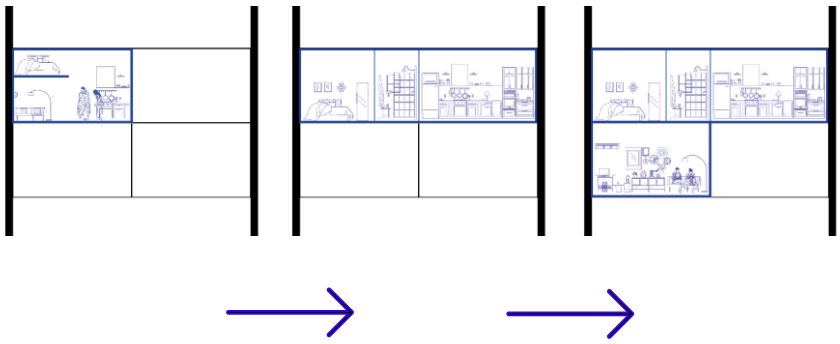
How can existing underused industrial structures be transformed into highly adaptable housing solutions, preserving the inherent value of the original building and enhancing its potential for transformability, while simultaneously ensuring adaptability of the new intervention in the face of evolving societal needs and environmental requirements?

REFLECTION ON THE RELEVANCE

The design question addresses the shortage of housing, which is a widespread concern impacting various demographic groups. The reason for that is that new residential projects take a long time to be realised. Prevailing housing shortage is challenged by creating a temporary housing solution that can become a strategy applicable in multiple contexts. The temporality of the solution corelates with the quick assembly and therefore making it exceptionally relevant as it provides immediate relief from housing pressure. The housing units can be deployed in available locations and the disassembled when no longer needed. Such housing solutions can benefit not only students but also refugees, the homeless, young families, and other vulnerable demographic groups.

The cities affected the most by this issue are the bigger cities which due to the historical context often have industrial areas that are in need of adaptive reuse development. The industrial structures that are in those areas are suitable for reuse as the often have open floorplans and tall ceilings. By aiming to transform existing industrial structures, the project not only touches upon the importance of heritage preservation, but also contributes to the developing of a circular built environment.

The project aims to research on transforming buildings in a way that ensures their easy adaptability in the future. By the incorporation of adaptable architectural elements, the research contributes to making the built environment more circular, reinforcing the project's commitment to sustainable and forward-thinking design principles. The outcome of the research will be a design strategy that results in creation of an easily and efficiently adaptable structure and therefore making the transformation not only more sustainable, but also more feasible.

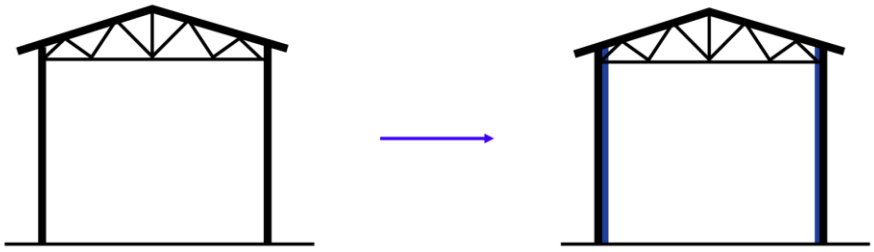


THEMATIC RESEARCH OBJECTIVE

The thematic research objective of this project encompasses a multifaceted exploration aimed at designing a highly adaptable and flexible intervention within existing industrial structures while preserving and enhancing their inherent value for future transformations. The research dives deep into the technical aspects of achieving adaptability and flexibility, evaluating existing adaptable architectural principles in the context of this design assignment. Additionally, the study delves into flexible housing principles, selecting those relevant and attainable through the identified adaptability principles. This exploration culminates in the formulation of a comprehensive checklist, serving as a design guideline for the intervention. The checklist acts as the foundation for evaluating the physical possibilities and constraints of the new intervention, guiding the definition and extraction of essential parameters crucial for the design process.

Subsequently, the study shifts its attention to the analysis and evaluation of existing industrial buildings, categorizing them based on their defining architectural features. Pre-transformation preparations are proposed for each building category, emphasizing the preservation o the original structure and exploring potential enhancement which improves future adaptability. An exemplary case study is selected to define constraining parameters of the existing structure, providing the contextual framework for the design assignments in subsequent phases. The systematic extraction of these parameters serves as a demonstration of the strategy to parametrize the transformation process. The selected case will be the context for the design assignment in P3 and P4.

The research objective seeks to bridge the gap between transformation strategies and adaptive architecture, addressing the fundamental cornerstones of circularity in the built environment. This project aims to develop a strategy that enhances the adaptability potential of existing industrial structures, ensuring that the new intervention remains adaptable in the future. To enhance the research's practical relevance, it not only offers a theoretical overview of the strategy but also demonstrates the practical extraction of parameters, facilitating the development of the design.



THEMATIC RESEARCH QUESTION:

What architectural strategies can be employed to develop an adaptable, flexible and transformable structure for an existing industrial space, while preserving the integrity of the original building post-dismantlement?

Sub questions:

- *What are the prevailing typologies of industrial buildings and how do these typologies constrain the possibilities of the transformation?*
- *How can permanent and temporary elements be utilised in a transformation of an industrial building that would result in creating of temporary and adaptable intervention?*
- *To what extend is the integrity of the building preserved?*
- *What are the future scenarios how the building can develop and which aspects of adaptable architecture are particularly important for the specific scenario?*

REFLECTION ON THE RELEVANCE

As the world is facing urbanisation and changing societal needs the architecture has to change too. We no longer can design buildings assuming that their design will be eternally static. Therefore the new architecture that we create should anticipate the inevitable change that is to come, the design is therefore mortal. However, the building can be seen as an everchanging and developing organism that grows on each land parcel. We cannot prevent it but we can make the process easier and more efficient.

By focusing on the transformation of an existing structure, the research contributes to the development of a circular built environment – utilising existing structure and materials as well as promoting social sustainability by revitalisation efforts.

From the scientific point of view the research is filling some of the knowledge gaps in the field. While the adaptive and temporary architecture has been explored, the integration of these school of thoughts within the scope of transformation projects still lacks research. Thanks to shared history of the industrial developments in Europe, the presence of the industrial buildings is also shared amongst the countries. The outcomes of this research can therefore be applied not only on a specific building, but also on the many other industrial buildings present in Europe. As the issues discussed in the problem statements are also prevailing in other parts of Europe, the research carries an immense value to rethinking the future of architecture.

THEMATIC RESEARCH METHODOLOGY

The methodology of this research is twofold, focusing both on researching the new intervention and the existing structure, ensuring that both parts result in a holistic guideline definition that can guide the design process in P3 and P4.

NEW STRUCTURE

Firstly a comprehensive understanding of adaptable architecture will be achieved through the literature study – this will involve understanding of the main principles that make architecture adaptable such as design in layers, design for disassembly, over-dimensioning for expansion and so on. The study of flexible housing will be part of the adaptability research – the study will focus on how can adaptable architecture principles can also be applied to create flexibility of the floorplan - allowing reorganisation of the building spaces in order to allow adaptability to different demographics. It is important to note that within the scope the this paper will build upon the existing extensive research that has been done on this topic. For each of the approaches, case studies will be conducted to understand the applicability of the approaches – their technological possibilities and restrictions, pros and cons.

Following this, the identified principles will be articulated into a comprehensive design checklist, providing essential guidance for the characteristics of the new intervention. , This checklist will then inform the primary and most extensive phase of the research, focusing on identifying possibilities and constraints. This will encompass material specifications, building systems, connections, dimensions, and other specifics. The outcome will be extracted parameters for the new structure, forming an integral part of the final strategy and design toolkit.

Given the inherent uncertainty of the future, a scenario analysis will be undertaken to explore potential trajectories for the building's development. These scenarios will undergo evaluation based on defined criteria, leading to the selection of the most desirable and probable scenario, hereby referred to as the goal scenario.

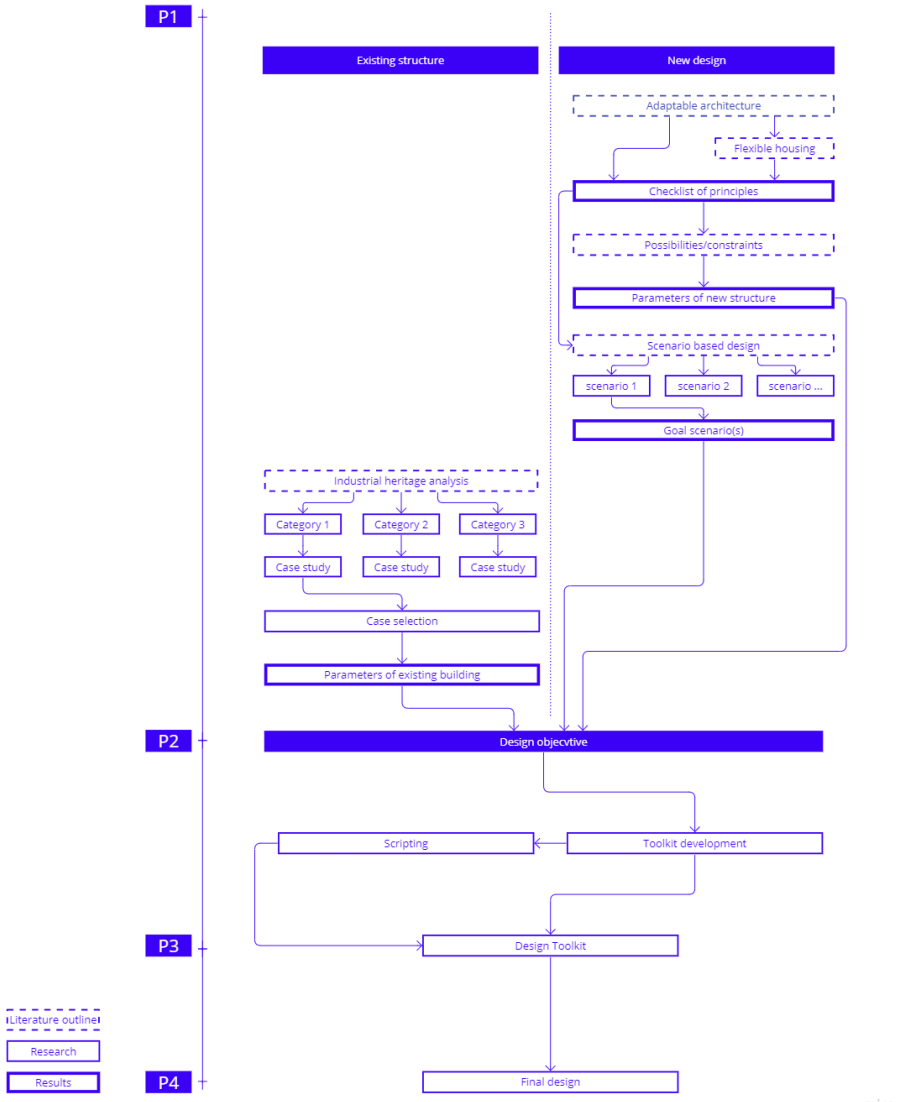
EXISTING STRUCTURE

Then the research will then delve into the context of industrial buildings, analysing and identifying common traits as well as typological differences. These classifications will be based on distinct architectural features such as high ceilings, windows, and flooring. For each category, specific case examples will be researched.

Considering the goal scenario, proposals for pre-transformation preparation will be developed for each category, including actions like removing floors, adding windows, or reinforcing the structure. An evaluation will be made regarding the permanence of the intervention. The objective is to minimize permanent alterations, ensuring that any intervention remains adaptable for future transformations. This assessment will test the needed permanent elements against the building's potential for future alterations, aiming to preserve the structure's integrity while enhancing its transformability.

Following the goal scenario, a selection of the exemplary case study will be made for in-depth examination within this research paper, which will also become the context for the design assignment. The constraints of the chosen cases will be clearly defined, and the building's parameters will be extracted. This parameter extraction process is a fundamental component of the ultimate research strategy.

METHODOLOGY & PLANNING



EXPECTED RESULTS OF THEMATIC RESEARCH AND DESIGN IMPLEMENTATION

The research phase will yield multifaceted outcomes. Firstly, a comprehensive exploration of adaptability principles will lead to the formulation of a design guideline checklist. This checklist, tailored to the selected goal scenario, will outline specific conditions that the new intervention design must incorporate. However, these conditions are inherently bound by physical constraints, encompassing materiality, dimensions, and other parameters, which will be identified and outlined. Concerning the industrial structures, a strategic framework will be proposed to guide the selection and evaluation process. The chosen existing structure will undergo detailed analysis, outlining the constraining parameters that will steer the subsequent design process. Within the design assignment, the permanent improvements to the structure can be likened to the “hardware” of the building, providing the foundational stability, while the non-permanent parts of the intervention is the “software”, representing the adaptable and changeable elements, will be “hooked” onto the permanent structure and can be modified and removed as needed. Ultimately, the research will provide clarity on how to technologically achieve the design goal – a new housing typology realised in an industrial building by designing a structure that incorporates permanent and flexible elements within the project, creating a highly flexible, transformable and overall adaptable architectural design.

LITERATURE REFERENCES

Within the research phase, literature will be studied to understand the expansive domains this project aims to connect: adaptive architecture and transformation projects. Specifically within adaptive architecture, the emphasis will be on outlining the evolving theories and principles. This will encompass concepts like Open Building, Design for Disassembly, and Design in Layers, among others. In this pursuit, a comprehensive array of open-source research papers and articles will be referenced to inform the research. Additionally, the research will be grounded in fundamental and recognized literature pieces. Kronenburg's seminal work, "Flexible: Architecture that Responds to Change," provides profound insights into the adaptability principles, offering a comprehensive understanding of architectural responsiveness. Similarly, Till and Schneider's "Flexible Housing" explores the multifaceted aspects of flexible dwellings, providing valuable theoretical frameworks that guide contemporary architectural practices.
With regards to the investigation of the industrial buildings, The Nizhny Tagil Charter for Industrial Heritage (2003) serves as a foundational document, outlining key principles for the preservation and adaptive reuse of industrial heritage sites.

Finally, the theoretical concepts explored will be grounded through several case studies, some of which will be detailed in the previously mentioned sources. This approach aims to provide a practical insight into how these theoretical principles manifest in real-world applications and provide deeper understanding of their practical implications.

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