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Abstract

While the conversion of industrial sites into residential spaces is a widely recognized approach to addressing housing shortages worldwide, the potential of this strategy remains largely untapped in Iran, where the industrial heritage, including grain silos, often receives minimal attention from both governmental bodies and private individuals. Despite the prevalence of abandoned grain silos in Iranian cities, the concept of adaptive reuse for housing remains virtually unexplored. A prime example of this neglect is the Hafezieh grain silo in Shiraz, a city renowned for its cultural, historical, and architectural significance on a global scale. However, Shiraz faces pressing housing challenges, particularly among its youth, exacerbated by economic and managerial issues.

In light of these circumstances, this thesis tries to investigate architectural approaches for repurposing the Hafezieh grain silo into housing. Moreover, it examines the question of which considerations should be considered to meet higher quality and lower costs through this transformation.

Regarding the methodology, the thesis is divided into two main parts: research and project. In the research section, the thesis investigates converting industrial buildings for residential use, focusing on the associated costs and quality. This part includes an extensive literature review using various sources such as articles, reports, books, and online materials. Additionally, three projects were selected as case studies to extract practical lessons, leading to the proposal of a framework that addresses key considerations for cost and quality in such transformations. The project section is centered on the Hafezieh grain silo. It starts with an introduction to the silo and examines the project's context from a broad country scale down to the building itself, detailing its typology, urban significance, historical background, and site analysis. Using insights from the research, the main concepts and vision for the project are developed and applied. This section outlines each step of the design process and concludes with detailed drawings and illustrations of the final design.

Keywords:

Adaptive reuse of Industrial sites, Grain Silo, Housing, Affordability, Quality of Life, Shiraz

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INTRODUCTION

Introduction

The initial inspiration for this thesis emerged from thinking about the potential of adaptive reuse of vacant urban spaces as a viable strategy to address the urban challenges and improve the well-being of citizens.

Today, housing provision has become a pressing global urban challenge, due to rapid urbanization along with an absence of a sustainable approach in the housing sector. According to UN Habitat Report, despite the fundamental human right to adequate housing, over a billion people are not adequately housed. (UNHABITAT, 2014) However, in countries like Iran, facing severe economic and political challenges, this issue is experienced even more acutely.

Adaptive reuse of abandoned buildings, on the other hand, presents a promising avenue for addressing the housing crisis while simultaneously contributing to a more sustainable built environment. This is validated by numerous successful transformation projects all over the world, repurposing existing buildings and structures for residential use.

With this background, the thesis aims to explore this potential by focusing on the transformation of a grain silo, located in a densely populated city in Iran, into a residential space.

Problem statement

Hafezieh grain silo as the city's first industrial building, holds significant historical value in the collective memory of the people of Shiraz. However, it has remained abandoned for over a decade due to functional obsolescence. Situated in the heart of Shiraz, the silo is part of a former industrial site that is now mainly used for administrative functions and company housing. some recent government initiatives aimed at revitalizing the site have not been completed which implies that the silo building still remains in its neglected state.

Shiraz, on the other hand, as Iran's fifth most populated city (Aboutalebi, 2018), grapples with significant challenges in the housing sector. The city's rapid urbanization and population growth have led to an increased demand for housing. The mismatch between the supply and demand in the housing market resulted in soaring property prices and a shortage of housing options.

In light of these circumstances, the transformation of the Hafezieh grain silo into a residential complex presents a promising solution. This adaptive reuse approach could serve as a win-win strategy by addressing the housing needs of citizens while revitalizing a vacant industrial building.

The transformation of industrial sites into residential spaces offers many opportunities, but it also faces challenges. Industrial buildings often have difficulties being adapted for residential purposes and providing the required qualities for a home. Additionally, this transformation is typically considered a costly process. Therefore, this thesis aims to explore various aspects that can improve the quality and reduce the cost of transforming industrial spaces into residential areas.

Methodology

The thesis is structured into two main parts: research and project. The research section explores two main topics: the conversion of industrial buildings for residential use, and the costs and quality associated with this conversion. Both topics were thoroughly discussed, and a comprehensive literature review was conducted using articles, reports, books, and online sources. Then, three projects were selected as examples to study and extract lessons from for implication into the project. At the end of the research part, a framework was proposed that includes the main considerations regarding the cost and quality involved in the transformation of industrial buildings to residential use.

The next part is dedicated to the project. It begins with introducing the Hafezieh grain silo, followed by exploring the context of the project from different perspectives, ranging from the country scale to the building itself. That describes the typology, urban significance, and historical background of the building and analyzes the site and silo. Based on this recognition and the outcomes of the research section, the main concepts and vision are developed and applied to the project. Each step of the design process is presented, and finally, the drawings and illustrations are shown.

PART ONE: RESEARCH

 

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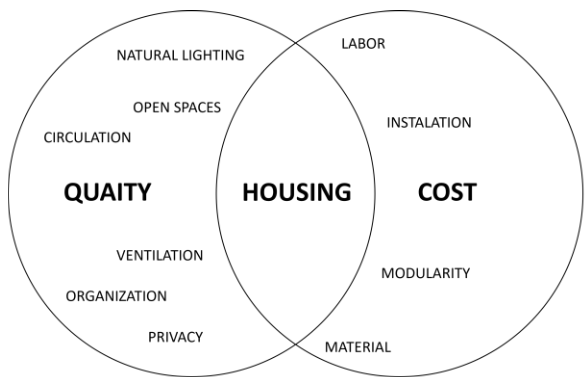

NATURAL LIGHTING
OPEN SPACES
CIRCULATION
QUAITY
VENTILATION
ORGANIZATION
PRIVACY
HOUSING
LABOR
INSTALATION
COST
MODULARITY
MATERIAL

Adaptive Reuse of Industrial Heritage for Housing Provision

Transformation of Industrial Sites

Our cities today hold the memory and presence of numerous buildings and sites that remain from industrial development while most of them have currently lost their functionality due to urban development.

Uymaz and Soyluk define industrial heritage as remains of industrial culture with historical, technological, social, architectural, or scientific values. This can include infrastructures, buildings as well as machinery and tools. (Uyumaz & Soyluk, 2023)

Over time, cities have witnessed many changes in their approaches to these remains and their development. A historical and theoretical review of the development of conservation theory regarding to industrial buildings by Karamustafa mentions the 18th century, onset of industrialization, as a starting point. This evolved align with progresses and developments in the industrialized world. Conservation efforts began in the early 20th century in Britain, leading to the emergence of the concept of industrial heritage. International initiatives such as the First and Second International Congress on Industrial Monuments and the establishment of The International Committee for the Conservation of Industrial Heritage (TICCIH) in 1978 broadened the scope of industrial heritage. Different guidelines were also introduced including the European Route of Industrial Heritage (ERIH) and the Charter for the Industrial Heritage (Nizhny Tagil Charter), providing a framework for the conservation, revitalization, and adaptive reuse of industrial buildings. They emphasize the importance of respecting historical integrity, authenticity, and tangible and intangible values while allowing for contemporary interventions. (Karamustafa, 2020)

In recent decades, however, adaptive reuse of industrial buildings has received considerable attention in both practice and theory of architecture and built environment. According to Aksoy this is because of a better understanding of their values, their importance in terms of cultural continuity, and their contribution both economically and functionally in urban development. (Aksoy, 2022) As cities transformed from the center of production to centers of consumption (Ma, Li, & Lan, 2023), these industrial buildings were left behind in the urban fabric and had lost their original function but still offer significant potential to contribute to urban development due to their embodied tangible and intangible values.

Housing Provision

Housing and its connection to other urban functions is a key factor for making a city viable. Hence it has been central in urban planning theory since the emergence of urbanization in the mid-nineteenth century. During the industrial period, the need for housing working class led to a very pragmatic way for housing provision. It consists of, as Plevoets & Cleempoel state "rapidly constructed barracks without any comfort or facilities in walking distance from the factories" (2019, PP. 57). However, during the next years, modern architects tried to improve this situation by building large residential complexes often on the outskirts of cities. Although some of these efforts such as le Corbusier's *Unite d'Habitation* in Marseille included community functions, the majority of post-war modern housing was characterized by their alienation from the human scale, separation of functions, and division of housing areas into income groups, and most of them lacked community facilities. This situation led to de-urbanization, with people moving to new housing estates and suburbs that offer more human-scaled, individual housing. During the whole of this period, the focus was on new construction with little or no attention to the improvement of existing dwellings. The process of re-urbanization has started since the 1980s in which redeveloping derelict areas and brownfields, renovating existing homes, and adapting non-residential buildings into residences, were some ways to provide comfortable housing in the city center. (Plevoets & Cleempoel, 2019, pp. 57-58)

Transformation From Industrial to Residential

Today, in addition to the renovation of existing residential spaces, the transformation of other types of buildings into housing plays its role in addressing housing provision. This trend started in the 1970s with the transformation of industrial buildings, such as warehouses or plants, into spacious apartments or lofts. (Plevoets & Cleempoel, 2019) During the 1980s and 1990s, as industries moved out of urban centers, vacant factories and industrial structures became an interesting subject for adaptive reuse offering large spaces that were suitable for conversation into residential spaces. From the late 20th century to the early 21st century, an increase of awareness about the importance of preserving cultural heritage gave new fresh meaning to the transformation of industrial buildings for housing that provides a new industrial-residential atmosphere to dwellings while maintaining historical significance. For instance, in the case of the Brewery Conservation Area in London, the transformation of the former Whitbread brewery into a mixed-use function including residential units has offered unique living spaces while preserving the buildings' historical character. (Corporation of London, 2000, pp. 3-4)

Sustainable and green architecture, especially from 2000 onward was also a driving force in promoting this trend. This was because of the considerable positive contribution of adaptive reuse practice on increasing environmental, economic, and social sustainability. It aligns with the principles of sustainable architecture by maximizing the use of existing resources, reducing environmental impact, and promoting the health and well-being of communities.

Today, the adaptation of former industrial sites into housing has become a frequent practice not only in vibrant metropoles but also, in smaller cities and towns. The type of these residential spaces has deviated from the initial loft concept and has become more diverse moving from traditional apartments, student housing, housing for the elderly, or more recently various types of collective housing. (Plevoets & Cleempoel, 2019, p. 64)

Opportunities and Challenges of Industrial to Residential Transformation

There are significant opportunities in transforming old industrial sites into residential spaces, although this process comes with its own set of challenges and obstacles.

To successfully undertake a reutilization project, it is crucial to have a comprehensive understanding of the potential benefits as well as the obstacles that may arise.

This can be viewed from different perspectives, including cultural and social values, environmental impact, functional and technical considerations, economic aspects, and regulatory and legal concerns, all of which will be elaborated upon in the following pages.

Social and cultural values

Adaptive reuse of industrial buildings contributes significantly to social sustainability. It provides a link to the past and contributes to the development of community identity. Therefore, it is important to consult with neighbors and engage the community for the ongoing effective reuse of industrial heritage (Heritage Council of Victoria, 2013).

This approach helps to preserve historical and social values for today's life as well as for the next generation (Yasmin, 2020). The embodied memory in these heritage buildings strengthens the sense of place and identity, which plays a role in urban regeneration. Moreover, reducing vandalism and crime, and enhancing the quality of life, can result from the increased sensitivity and attachment people feel towards their neighborhood through reuse projects.

Functional and technical considerations

Converting industrial spaces into residential spaces is challenging because they are primarily designed for products and industry, rather than for human habitation. For example, they often lack a human scale, proper lighting, and a welcoming atmosphere with its cold and rough materiality. However, with creative design that considers functional parameters, it's possible to create a unique living experience. As Heat points out, this transformation can only be effective if it considers all the specifics of these buildings to meet the needs of future tenants. (Heath, 2000) For these spaces to function effectively as homes, several criteria must be considered, including the spatial capacity of the building, natural lighting, functional organization, open areas, and communication possibilities. These Functional parameters can be categorized into five main groups: clustering, circulation, plan layout, outdoor spaces, and privacy. (Grozdanovića, Stoiljković, Keković, & Murgul, 2016)

However, it's essential to thoroughly assess the building before making any decisions to determine the best strategies. Reusing existing structures and installations, such as staircases, piping, and lighting, can reduce costs and maintain the building's character, but may also present challenges in terms of meeting new regulations and ensuring future safety and functionality.

Environmental Impact

Preserving existing structures has several environmental advantages. It can help reduce demolition waste, lower resource consumption compared to demolishing and rebuilding, and retain the building's embodied energy. According to the Australian Greenhouse Office, reusing building materials can save approximately 95 percent of the embodied energy that would otherwise be wasted. Additionally, when adapting industrial sites for reuse, there is an opportunity to integrate modern energy-efficient systems such as HVAC, insulation, and windows during the conversion process to enhance sustainability (Heritage Council of Victoria, 2013). However, contamination is a significant challenge in many industrial sites. Cleaning up can be a costly and time-consuming process, which may even lead to the suggestion of demolition in some cases. Therefore, it is crucial to learn from international examples and collaborate with heritage architects and specialists to identify key issues and cost-effective solutions.

Economic Aspects

Adaptive reuse of industrial buildings can offer significant economic benefits. The report "Making Heritage Happen: Incentives and Policy Tools for Conserving Our Historic Heritage" identifies a number of ways that heritage sites can contribute to sustainable economic development. Firstly, providing landmarks act as focal points for economic development and community identity. They strengthen the sense of belonging and social connection by reflecting on collective memory and shared history. The second contribution is tourism attraction which can be beneficial in different scales from the site to the city. Attracting people and investment by enhancing the amenity or 'livability' is another factor in enhancing economic sustainability. In addition, adaptive reuse creates proportionately more jobs than new construction and ensures better retention of local income. Moreover, besides the environmental benefits, the final cost of construction will be less through reduced demolition waste and reduced resources required to demolish and rebuild. (EPHC, 2004) On the other hand, the process of transformation of industrial sites is generally considered a costly project, especially in the initial phases. Therefore, the opportunities and risks of investment return should be examined through feasibility studies and managed with strategic planning. However, not all adaptive reuse is costly. Some highly effective, low-impact reuses can be achieved on extremely tight budgets. Economic constraints can also lead to creative reuse solutions that support the heritage aims of the project. (Heritage Council of Victoria, 2013)

Regulations and Legal Concerns

The regulatory framework can both facilitate and hinder the adaptive reuse of industrial sites and buildings. Zoning regulation and urban planning policies have to be considered carefully. The legal process itself can be time and energy-consuming, since transforming industrial sites into residential areas may require rezoning which needs governmental approval. There are also other codes and standards to meet including regulations on structural integrity, fire safety, accessibility, and health standards. However, as Wallenberg & Clark state, effective solutions to regulatory requirements would be the result of close collaborative working relationships between consultants, and with regulatory bodies. (Heritage Council of Victoria, 2013)

This cooperative approach ensures that all stakeholders understand each other's needs and limitations, leading to more practical and adherent outcomes.

Cost and Quality in Industrial to Residential Transformation

This section will discuss the various parameters that influence the quality of space and the cost of the project. These factors can be examined from different perspectives, depending on the scope of the study and the scale of the project. The cost and quality of residential projects both affect and are affected by various fields, including architecture, urban planning, environmental psychology, and sustainable development. However, this study will focus on the architectural design for adaptive reuse and strategies associated with the overall quality and cost in scale of the building.

Toward More Quality

Although the notion of quality frequently appears in architectural discourse and is broadly discussed in architectural practice, it is a concept that is challenging to define precisely. This is because quality can be a subjective matter, heavily influenced by cultural, geographical, historical, and individual backgrounds. However, as Amole states, the shared concept in previous studies is that quality is understood in terms of being 'closer' or 'further away' from the 'ideal'. More explicitly, 'closer' can be interpreted as 'better' quality. In this context, the 'ideal' can be based on certain standards that already exist in the form of data and codes, or it can be defined by users and individuals (Amole, 2008).

In the context of the built environment, quality can be approached and evaluated from different perspectives. For instance, it may be seen as the 'performance' of the project (Preiser, 1989), the 'habitability' of the space (Onibokun, 1974), the 'satisfaction' of users (Wiedmann and Anderson, 1985), or its 'acceptability' among individuals (Amole, 1989). Despite this broad background, it is still possible to identify commonly accepted factors that can enhance the quality of the built environment, based on studies and observations. For example, Golkar classified these factors into three groups: functional, environmental, and aesthetic (Golkar, 2000). Evans and Kantrowitz suggest two groups: internal and external factors (Evans & Kantrowitz, 2002). Bahmani and Rahmati identified four categories: physical, social, environmental, and economic considerations, which should be taken into account to increase the quality of a housing project (Bahmani & Ghaed Rahmati, 2016).

While considering previous studies, this thesis aims to focus more on transformation projects. To achieve this, the following section will highlight the considerations of housing quality in four groups: physical and structural quality, indoor environmental quality, aesthetic and psychological quality, and functional quality.

Physical and structural quality

The overall quality of construction and its components is one of the most important factors to consider (Golkar, 2000). This includes the durability of structural elements such as slabs and columns, construction components such as stairs and openings, and materials used in different parts of the building such as flooring, finishing, and covering.

Craftsmanship, attention to detail, and joints are crucial aspects that have a lasting impact on the building's life cycle. According to DBARK, quality workmanship involves the skill, care, and attention to detail that workers apply to their craft. This level of workmanship significantly affects the durability of construction throughout the building's life cycle. In adaptive reuse projects, this aspect is particularly important, as it contributes to meeting safety standards and reducing potential risks. (DBARK, 2024)

The harmony between the changes in construction and the existing conditions also needs to be considered, as alterations in structural elements can change the character of the building. (Uyumaz & Soyluk, 2023) Thus, in terms of physical measures, it's important to pay attention to the harmony between architectural requirements and the dimensions of the space. The depth, height, area, and form of the space should suit the function and also respond to new needs.

Indoor environmental quality

The environmental quality of spaces is important not only for providing people's satisfaction but also for their well-being and health. As stated by the Colorado Department of Public Health, poor indoor air quality, noise pollution, lack of lighting especially daylight, and insufficient heating and ventilation can lead to health issues, especially in children who live in such environments. (Colorado Department of Public Health, 2017)

Natural ventilation and lighting also play a key role in creating a high-quality indoor atmosphere (Aboulnaga & Elsharkawy , 2022) . That helps to connect people with nature and promotes a sense of relaxation and pleasure. Additionally, they are important regarding environmental sustainability which is a key factor in achieving a high-quality house. (OPR, 2007) They also reduce the need for artificial lighting and ventilation. Therefore, they contribute to minimizing energy consumption through climate-responsive strategies. For instance, this can be achieved by carefully considering the orientation and placement of openings, choosing appropriate window and wall depths, and paying attention to the size and characteristics of shading.

The next factor to be addressed is thermal comfort. As stated by Frontczak & Wargocki, for achieving overall satisfaction with environmental quality, creating a comfortable thermal condition is often considered the most important factor (Frontczak & Wargocki, 2011). To provide that condition various parameters should be considered such as air temperatures, mean radiant temperature, humidity, clothing, and user preference. (Jamaludin, Mohammed, Khamidi, & Abdul Wahab, 2015)

Aesthetic and psychological quality

According to Jevremovic, Vasic, and Jordanovic, “Seeing beauty in industrial buildings has been critical to their renovation” (2012, PP 83). They state the unique beauty of industrial buildings can be considered a key to renovation success as it pleases today’s modern eyes. (Jevremovic, Vasic, & Jordanovic, 2012)

While industrial buildings may not traditionally align with the perception of residential spaces, due to their materiality and neutral color atmosphere, this can be turned into an advantage by offering a new and unique experience of industrial beauty in living spaces. “The term “industrial aesthetics” can refer to the deliberate exposure of structural and mechanical elements as well as the repurposing of the objects of manufacture.” (Jevremovic, Vasic, & Jordanovic, 2012, PP.85)

Golkar mentions material, color, and spatial organization as key contributors to achieving visual pleasure, which plays a significant role in enhancing aesthetic and psychological quality. (Golkar, 2000) Other Important qualities are geometry, proportion, harmony, and order. (Vahdat Talab, Yaran, & Mohammadi , 2020)

Although these are general factors in creating more visually qualitative spaces, they should be approached with greater care in the context of the adaptive reuse of industrial buildings into residential projects, as people's perceptions of industrial beauty are more controversial. While some people find the materiality cold and soulless, making it unsuitable for living spaces, others argue that it is more artistic and modern. As Jeveromic explains, the beauty of industrial buildings was first appreciated by artists, and this eventually led to the trend of 'industrial chic' an interior style that uses exposed materials and details in a symbolic manner. (Jevremovic, Vasic, & Jordanovic, 2012)

When it comes to interior design, it's also essential to consider both the character of the building and the preferences of the users. While the overall design concept should be respected, there should also be room for users to personalize their own spaces and showcase their identity and preferences.

Functional quality

A key factor in providing functional quality is strategic circulation and accessibility since it has a key effect on the organization of spaces in the building. Natapov and Kuliga mention circulation as the key element to developing the layout of the plan. (Natapov & Kuliga, 2020). Therefore, it can contribute significantly to enhancing the occupant's experience. A thoughtful design and placement of elements such as stairs, elevators, and corridors are essential as they can enhance the user’s satisfaction by providing intuitive movement, seamless accessibility, and easy wayfinding. (Natapov & Kuliga, 2020) So, the decision about their size, number, and location should be made carefully to ensure efficient and logical circulation.

Optimal use of available spaces and efficiency of design also increases functional quality. That can be achieved by designing flexible areas which serve multiple purposes or they are adaptable to new needs with minimum effort. So, they not only maximize space efficiency but also respond to the changing needs of users in the future.

Another fundamental consideration is the zoning of different areas within a building. Nasr Esfahani notes that in today's Iranian architecture, the lack of proper zoning in residential spaces has negatively affected the sense of security, privacy, and functionality of these spaces. (Nasr Esfahani, 2016)

Additionally, functional zoning maximizes space utilization while minimizing disruption. Providing some examples, it is important to ensure related spaces, such as the dining room and kitchen, are placed near each other, or public and private spaces are separated suitably.

Toward Less Cost

The cost of adaptive reuse, as Isenia states (2022, PP.27), is commonly defined as “the total cost of adapting and delivering a building and includes the land and building acquisition cost, the hard costs (i.e., construction costs), and the soft costs (i.e., architectural and engineering fees, insurance, and permitting costs).” Previous studies generally state that the cost of adaptive reuse is comparatively lower than the demolition of an existing building and then constructing a new one from the beginning (Isenia, 2022, referencing to: Highfield & Gorse, 2009; Ball, 2002; Douglas, 2006). This reduced total cost mainly results from the reduced cost of construction and materials, with already existing roofs, walls, and floors. This saving can be greater if any part of the building, such as lighting, plumbing, heating, and services, is reused. However, this process is not always straightforward, as many factors can affect the total cost of the project. Previous research pointed out that costs can be significantly influenced by market factors, building conditions, and compliance with modern regulations. Specific challenges include high prices for skilled labor and traditional materials, extensive repairs in some cases, geometry issues of some historic buildings leading to unused spaces, quality of finishing, difficulties in specific material remediation, and unexpected events during construction (Isenia, 2022). The scale and typology of the project also play a crucial role in determining whether the total cost of adaptive reuse is higher or lower. In a comparative study in Canada analyzing the costs of heritage adaptive reuse versus new construction, the findings indicated that adaptive reuse is not always less expensive than new construction. For instance, in large residential conversions in Canada, the cost per square foot was significantly higher (44%) compared to new builds. In contrast, for large commercial conversions, the cost per square foot was substantially lower (38%) than building new. This was also true for medium-scale residential adaptive reuse projects, where the costs were lower (8%). (Shipley, Utz, & Parsons, 2006).

This background highlights the importance of considering the specific features and context of each project regarding the total cost. However, this study will mainly focus on the architectural factors that can help reduce it in general. To do so, it explores different aspects of industrial-to-residential adaptive reuse projects to find out how these kinds of projects could be less expensive.

Planning and management

To make the most out of any project, it is crucial to have clear and detailed planning followed by careful and effective project management. Particularly in adaptive reuse projects, as pointed out by the Heritage Council of Victoria, the conservation management plan and the master plan need to be budged for and invested in. They are essential to guiding the ongoing project. It is also important to conduct feasibility studies to explore options and opportunities. (Heritage Council of Victoria, 2013). Conducting thorough feasibility studies in the early stages identifies potential challenges that can be costly later. So, they can be avoided. As Douglas states Hidden costs arising during the project process are one of the challenging aspects of the adaptation scheme. (Douglas, 2006) However, considering the mentioned documents helps to maintain the budget as unexpected expenses and additional costs due to increased work time and labor costs will be avoided.

Value engineering is also an effective tool. That can be defined as “a professionally applied, function-oriented, systematic team approach used to analyze and improve value in a product, facility design, system, or service, a powerful methodology for solving problems and/or reducing costs while improving performance/ quality requirements” (JSVE 2005, as cited in Al-Yami 2005) It involves breaking down the process or product into its basic elements and functions and categorizing them. Then the alternative ways to perform these categories will be explored to meet more efficiency at a lower cost. (Investopedia Team, 2024)

Another part of management is efficient resource management. These resources include manpower, material, money, equipment, time, or space. (Moshin, Wiqar, & Fawad, 2019). That can contribute to the overall profitability of the project by minimizing the waste and optimizing the utilization.

In addition to the abovementioned factors, close observation and continuous monitoring of the process are essential to guarantee that it is progressing as expected and planned. In transformation projects, this becomes even more important, as Douglas notes, because there's a higher chance of facing unexpected challenges. (Douglas, 2006)

Architectural design

To emphasize the importance of design, Hamzah states “80 % of the construction cost was taken as soon as the design sketch was made”. (Hamzah, et al., 2011) Generally, a simple and straightforward design that requires minimal alteration and maximizes the usage of the existing layout and structure will definitely decrease the overall cost. This is also true for spaces and components like doors and windows, as well as details such as finishing and furniture. In a transformation project, all of these aspects need to be considered in the early stage of architectural design to save on demolition and new construction costs.

The organization of spaces and layout of the plan are key factors in achieving a high-quality house. (Colorado Department of Public Health, 2017) For this purpose, two important factors are zoning and circulation. Well-considered zoning can decrease several related costs. For instance, the cost of plumbing decreases by keeping wet areas like the kitchen and services close together. Similarly, energy costs can be reduced by designing in-between spaces for controlled and uncontrolled rooms, such as living rooms and terraces. An efficient circulation is also a key part of architectural design. Well-placed circulation elements such as stairs and elevators play a crucial role as they are fundamental in shaping the overall layout (Natapov & Kuliga, 2020). Therefore, they can contribute effectively to creating an optimized plan with maximum usable space.

Another important consideration is standardization and modularity. By incorporating standard and modular dimensions for spaces and components such as doors, windows, and fixtures, the project can take advantage of mass production and bulk purchases, reducing customization costs. Subramanya, Kermanshachi, and Rouhanizadeh pointed out that about 10%-25% of construction costs can be decreased by implementing modularization. They mention several factors which contribute to this lower cost such as reduced material transportation for on-site labor, the highly efficient installation of construction components, and saving on time and labor. (Subramanya, Kermanshachi, & Rouhanizadeh, 2020)

Incorporating architectural strategies to enhance the flexibility and adaptability of spaces is another factor that increases profitability. As emphasized by the Colorado Department of Public Health, designers should take into account both the current needs of future occupants and how those needs may evolve over time. (Colorado Department of Public Health, 2017) So, it's important to design spaces that can serve multiple purposes or be easily reconfigured. This approach reduces the need for additional changes and costs in the future.

Installation and building systems

Approximately, about 29% of the budget of architectural projects is spent on installations and facilities. (Kermanshachi, Safapour, Anderson, Molenaar, & Schexnayder, 2018) Similarly, in a transformation project, adapting, upgrading, or installing new systems for the building in a way that meets residential requirements and standards takes a considerable amount of the costs. However, there are several ways leading to a less costly project.

Firstly, to maximize the usage of existing situations, the potentials and conditions of existing installation should be explored to have the minimum alteration. Moreover, keeping the mechanical and electrical systems exposed when it is favorable aesthetically and functionally can reduce the cost of additional finishing. Moreover, that maintains the industrial character of the building.

Installation expenses can also be cut down by a well-designed plan. For instance, it can minimize the need for electrical wiring or plumbing by clever zoning and organizing of the living spaces.

Likewise, considering a sustainable approach and energy-efficient design strategies cause substantial savings due to reducing the need for artificial heating, cooling, and lighting (OPR, 2007). That includes providing natural lighting and ventilation through passive strategies such as appropriate orientation for the spaces, climate-responsive design of openings (in terms of placement, orientation, size, depth, etc.) as well as active strategies such as usage of renewable energies.

In addition to common factors, each building needs to be individually examined for its specific potential to be revealed. For instance, thick concrete walls, widely used in industrial buildings, can positively affect reducing the required energy to meet thermal comfort. These walls have high thermal mass, meaning they can absorb heat during the day and release it slowly at night. This helps in maintaining a balanced indoor temperature and providing a more comfortable living environment.

Construction

The major savings in an adaptive reuse project are related to the construction phase, as the structure is already there. "On average, adapting a pre-existing structure costs 16 percent less than ground-up construction and reduces construction timelines by 18 percent." (Feniak, 2022)

The amount of reduced cost is directly related to the changes required. The fewer the changes, the greater the savings. Therefore, it's best to use the existing structure as much as possible utilizing a thoughtful demolition plan. However, in case of required structural modifications such as reinforcing, adding or removing walls, or revising the building envelope, it is necessary to choose suitable construction systems and techniques. For instance, using prefabricated panels and lightweight materials can cut down on the cost by reducing the required energy, time, and labor.

Moving to material selection, this can be approached from different aspects to reduce construction costs. Recycling or reclaiming existing materials and components where feasible significantly cuts costs and is also more environmentally friendly. Uyumaz and Soyluk mentioned that adaptive reuse is a great opportunity for a cost and energy-efficient architecture. They argue that reusing existing material during a transformation project provides energy saving, sustainability, and economic benefits (Uyumaz & Soyluk, 2023). However, that should be considered in the reconstruction and dismantling phase to keep them usable and reduce waste.

Using cost-effective finishing techniques is also beneficial. For instance, incorporating exposed structure by keeping the raw appearance of materials such as bricks or concrete saves on finishing material costs while creating an industrial look. If new material is needed, it is better to consider local materials, which could be cheaper and economically more sustainable. Since it can reduce the cost of transportation and also improve the local economy. In addition, planning for bulk purchasing is helpful as it takes advantage of discounts, reducing per-unit costs.

From a broader perspective, the construction process itself can be managed and planned in a more cost-effective way. For instance, considering a phased construction process and incremental development allows the cost to be spread over time and reduces initial investment. Greene and Rojasi argue that incremental construction can make a significant contribution to solving the housing problem in Latin America due to its economic benefits. (Greene & Rojas, 2008)

By postponing the construction of non-crucial parts and upgrading them later, the expense flow is more likely to be manageable and controlled.

Income Generation Strategies and Financial Diversification Plans

Reducing the risk of return on investment and generating further income for the project can be achieved through the implementation of various strategies and plans. As Birkes says, in today's challenging economy, diversifying is a wise strategy for maintaining financial stability. (Birkes, 2023) These strategies aim to create direct or indirect incomes from different sources in the development process.

An important method is the integration of different functions for the building, such as residential, commercial, and public spaces. As Elsayed mentioned, mixed-use buildings are economically efficient and sustainable due to their financial benefits. (Elsayed, 2021)

This mixed-used development can increase the project's income. For instance, Commercial and retail spaces can be rented out to businesses and individuals, providing steady rental income. Additionally, the income from each function will vary. The rent price for commercial spaces is higher than for residential spaces, so incorporating this function leads to an increase in total rental income in a residential building. Providing public amenities and services is also an effective revenue-generating method. Offering public parking, gyms, and libraries provides a stream of revenue through membership fees or hourly charges for the use of these spaces. It is also profitable to design creative and multi-functional spaces depending on the particular potential and unique features of each project. These flexible spaces can be rented for various events like conferences, parties, wedding ceremonies, or even exhibitions, contributing to increased overall revenue.

Conclusion

The following tables show the architectural considerations that should be taken into account regarding optimizing cost and quality in adaptive reuse of industrial buildings into residential spaces:

Quality	Physical and Structural Quality	Durable Structural Elements
		Craftsmanship
		Attention to Detail and Joints
		Qualitative Material
		Harmony between New Design and Existing
	Indoor Environmental Quality	Ventilation
		Lighting
		Acoustic
		Thermal Comfort
		Environmental Sustainability
	Aesthetic and psychological quality	Color Scheme
		Material Selection
		Harmony
		Personalization
		Special Geometry
	Functional quality	Strategic Circulation
		Accessibility
		Efficient Design
		Zoning

COST	Planning and management	Feasibility Study
		Value Engineering
		Resource Management
		Process Monitoring
	Architectural design	Minimum Possible Change
		Maximum use of Existing
		Circulation
		Organization and Zoning
		Adaptability
		Modularity
	Installation and building systems	Maximum use of Existing
		Exposed System
		Well-Designed Plan
		Sustainable Design Energy-Efficient)
		Sustainable Design (Climate - Responsive)
	Construction	Minimum Changes
		Strategic Demolition Plan
		Suitable Construction System and Technique
		Material Selection
		Recycling / Reclaiming
		Careful Dismantling
		Local Material
		Cost-Effective Finishing Techniques
		Phased Construction and Incremental Development
	Income Generation Strategies and Financial Diversification Plans	Mixed-used Development
		Public Amenities
		Flexible and Multi-functional Spaces

Case Studies

In this section, relevant cases are explored to deepen understanding of similar practices. Then the lessons that can be transferable to my project are identified and applied in the design process as will be explained in the next chapters. The following written text is the author’s analysis of the projects according to the data provided in the mentioned references.

Grünerløkka Student House

Studentsiloen was originally built as a grain silo in 1935. Today, this silo transformed into a lively student housing complex offering 226 dormitories and apartments and stands as a remarkable testament to adaptive reuse in Oslo's Grünerløkka district. In this transformation, the layout of the plan and organization of spaces have been done in a way that fewer changes are necessary. Each bin is allocated to a room while the space between them provides room for services. New circulation is simple and straightforward. It perfectly adapted to the typology of dormitories with a corridor that passes through modular silo shafts and provides access to the student rooms. Regarding the character of the building, the façade is mainly retained despite creating openings to provide necessary lighting. However, openings have a standard organization and vertical shape, which is in harmony with the form of the bins. Moreover, to be respectful of the memory of the site, several artifacts were incorporated into the project, such as a gray grain tram that transported grain from Vippetangen to the mills and an old flour scale. Another important feature is the connection with the urban context. It perfectly benefits the potential of the neighboring park to increase the livelihood and vitality of the project by offering visually and spatially connected areas. These open spaces include places for socializing, gathering, and doing sports activities. Regarding interior space, the furniture has been specially designed to fit the circular space, taking advantage of standardization, modularity, and bulk purchasing. (Wikipedia, 2023) (HRTB, 2024)

Lessons for My project:

If the transformation responds appropriately to the new needs, minimal demolition can significantly reduce costs while helping to maintain the qualities of the industrial character.

Furniture design could be an effective tool that affects cost and quality.

Visual and special connection with urban context is a powerful strategy to increase the vitality of the site and improve its functionality.

Figure 1.Grünerløkka Student House, Oslo. Norway (Erden, 2018)

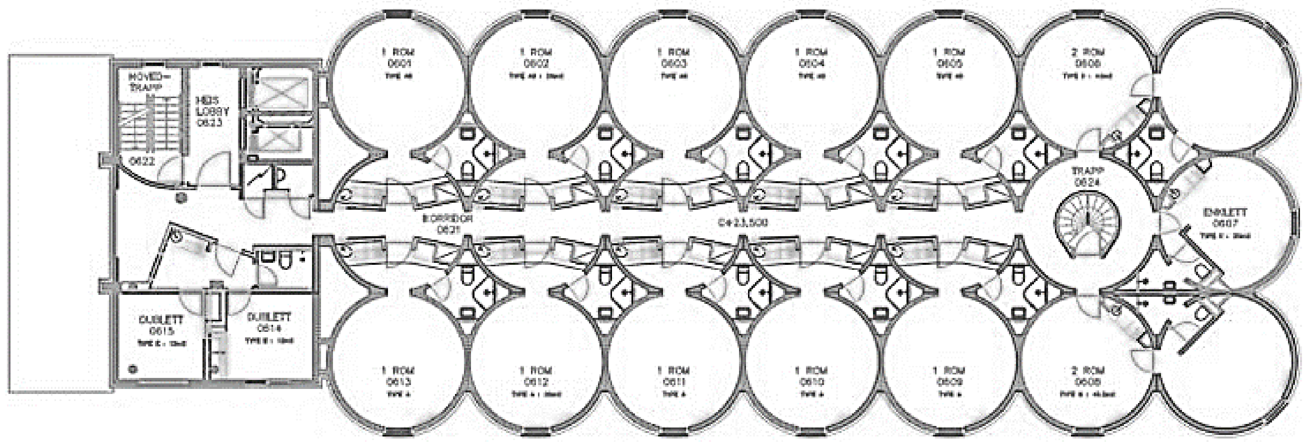


Figure 2.Typical Plan (Erden, 2018)

Figure 4. Interior space and furniture (Erden, 2018)

Figure 3. Exterior and public space (Wikipedia, 2023)

La Fábrica

La Fábrica is a former polluting industrial site that was transformed into a mixed-used project between 1973 and 1975, functioning as the headquarters of Taller de Arquitectura (RBTA) and the residence of the Bofill family.

In the initial configuration of the site, several buildings and elements, such as a memorable 105-meter-high chimney, 30 silos from the former cement factory, and large rooms dedicated to the machinery, spanned over an area of approximately four kilometers. However, in the transformation process, Bofil chose different approaches for different parts varying from selective preservation, demolition, and repurposing to creating his own architectural vocabulary to convey his ideas and concepts.

The project can be seen as a mixture of ideas and functions. It blends various architectural styles such as Catalan gothic, surrealism, abstraction, and brutalism, with echoes of both architectural postmodernism and critical regionalism. It is also a mixed-use complex for work and living.

Another formative feature of the project is the relationship between space and nature. The quality of the user experience is considerably enhanced by introducing gardens and green spaces. Wild vegetation with trees such as palms, cypresses, and olive trees, along with ivies hanging from the structures, create a harmonious integration of nature and the raw beauty of the industrial site. That also perfectly matches the required qualities for a residential project by its impact on enhancing air quality, providing pleasant shade, reducing noise, and improving overall visual beauty.

Regarding the interior atmosphere, La Fábrica is designed in a way that maintains the brutalist character of an industrial building and uses this quality to offer a new captivating repurposed work and living space. This is achieved by means of well-chosen materials, finishings, and furniture. All of them respond the future needs while simultaneously are respectful to the past character. Additionally, well-considered light and ventilation enhanced the quality of the interior environment. Spaces benefit natural lighting and ventilation significantly with generous high windows, suitable orientation and well-placed openings. (BOFILL, n.d.) (Leete, 2022)

Lessons for My project:

The industrial character of a silo is not only adaptable to various architectural styles but also can add significant value by offering a new experience of living space by introducing innovative special qualities.

Greenery and vegetation play an important role in improving the overall quality of spaces while simultaneously being able to convey a new meaning and concepts in harmony with the history and spirit of the project.

Figure 5. LA Fabrica site and building. (Keblog, n.d.)

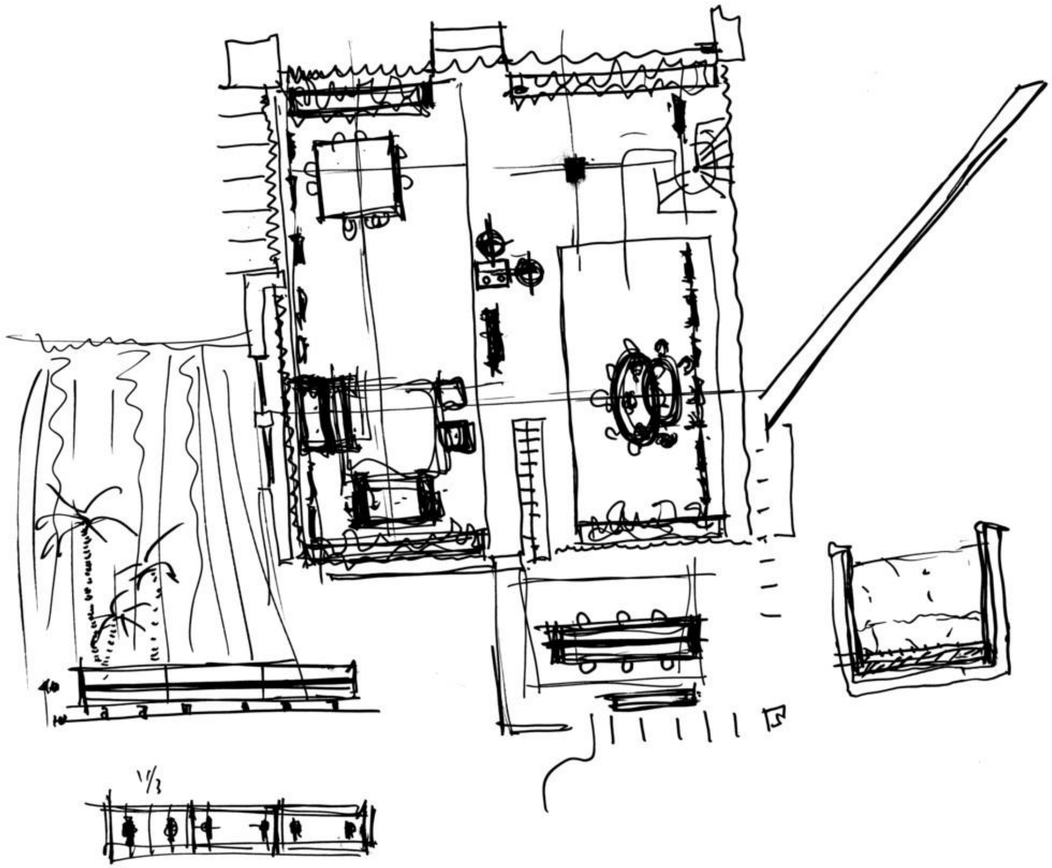


Figure 7. Sketches by Architect (Johnson, 2012)

Figure 8. Interior spaces of la fabrica (Keblog, n.d.)

The Silo

The Silo stands as a testament to the innovative transformation of a former grain silo into a multifunctional residential complex and public facility in Copenhagen's Nordhavn district. With a size of 10,000 square meters and spanning 17 stories, this structure serves as a focal point in the redevelopment of Nordhavn.

The original silo, a towering industrial landmark, presented a spatial challenge and opportunity due to its history of storing and handling grain. The architects, COBE, capitalized on this variability and created 39 unique apartments ranging from 73 to 305 square meters in size, with floor heights reaching up to 7 meters. The top and lower levels were intentionally designed for public access, ensuring a multidimensional experience for diverse users. (Cobe Architect, 2021)

One striking aspect of The Silo's transformation is its commitment to sustainability and heritage preservation. Emphasizing resource efficiency and environmental sustainability, a substantial amount of concrete, about 2,740 cubic meters, was reused. This repurposed concrete was incorporated into the landscape surrounding the building, transformed into seating and podiums.

The project significantly benefits from the combination of outdoor and indoor spaces with either private or public use. This is done by adding two elements: a metal façade draping the existing structure and a glass box on the top. The galvanized steel façade hosts traces in various shapes for the apartments. In addition, it completely matches the industrial past of the building with its metal material, rough beauty, and raw patina. A layer of insulation also served as the new building envelope, enhancing energy efficiency. likewise, introducing a new glass volume on the top of the silos provides notable outdoor spaces for a public restaurant and viewing platform with a glass façade offering a pangrammatic view over the city and sea. (Cobe, n.d.) (Slessor , 2017)

Lessons for My project:

Mixed-used development of industrial sites attracts diverse users and thus makes the project more active and efficient offering more options for experience or investment.

In the transformation of industrial buildings into residential, incorporating outdoor spaces can be an effective architectural strategy to positively impact the user’s experience. It can help with enhancing indoor environment quality, making room for new functions, and also improving the aesthetic quality of the project.

The reuse of existing material not only improves the environmental sustainability of the project but can also be seen as a source for supplying new elements and furniture.

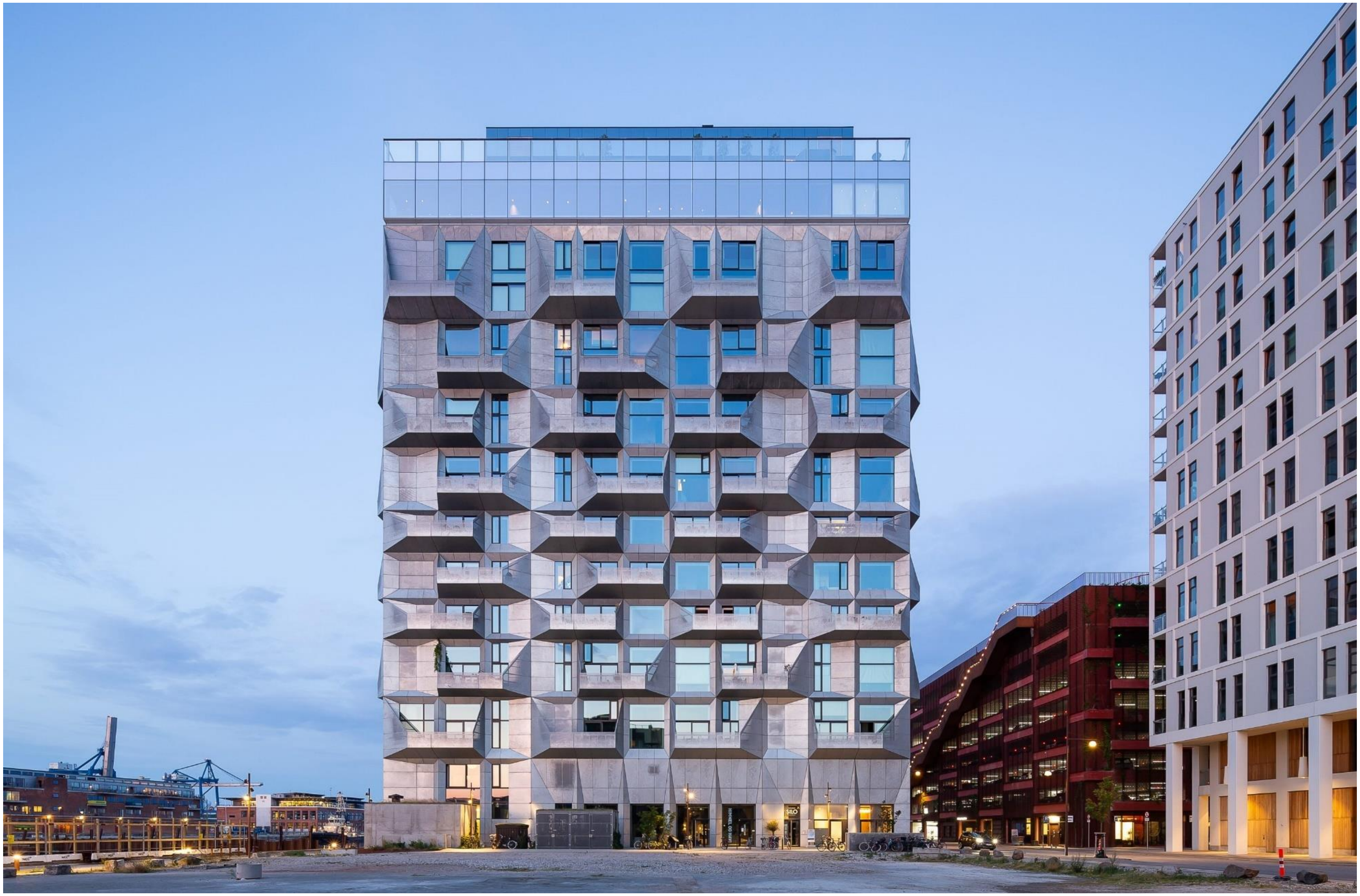


Figure 9. The silo by Cobe.Copenhagen, Denmark (Tukaj, 2024)

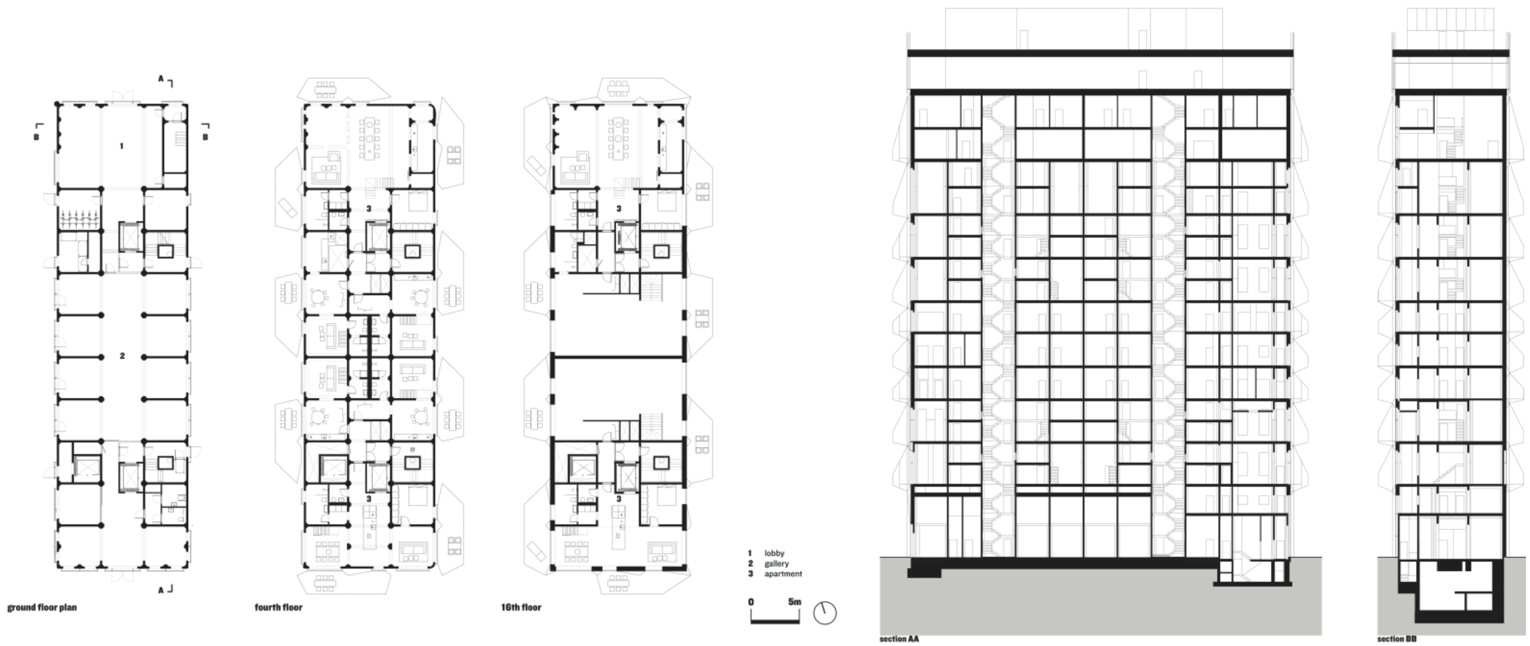


Figure 10. Drawing of the silo by Cobe Architect (Slessor , 2017)

Figure 11. Materiality and atmosphere of the interior and exterior (Cobe Architect, 2021)

PART TWO: PROJECT

Study & Recognition

Figure 12. Hafezieh Grain silo (by Narges Rasm, 2024)

Introduction of the project: Hafzieh Grain Silo

The 80-year-old grain silo of Shiraz is located in an industrial site with a 2000 square meters area. This building dates back to the Pahlavi era and stands as a reminder of the industrialization period in Iran with the vast construction of industrial buildings in major cities.

Construction of the silo started in 1935 under the supervision of German engineers during the first Pahlavi era. This was part of a nationwide initiative by the Grain and Bread administration to build a series of silos across the country. However, due to the departure of German forces during World War II, the construction process was stopped. Subsequently, Russian engineers took over and completed the construction in 1995 and the silo officially started to operate.

In 2001, the silo was abandoned due to climatic and functional issues. Although there have been recent initiatives by the government to revitalize the site, these efforts have not been completed, mainly because of financial and managerial problems. However, now only certain parts of the site, such as company housing and administrative areas, remain active. (Eftekhaar, 2017) (Aboutalebi, 2018)

Figure 13.Hafezieh Grain Silo (Mahdiun, 2018)

Understanding the Context: Industrial Heritage in Iran

In Iran, the adaptive reuse of industrial sites has not been a subject of much attention until recently. The first attention to the conservation of cultural heritage in Iran dates back to 1930 with the passing 'heritage law 'by the National Consultee Assembly. (Mahdiun, 2018) Despite this pioneer attempts and also a large amount of valuable architectural and cultural heritage in Iran, in reality, most of these heritage sites remained neglected, resulting in decay and even demolition in many cases. As Mahdiun stated, renewed interest in the preservation of industrial heritage started with the publication of 'Regeneration of cities, a Legacy for the Future' a book by Pirouz Hanachi and Mohammad-Javad Mahdavinejad published in 2010. Their book has taken initial steps toward introducing and recognizing valuable factories and industrial sites. Their efforts were succeeded with important contributions in the following years, such as the publications of Leyla Pahlavanzade including an eight-volume book named Iranian Industrial Architectural Heritage (2013), Restored Factories in Iran and World (2016) and Documents and Newspapers of Isfahan Factories (2013) . From a practical point of view, the process of conserving and reusing industrial heritage in the country strengthened simultaneously with increasing awareness about its importance among individuals and professionals.

In the following years, several adaptation and conservation projects started to introduce the possibilities and opportunities associated with industrial buildings regarding their economic, social, and cultural contribution to improving urban life. The most noticeable projects were the adaptive reuse of the Khosravi leather Factory in Tabriz to a part of the university campus (1997), the adaptive reuse of the textile factory in Shiraz to the Textile Art Gallery (2009) and the transformation of Match Factory in Zanjan to the museum of industry (2011). (Mahdiun, 2018)

This interest is increasing today but the situation still is not satisfactory mainly because of a lack of organizational support and encouragement. Given the number and significance of abandoned industrial sites in Iran, initiatives by governmental bodies or individual architects are not considerable yet and there is a long way to go to use their potential for the development of Iranian cities.

A Specific Typology: Grain Silo

Grain silos, with their pure geometrical shapes and impressive volumes, serve as examples of industrial buildings. The origin of grain silos dates back to ancient times when people built sheltered structures to store goods such as raw materials and food (Karamustafa, 2020). The early cases in Mesopotamia and Egypt were primarily functional, lacking any design considerations. However, over time they evolved from simple grain pits to the modern grain silos we know today, influenced by climatic, environmental, economic, and social conditions. (Giuliani, et al., 2018) Modern silos appeared in the 19th century (Uyumaz & Soyluk, 2023) , driven by the demand for larger and more efficient storage due to increasing agricultural production.

Karamustafa cited the emergence of reinforced concrete in 1899 as the most important contribution to the development of these high-rise buildings (Karamustafa, 2020). During this period, basic design elements aimed at improving functionality began to be incorporated, such as sloped floors for easier grain removal. As stated by Giuliani, in the early 20th century, they were admired by leading members of the Modern Movement, from Walter Gropius to Le Corbusier and Erich Mendelsohn (Giuliani, et al., 2018). In fact, with their functionality, aesthetics, and use of new materials like steel and reinforcement concrete, they could be seen as symbolic representations of modern architectural values, reflecting the spirit of their time. Nevertheless, by the 21st century, many silos became abandoned. This was because of changing shipping routes (bursa 2018) and urban development resulting in a mismatch between them and new urban fabric. Additionally, new technologies and agricultural progress introduced more effective typologies like steel silos. As a result, traditional silos with their giant monumental structures remained in the city fabric while losing their function.

In Iran, the construction of the first modern grain silo began in 1935 when Reza Shah Pahlavi, the king of the time, decided to build seven silos in major cities across the country to manage bread consumption and store necessary grains. The first silo was completed in 1939 in the capital, Tehran. (Aboutalebi, 2018) Hafezieh grain silo, built between 1935 and 1955, was another example in Shiraz. However, like other places around the world, grain silos in Iran also faced functional and architectural obsolescence, leading them to become vacant. Nevertheless, the transformation of these industrial structures for new uses could be a solution to revitalize these buildings and reintroduce them to urban life. Regarding the conservation and adaptation practices in Iran, grain silos, specifically, deserve even more attention as there is not a single example of adaptive reuse of a grain silo in the entire country, despite the many silos in cities that holds significant potential for contributing to urban development.

However, adapting this typology for new uses is more complicated than repurposing old office buildings or factories due to their specific characteristics, such as being windowless, the height, and having only one ground floor (Erden, 2018). The concrete construction and form made interventions more challenging, and its unconventional layout requires more creative design solutions for new programs. On the other hand, this cylindrical form and the aesthetic features of these buildings can inspire the creation of captivating interior and exterior spaces with curved walls and interesting volumetric configurations.

The architecture of a grain silo serves as a perfect example of principles of 'form following function 'as their design elements, from shape and material to the ventilation and lighting, directly influenced by its primary purpose: storing and preserving grain. This function-driven approach not only optimizes the performance of a grain silo but also contributes to its distinctive aesthetic character. According to Carson & Jenkin, the design of a grain silo is shaped by three main aspects: the stored material, geometric design, and structural design. (Carson & Jenkin, 1993). Each material requires specific conditions and design for proper maintenance and operation. For instance, providing suitable temperature and ventilation, as well as ensuring a smooth movement related to size, is necessary in a grain silo building. The geometry of the silo affects its usable capacity and the way material moves within it. For this reason, the rectangular and square silos evolved mainly to cylindrical forms. The structural design is also crucial, as the silo must withstand considerable pressure and stress on its walls and floors. (Carson & Jenkin, 1993)

Figure 14.World's largest reinforced concrete silo with a capacity of 275.000 tons located in South Africa (Karamustafa, 2020)

Urban Context

Hafezieh grain silo is located in the historic city of Shiraz in the southwest of Iran. Dating back to 2000 BC and ranking as the fifth-most populous city in Iran (Karimi, 2022) , it holds significant importance within the country renowned for its rich cultural heritage, ancient landmarks, and poetic legacy.

According to the latest census conducted in 2016, the city is home to 1,609,615 people and covers a total area of 217 square kilometers. Regarding Geographical features, Shiraz is situated at an elevation of approximately 1,500 meters above sea level in the Zagros Mountain range, resulting in a moderate climate and pleasant weather during most time of the year. (Shiraz Municipality, 2018)

In recent decades, Shiraz has undergone rapid urbanization and development, resulting in the expansion of its infrastructure and population growth. The city's urban fabric is a mixture of traditional and modern architecture, with historic neighborhoods coexisting alongside new residential and commercial developments.

The silo site is located in district three which is the historical core of the city. This district spans 17.44 square kilometers and is home to approximately 165,000 people. Situated in the northern part of Shiraz, it holds a unique position within the city due to its distinctive landscape, rich cultural elements, and historical heritage sites. (Eftekhar, Ekhtiari, & Taheri Shahraeini, 2019)

SHIRAZ CITY

AN ANCIENT CITY WITH RICH CULTURAL HERITAGE
IN MILD CLIMATE OF SOUTH OF IRAN

DISTRICT

CULTURAL AND HISTORICAL DISTRICT
NEAR ONE OF THE MAIN URBAN AXES

SILO SITE

FIRST MODERN INDUSTRIAL SITE

Figure 15. Location of the Silo Site in different scales, by Author

The site is located along the main axis of the city, known as Darvaze-Ghoran. This urban axis plays a key role in shaping the characteristics of the area. It extended from Darvaze-Ghoran Entrance Gate to Hamze-ben-Ali Tomb, both of which are important historical and architectural heritage of the city. The Darvaze-Ghoran Axis also holds considerable importance in the collective memory of the people of Shiraz as it functioned as the trading route between Shiraz and Isfahan and was also part of the northern City-Gardens. This route and its associated gardens are frequently cited in historians' explanations and tourists' travelogues as a vital area of the city with a unique and pleasurable atmosphere. (Rasm, 2022)

Figure 16. Darvaze-Ghoran, Old Paintings (Akbari Parsa, 2020)

In terms of architectural and socio-cultural richness, the area is home to several significant urban landmarks, including the Hafezieh Tomb, Jahan-Nama Garden, and Bagh-Melli Garden, which are pivotal points within the city's urban fabric

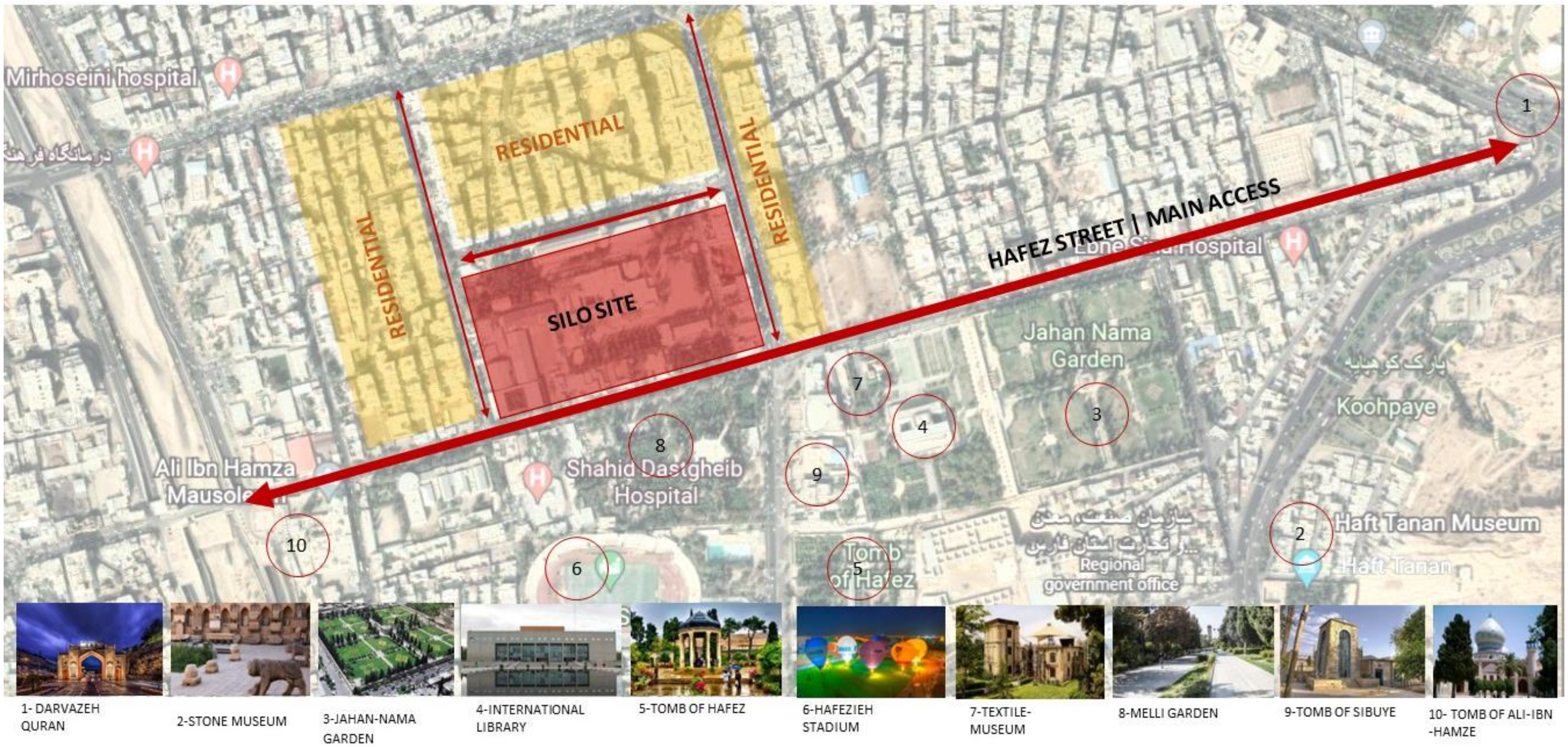


Figure 17. Urban Fabric and Landmarks in the Area by Author

Historical background

"The city gate leads to a very beautiful street that is narrow and long. Its width is 50 feet. There are gardens on both sides of this street, each of which has a side of 200 feet towards the street. Each of these gardens has a magnificent entrance and entrance, which are placed opposite each other on both sides of the street, creating a beautiful shape." A quote by Chardin (Rasm, 2022, pp. 21 , translated by author)

According to descriptions in travelogues by Jean Chardin and Jean-Baptiste Tavernier, and also the remaining photos and paintings, the grain silo site used to be a part of the city's Gardens which were known as Safavi's Charbagh. (Aboutalebi, 2018) As mentioned before this street was one of the most important routes of the city before and after its development. First as a part of the trading route between Shiraz and Esfahan and then as the first street of the city. Although, over time, it witnessed changes, the People of Shiraz still recall this street and its garden as a significant part of their collective memory. The remaining parts of these gardens such as Jahan-Nama and Melli Garden, still play their role in the life of Shiraz citizens as active and alive public spaces.

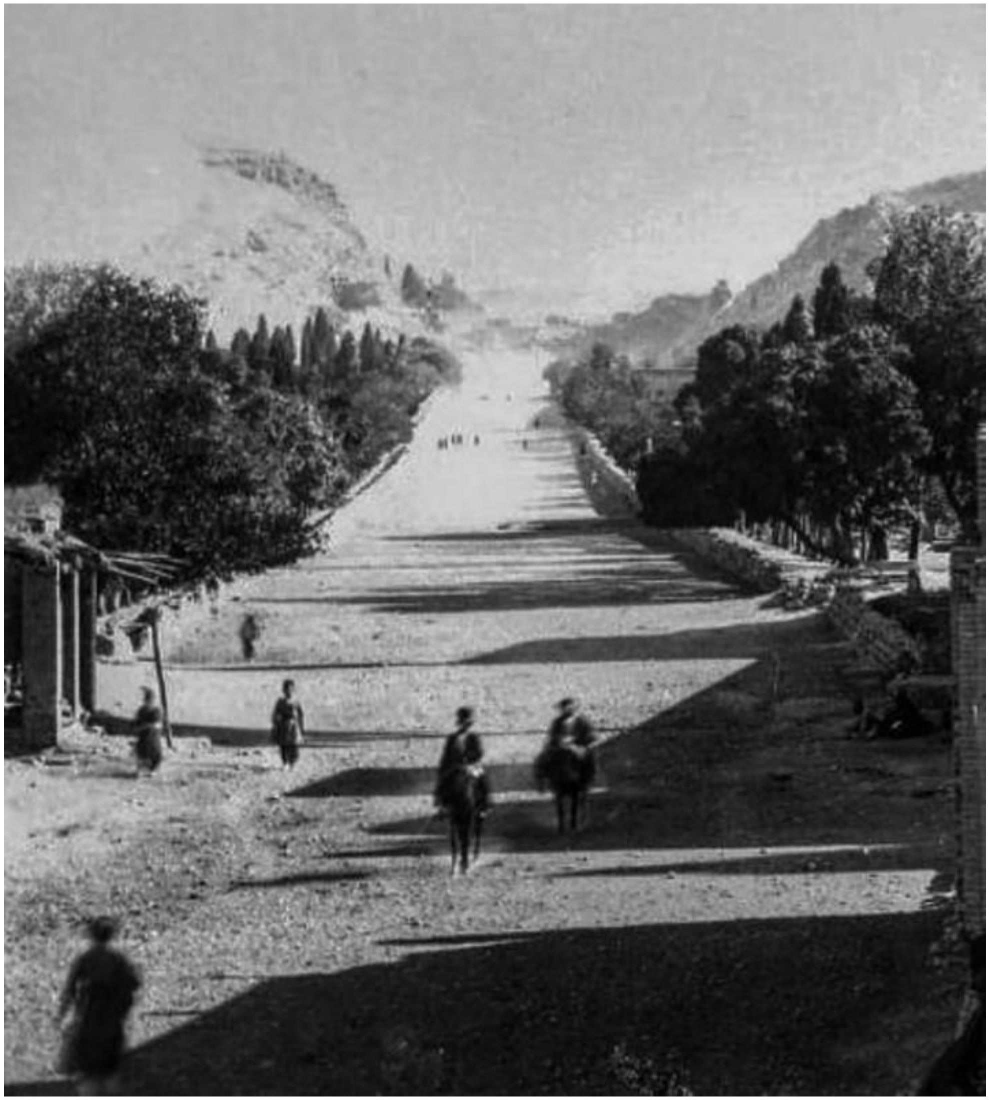


Figure 19. Char Bagh Shiraz, Hafez Street in the Past (Sane', 2001)

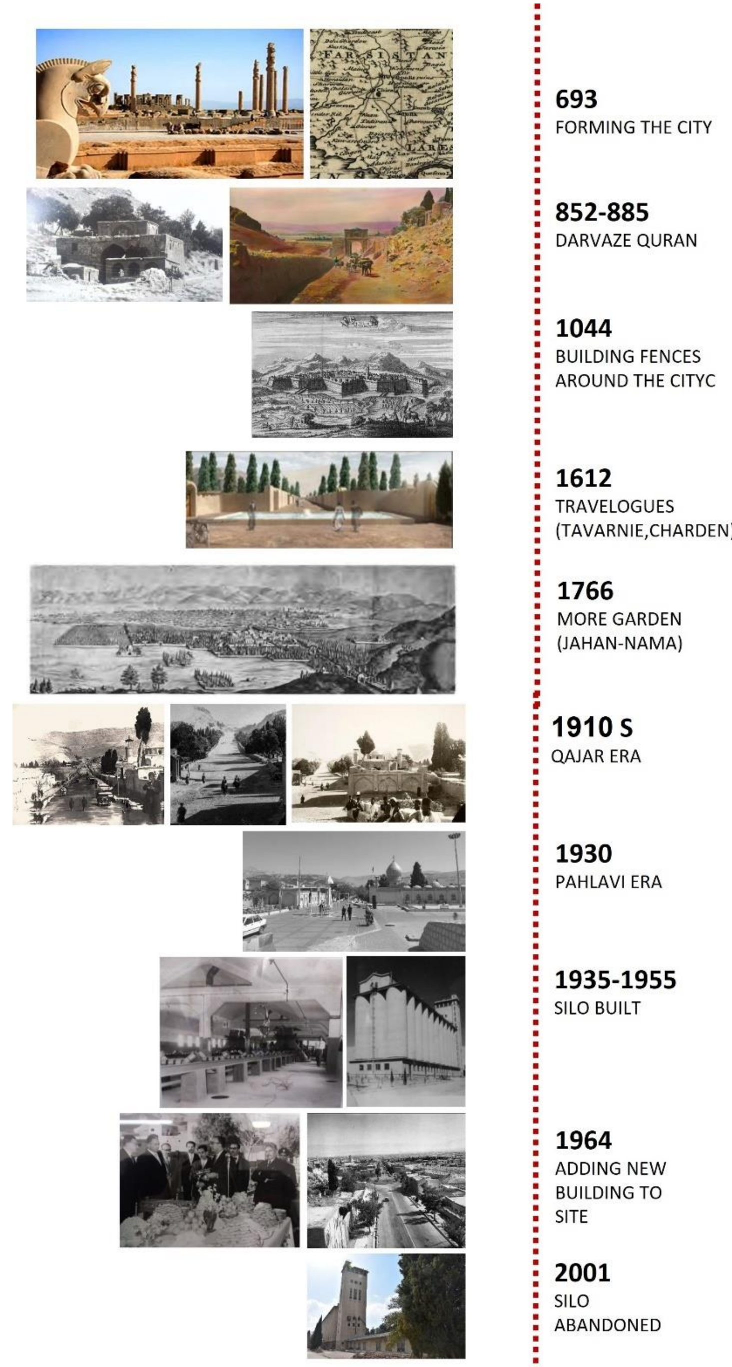


Figure 18. Timeline by Author

Site Analysis

Climate:

The silo building is in an acceptable condition in terms of harmony with the climate. This provides the possibility of using natural ventilation and lighting. The silo has a 30 degrees rotation to the southwest, which leads to less radiation absorption and is considered a favorable condition in the Shiraz climate. Based on the Shiraz’s meteorological organization reports, the dominant wind is the northwest having the highest frequency and strength.

Noise Pollution:

The site is accessible from four sides. The main access is Hafez Street in the east-south of the site which is also the main source of noise in the site. Due to being in the northwest of the site and adjacent to the residential areas, the noise pollution for the silo building is relatively low, with the minimum number of noises among the four sides of the site. This location provides sound comport potential for the residential spaces in the building.

Traffic:

the neighborhood can be considered as high high-traffic area in the scope of the city. As mentioned, this district hosts several important cultural and recreational destinations as the historical core of Shiraz. Moreover, during the author's conversation with residents, they widely complained about the lack of sufficient parking spaces.

Greenery:

One of the most important features of the site is its greenery. It reflects the history of the site as a city garden and also offers a unique opportunity for improving the overall quality of the project. Unfortunately, some trees were cut down during the years of construction on the site but there is still a considerable area of various native plants such as Cypress, Pine, Palm, Orange, and Plantain.

Figure 20. Site Analysis

Problems and Opportunities

After the urban analyses, opportunities and problems were identified through site visits and conversations with neighbors. The results are presented in the following table.

PROBLEMS	Apartments	Insufficient natural lighting and ventilation
		Lack of open and green spaces
		Poor views
		Poor relationships with neighboring buildings
		Mismatch between price and quality
	Urban Neighborhoods	Poor connection (physically and visually)
		Green areas on the site are not accessible
		No attention to pedestrian and walkability
		Lack of public parking space
OPPORTUNITIES	Site	Greenery and trees in the site
		Melli Garden as an adjacent public space
		Hafez Street as an urban axis
		Four-sided site access
	Silo Building	Remaining industrial machinery
		Modular plan
		Good views
		Well-maintained material and structure

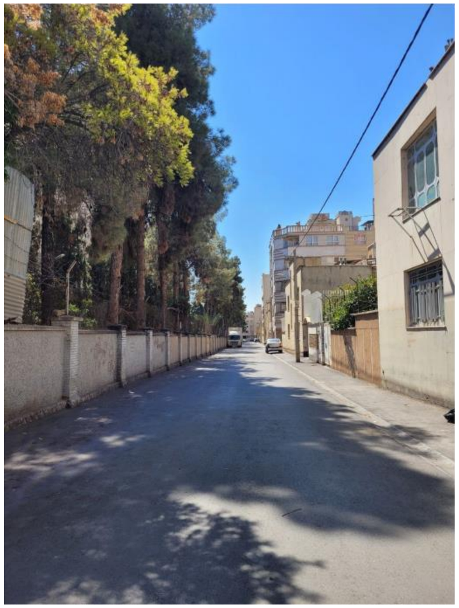


Figure 21.Melli Garden with view and Access to silo site (Rasm, 2022)

Figure 22. View to the City from the top (Rasm, 2022)

Figure 23. View from northeast street to site and neighborhood (by Mahbube Razvi, 2024)

Figure 24. Example of interior spaces of apartments in neighborhood (by Mahbube Razavi, 2024)

Functions and Access

Despite integrated management and operation during the working years of the silo, in recent years the site divided into several parts which belong to different private or public stakeholders and manage separately by various organizations. This situation leads to a lack of an integrated and consistent approach to site management, operation, and development.

The main functions are administrative including the Shiraz commerce department and Shiraz branch of national grain production management, utilities including laboratory, guesthouse, services, warehouses, and company housing.

In the middle of the site, there is an unfinished project which planned to be a cultural center. However, the construction process stopped due to managerial and financial issues for more than 4 years. Unfortunately, the future plan and function of this project are unclear at the moment. The approach to this part of the site would be acceptance of it 'as found' and incorporate it in the master plan as an unfinished abandoned structure.

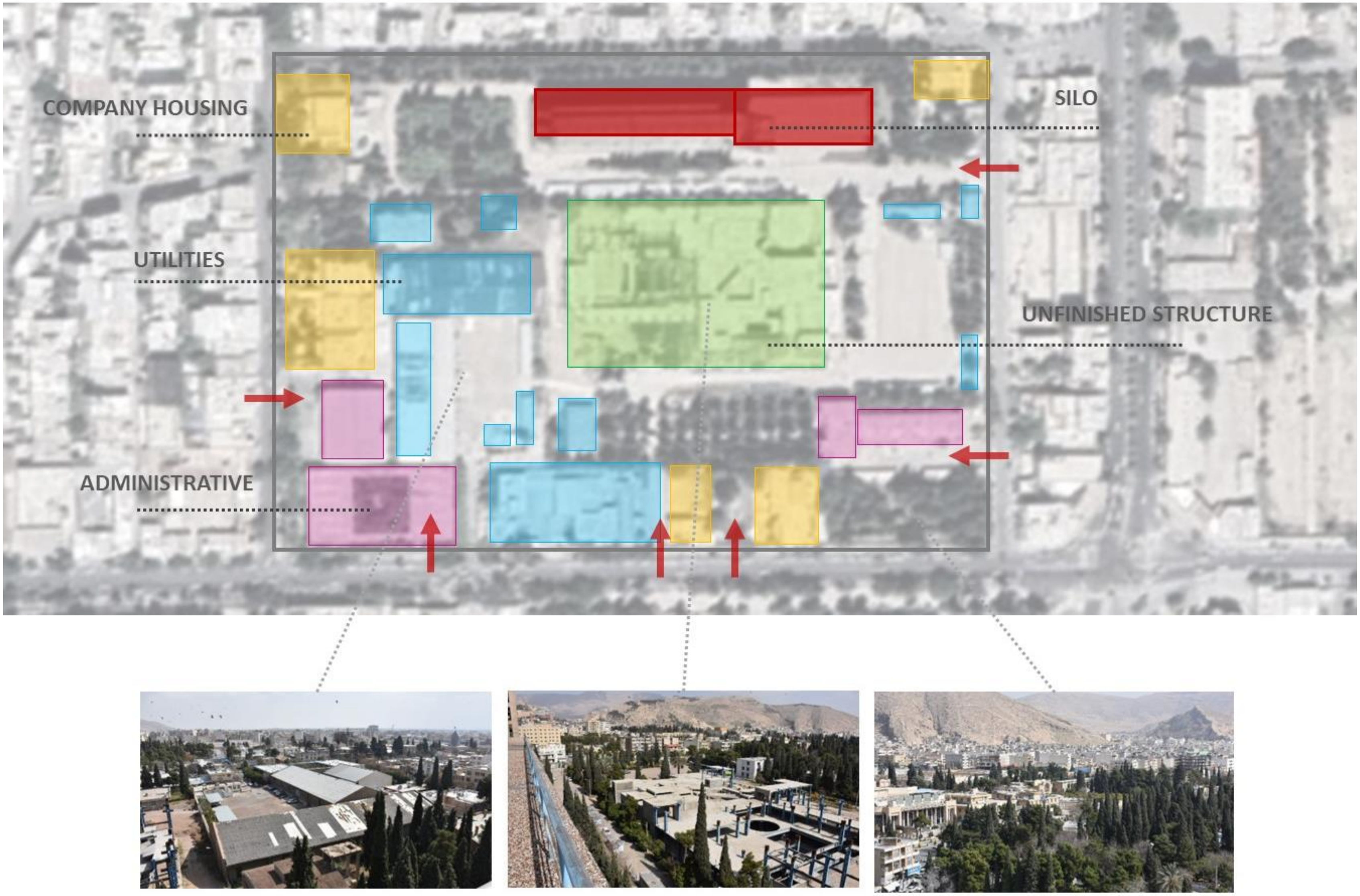


Figure 22.Site Access and Functions with Green Areas by Author

The Silo Building

The building has 5 parts. The main part of the silo consists of 33 bins, each with a diameter of 6 meters and a height of 22.5 meters, arranged in three rows of 11. These bins have a capacity of 500 tons each. Additionally, there are 16 star-shaped bins situated between the main bins, used for wheat storage when necessary, adding an extra 100 tons of capacity to the silo. The tallest part of the building is the tower, which stands at 54.5 meters and includes workrooms with remaining equipment distributed across seven floors of varying heights. This tower also houses the vertical access staircase and the building's elevator, which is notable for being the first elevator built in Shiraz and an important part of the structure.

The warehouses are located to the north of the tower and are connected to it. The underground level is also dedicated to grain storage.

The building has a modular structure made with high-quality materials. The old tools, materials, and wooden frames contribute to the architectural value and identity of this historic building. Additionally, the valuable old equipment and machinery highlight the industrial architecture and interior decoration. These remnants recall the building's industrial heritage and reflect its history.

Despite being neglected for more than 10 years, the building is secure and acceptable regarding its structure and overall condition. This 80-year-old silo is made of reinforced concrete with thick walls and a strong structure. The bin structures are also made of reinforced concrete, each independently supported by underlying columns. In addition to concrete and cement as the main materials, glass, wood, and metal are largely used in components such as doors, window frames, and equipment.

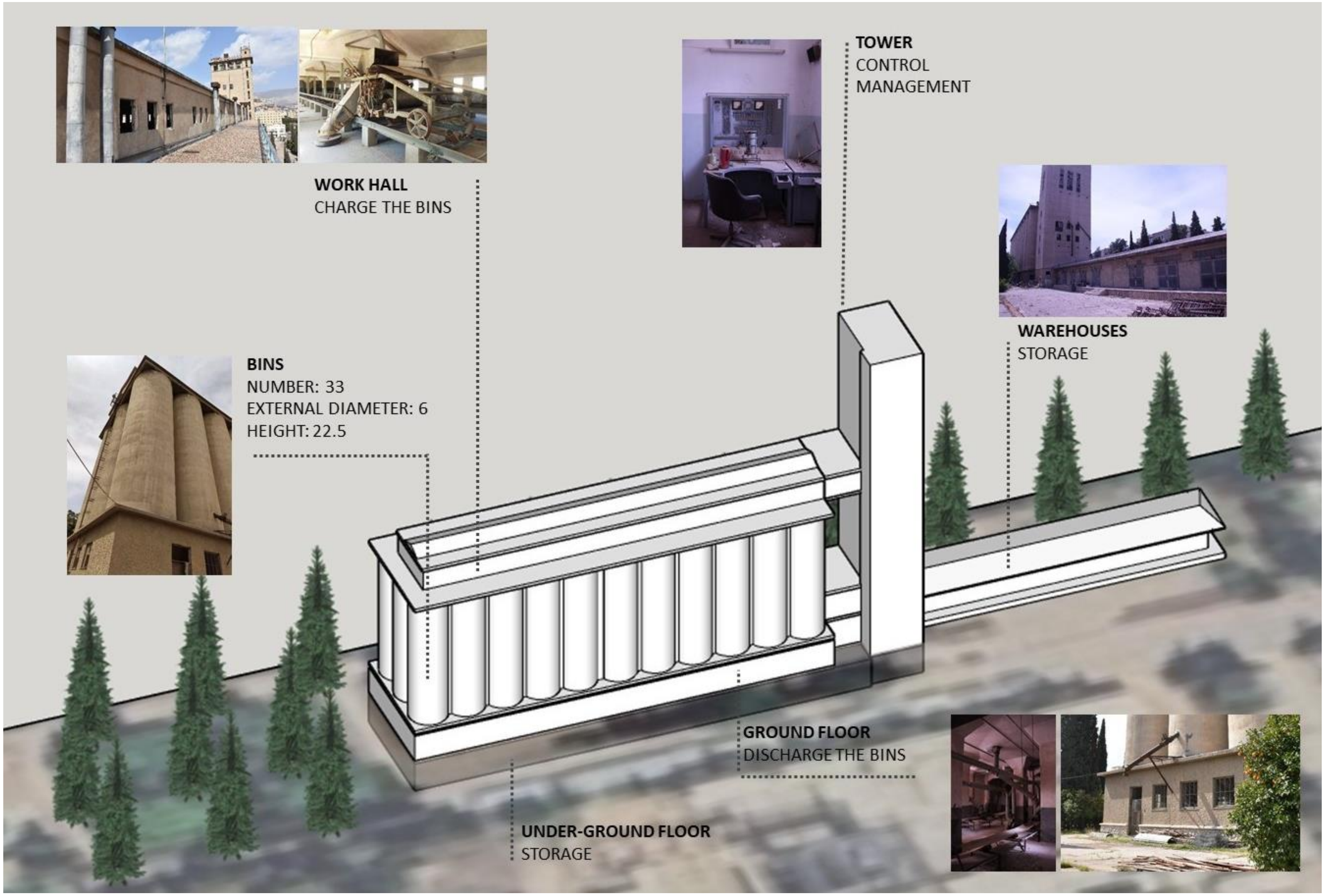


Figure 23. Parts of Existing Silo Building with Previous Functions by Author

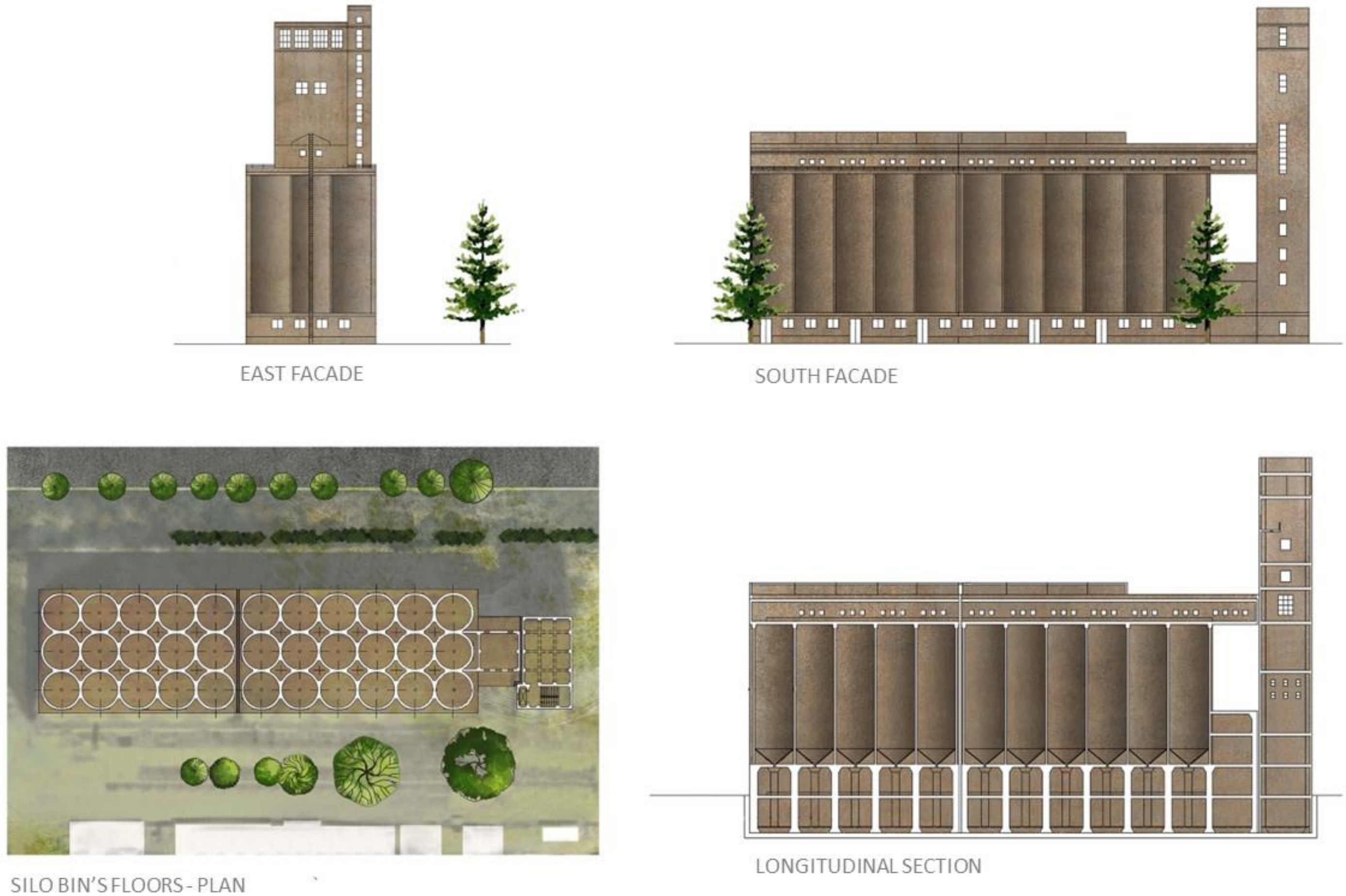


Figure 24.Drawings of Existing Building (Karimi, 2022)

Figure 25. Panorama view from the balcony of the working hall located on the upper floor of the bins. (Mahdiun, 2018)

Figure 26. Panorama Picture of the working hall located on the upper floor of the bins (Mahdiun, 2018)

Design Vision and Process

This Chapter explains the design process. After a thorough study and analysis of the site, Building, and its context, the design process began considering the outcomes of the previous parts.

To identify the most relevant and applicable factors for improving the cost and quality of the project, the potentials and challenges of the site are considered. Intervention strategies are then developed by translating lessons from similar case studies into the project. The process is illustrated in Figure 25.

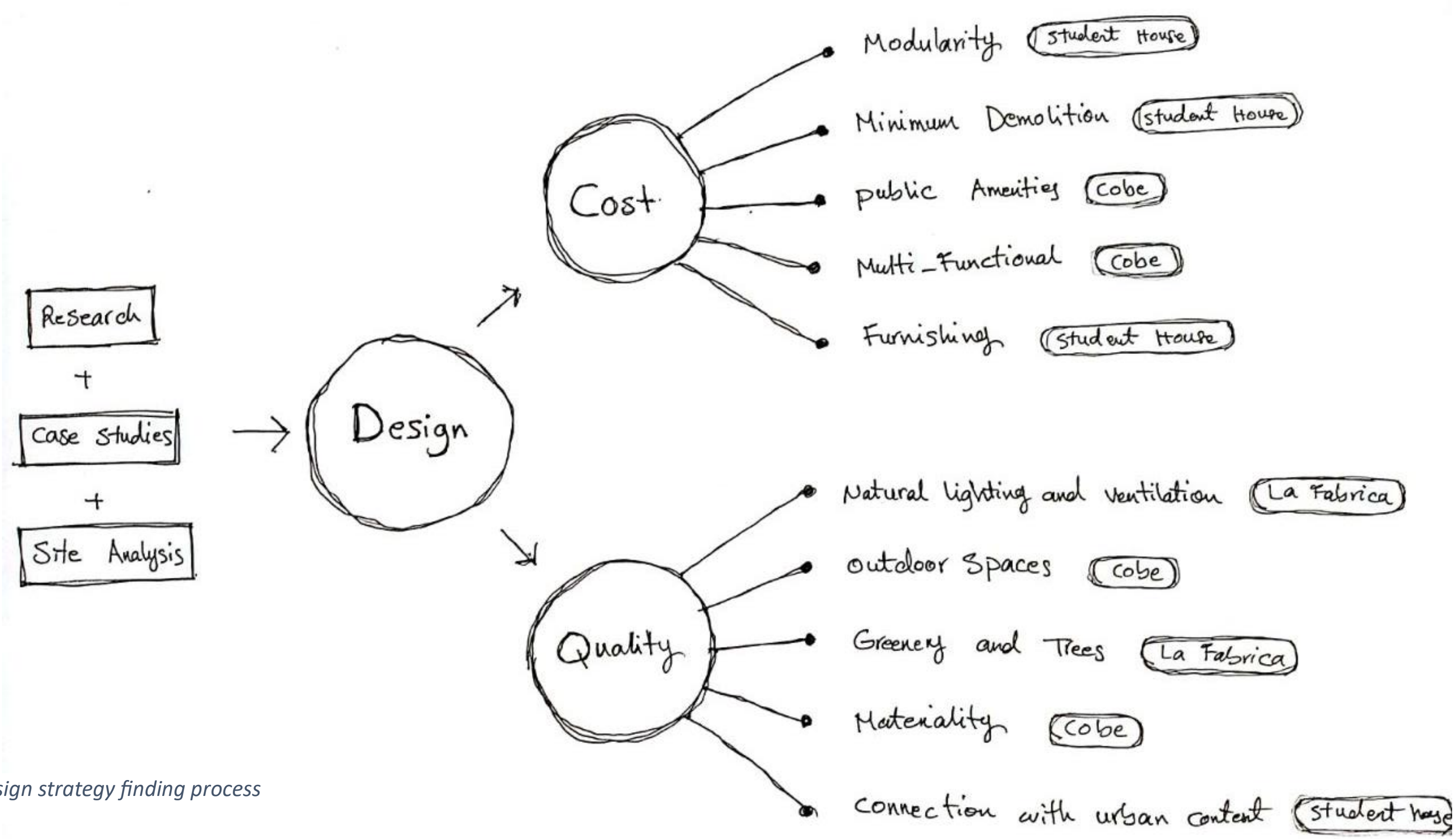


Figure 27Design strategy finding process

Based on the opportunities and challenges in the project, the interventions are implied in three scales. First, a master plan for the whole site is presented aiming at making the site more active, alive, and connected with the urban context. Then a multifunctional program was suggested for the silo building developing an effective revenue generation strategy and income diversification plan while addressing the user's need for services and amenities. Finally, the residential plans of the building were designed with special attention to minimum demolition, optimum circulation, and modularity. The plan consists of four main typologies with seventeen alterations, all of them following the same logic as a combination of outdoor and indoor spaces. Showcasing the typologies, two units were selected for more detailed design as examples of apartments for upper and middle-class single-family housing.

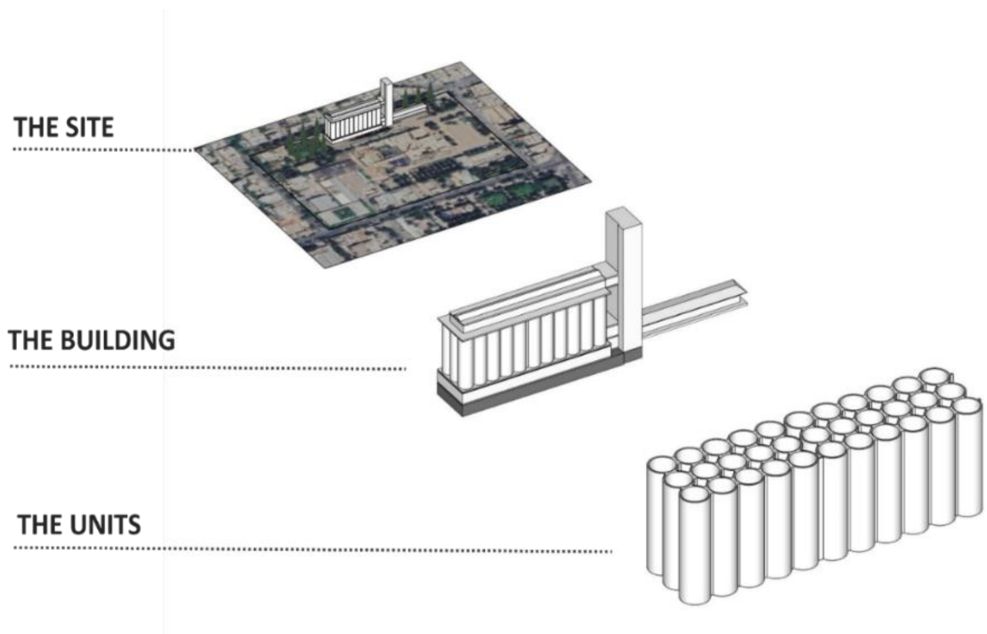
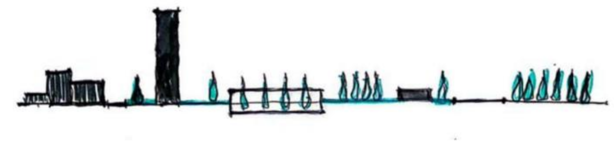


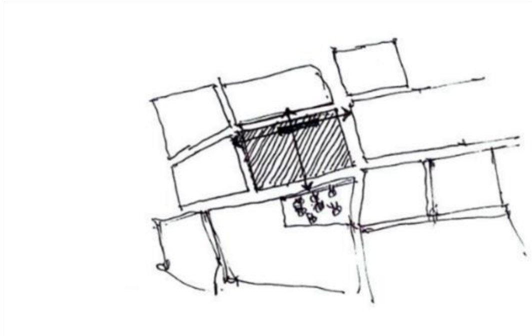
Figure 28. Three scale of interventions by Autor

Master Plan and Site

The proposal includes several interventions aiming at making the site more active and alive. These interventions take into account the spaces in the site as well as its connections with the surrounding neighborhood.



- Converting the unfinished structure to a public green space to increase the liveliness and vitality



- Creating new pedestrian routes to improve connections (in-site and out-site)
- Providing spaces for recreational activities and socializing to improve the sense of belonging and well-being
- Providing public parking for the neighborhood

Figure 29.Sketches of Interventions by Author

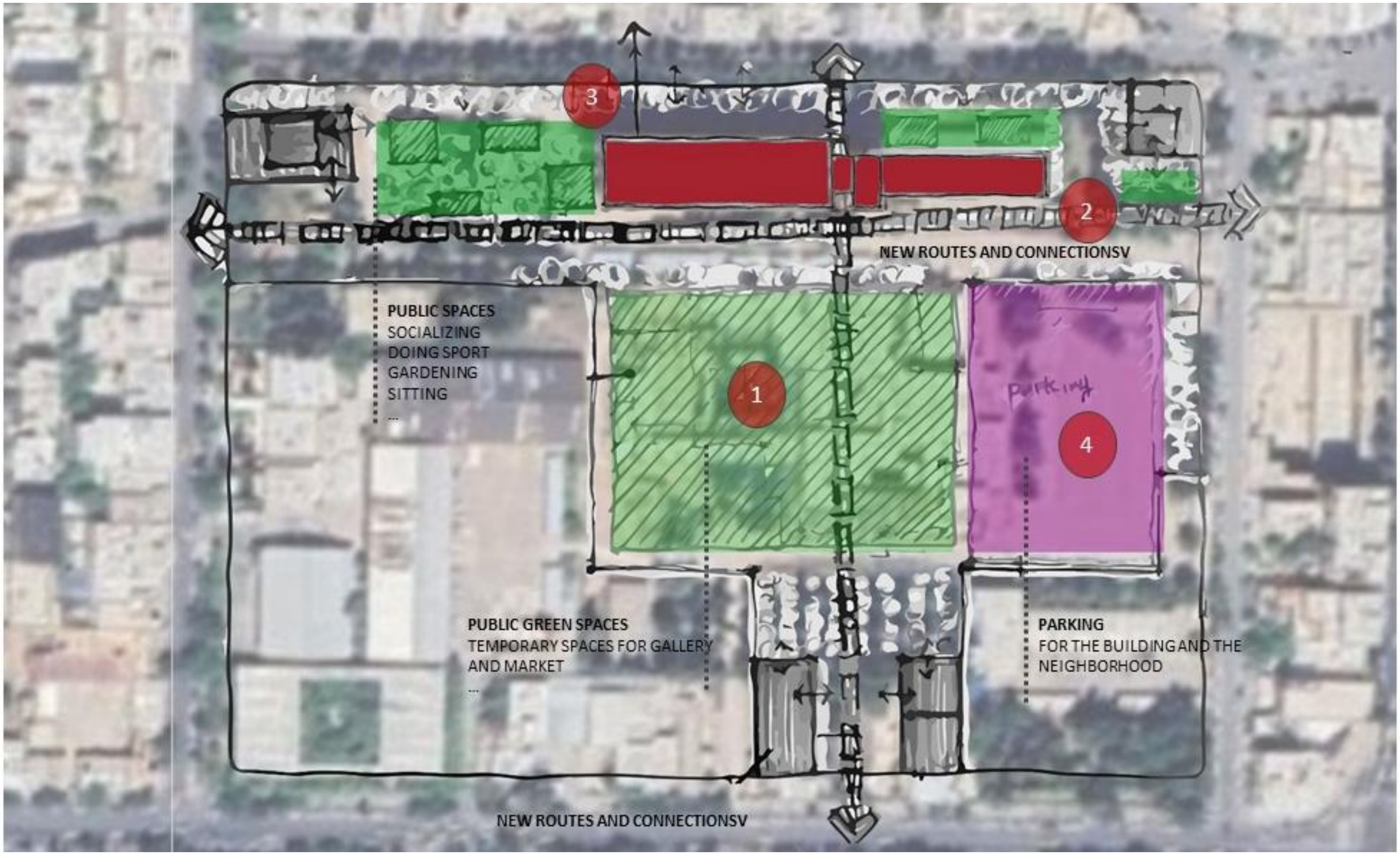


Figure 30.Intervention in Site by Author

The Building and Units

In the second scale, the silo transformed into a multi-functional building. The conceptual program hosted various functions and spaces such as public spaces, services and facilities, shops, storage and utilities, and residential apartments as the main function. The warehouses are also repurposed into coworking spaces for public and individual users. In addition to addressing the dweller's needs, this multifunctionality helps to make the building more vibrant and dynamic. Moreover, it is an effective strategy for increasing income generation. Regarding structural interventions, the design aimed to keep changes in minimum necessary initiatives. The main initiative was adding six floors for the bins to provide space for residential units. The structure of other parts didn't change considerably and the interventions remained limited to just necessary justifications.

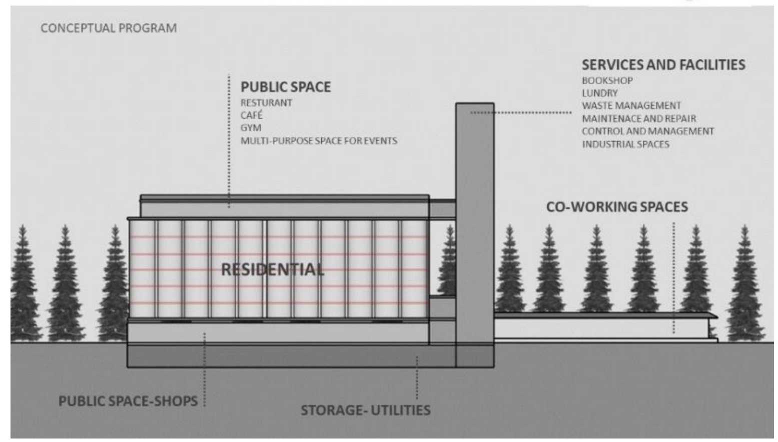
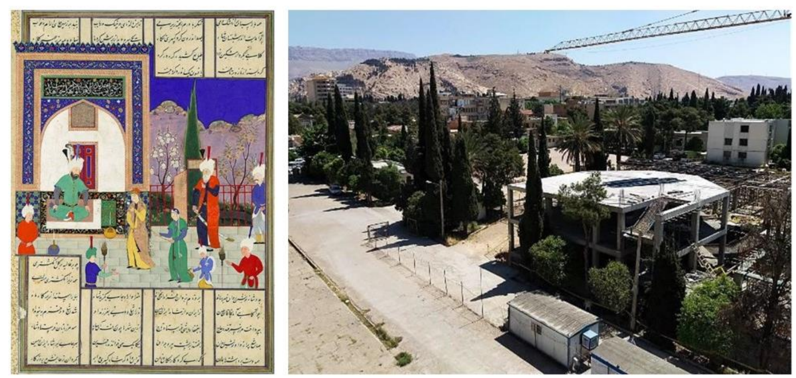


Figure 31.Conceptual Program by Author

Another important intervention was incorporating green spaces. Not only in the landscape but also within the building and its façade. As previously mentioned, holding the memories of Charbagh Gardens in the past is an identical feature of the site which reflects its historical significance. Thus, the greenery is integrated into the design process in a way that recalls this historical background. It also significantly improved the environmental quality, aesthetic appeal, and psychological well-being of the users through their refreshing and beautiful nature. In particular, the cypress tree is chosen to be incorporated. As a symbolic element in the representation of the garden in the context of Iranian art and culture. It always has been a source of inspiration and frequently appeared in Iranian paintings, miniatures, and poetry as well as architecture and urban spaces. They are also the dominant tree species in the site as Shiraz's well-known native plants.

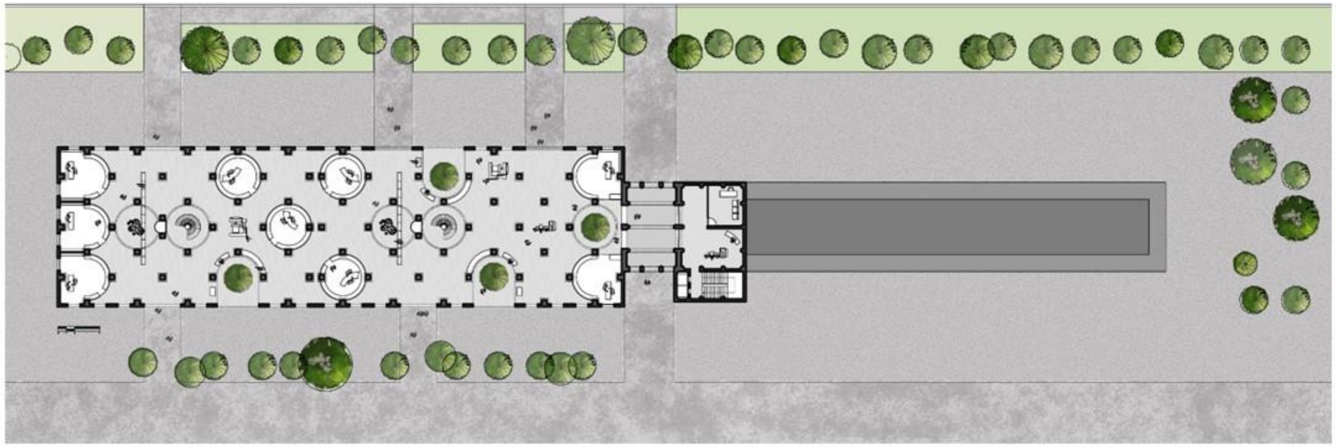


IRANIAN CYPRESSESS
IN CULTURAL ELEMENTS

IDENTICAL TREE IN THE SITE AND SHIRAZ

Figure 32.Cypress Trees in Site (Rasm, 2022) and Iranian Miniature (Dust Muhammad, n.d.)

GROUND FLOOR PLAN



SECTION

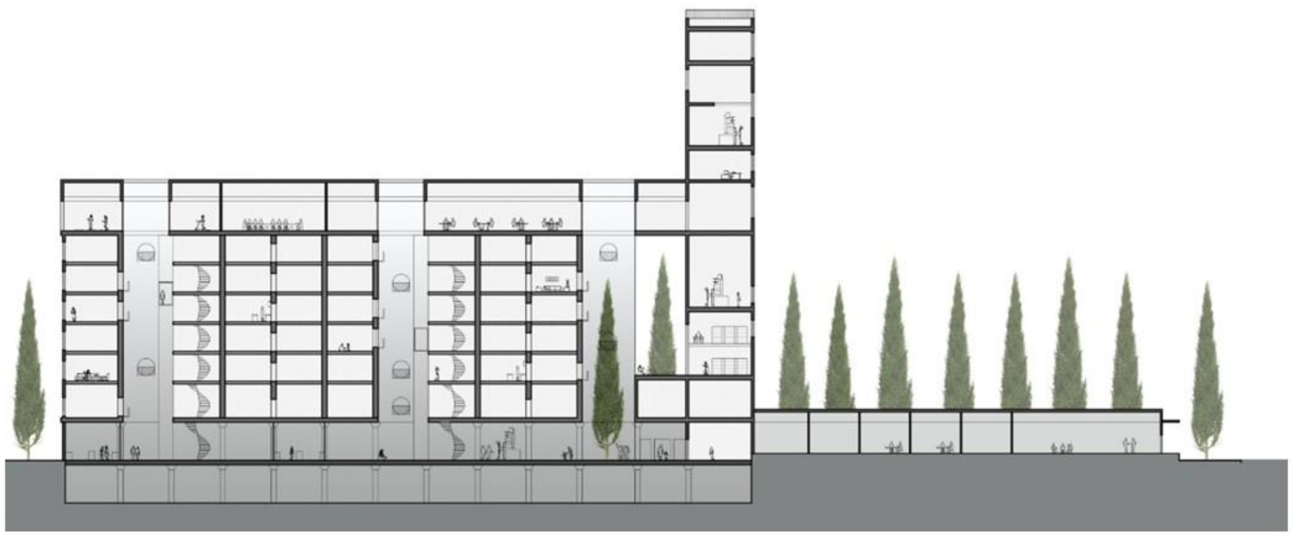


Figure 33. Drawings, Introducing Green spaces in plan and section and illustrating multifunctionality of the building by Author

Study of Organization and Circulation

To find optimum conceptual circulation five alternatives with different organization and number of stairs and corridors are explored. The criteria for decision-making include natural lighting and ventilation, adaptability with modular design, form, and usable area for the units. The selection, evaluation, and weighting of these criteria are based on consultations with a group of architects (four architects from Shiraz with over 10 years of practical experience) and the author's interpretation of the priority of the factors presented in the research part of the thesis, aligned with the design objectives.

The following tables and charts illustrate the process. Each alternative was scored from one to five for each given criteria, then the optimum option was chosen. For more certainty, the criteria were weighted and the total scores were compared. The results were equal; therefore, the second alternative was accepted as the optimum option.

CONSIDERATION	ALT.1	ALT.2	ALT.3	ALT.4	ALT.5
NATURAL LIGHTING	2	5	4	1	3
NATURAL VENTILATION	1	5	2	3	4
UNIT AREA	5	3	4	2	1
MODULAR DESIGN	2	4	3	5	1
FORM	1	5	4	3	2
Total Score	11	22	17	14	11

CONSIDERATION	WEIGHT	ALT.1	ALT.2	ALT.3	ALT.4	ALT.5
NATURAL LIGHTING	30	2	5	4	1	3
NATURAL VENTILATION	20	1	5	2	3	4
UNIT AREA	25	5	3	4	2	1
MODULAR DESIGN	15	2	4	3	5	1
FORM	10	1	5	4	3	2
Total Score		245	435	345	245	230

Figure 34. Extracted result from Study of Circulation by Author

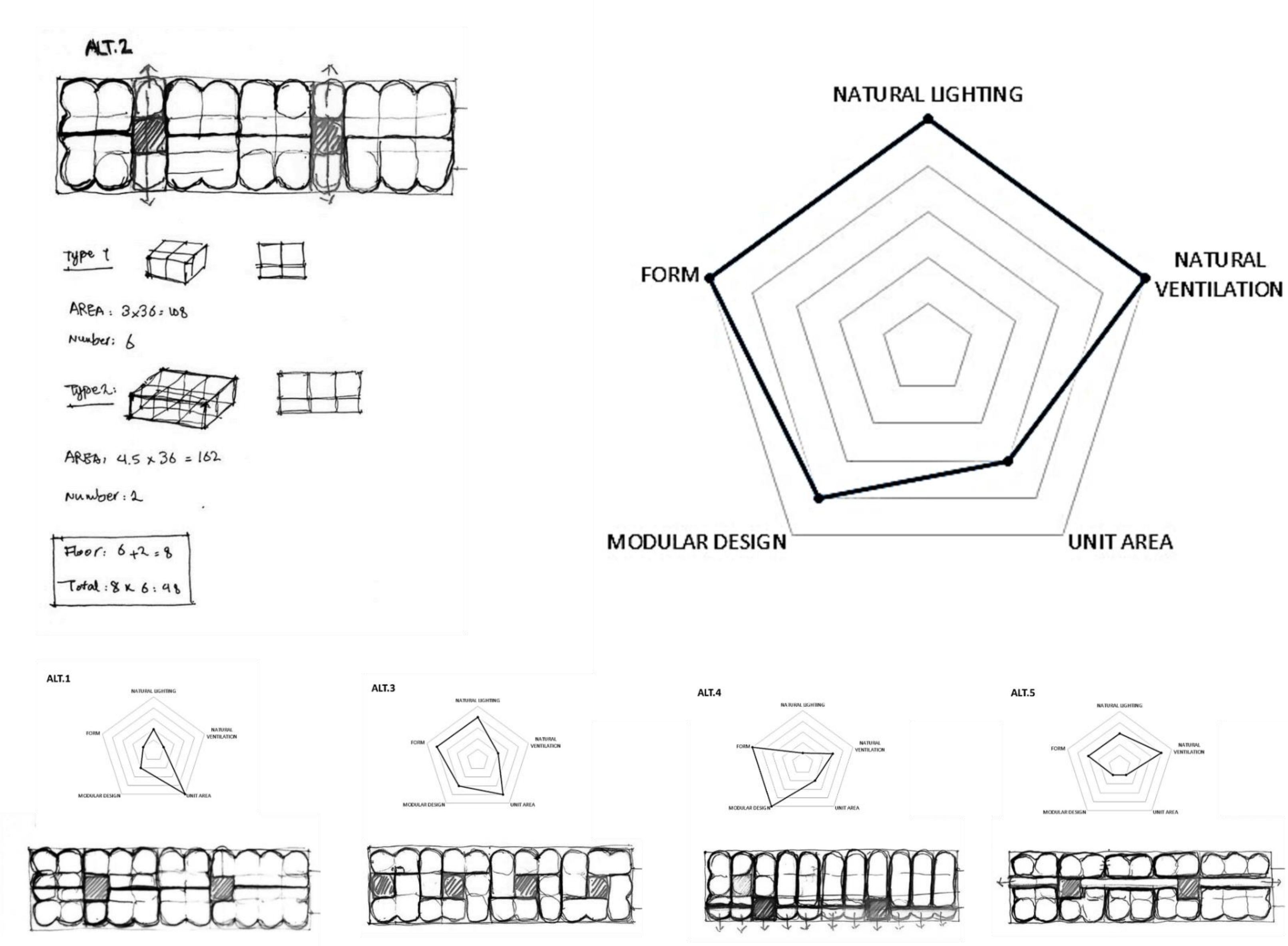


Figure 35.Study of Circulation

Exploring Units and Typologies

In the next step, the typology of the units was explored with a focus on integrating green and open spaces into the residential areas. Each bin is designated for a specific type of space, and categorized into five groups based on their function. Outdoor spaces feature various types of greenery, including cypress trees for public areas and houseplants on terraces.

The layout of the units is designed in four main types with a total of seventeen variations. All layouts adhere to the same principle, combining residential and public outdoor and indoor spaces. The design considers key factors from the research, such as minimal demolition, natural ventilation and lighting, accessibility, and efficient zoning. The following pages illustrate the typology and present two types of apartments as examples.

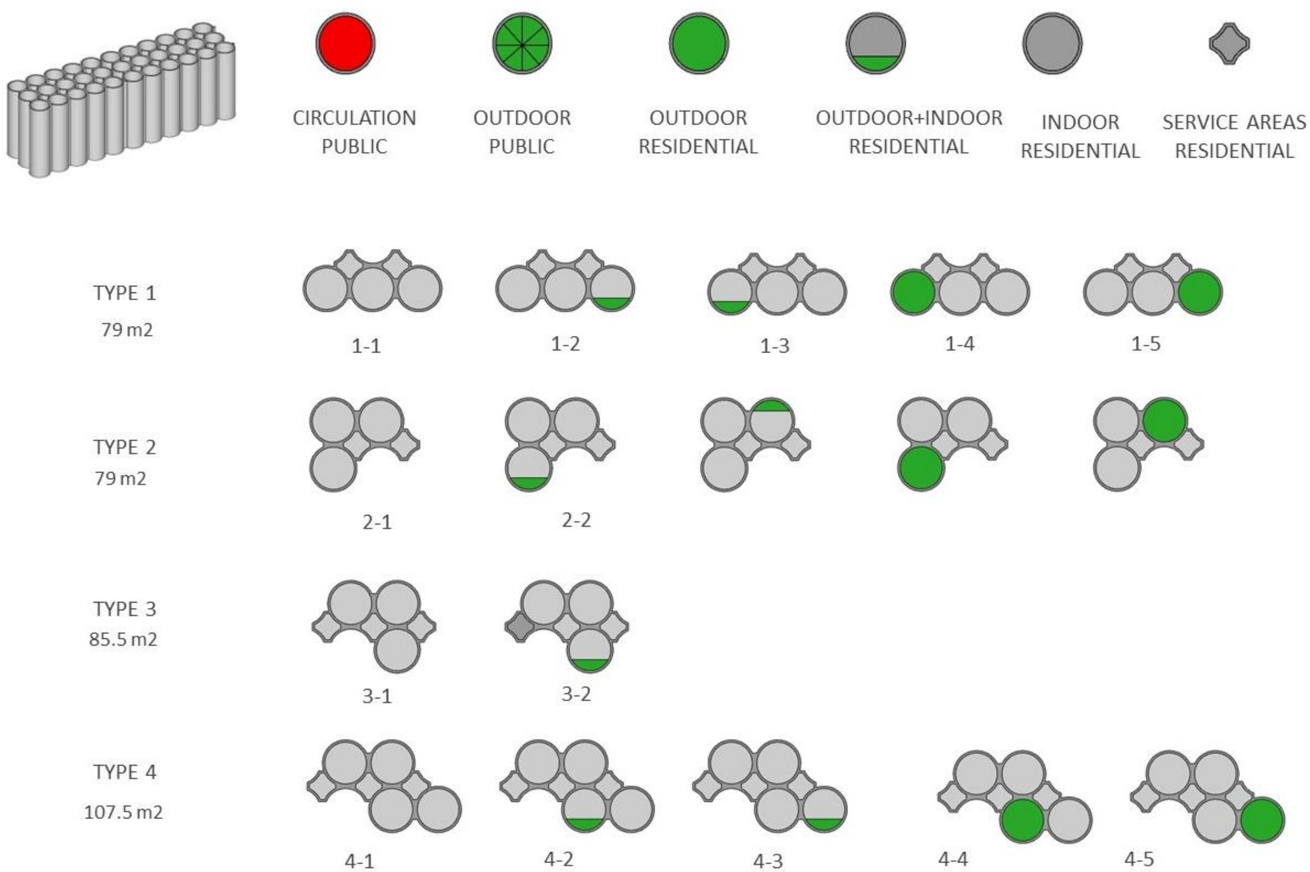


Figure 36.Typologies of Residential units

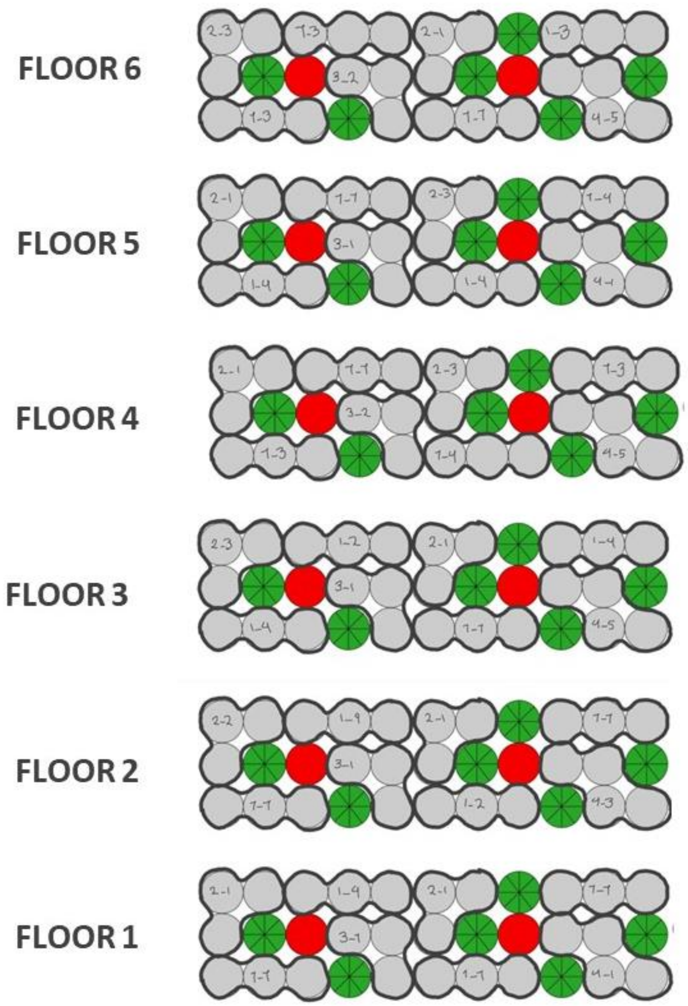


Figure 38.Typology of Residential Plans

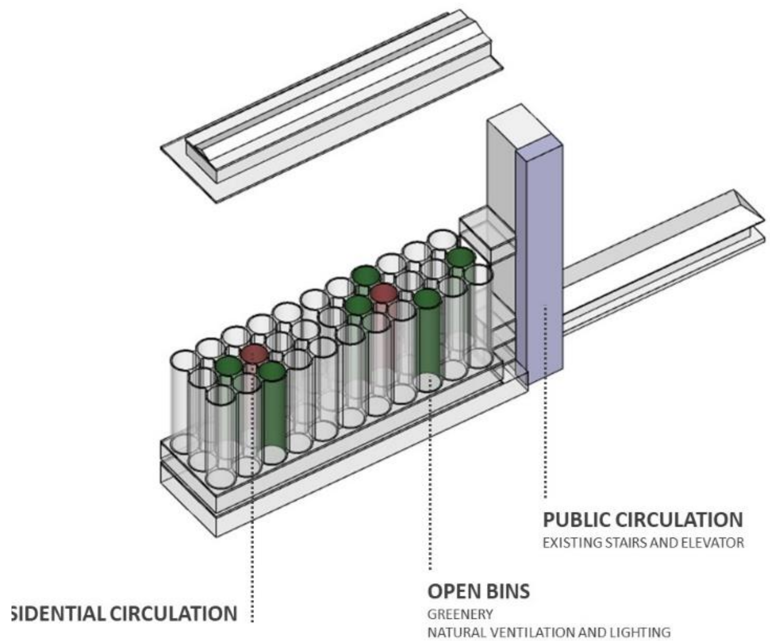
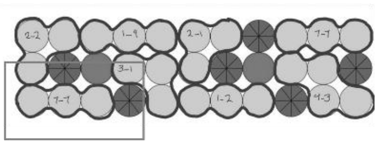
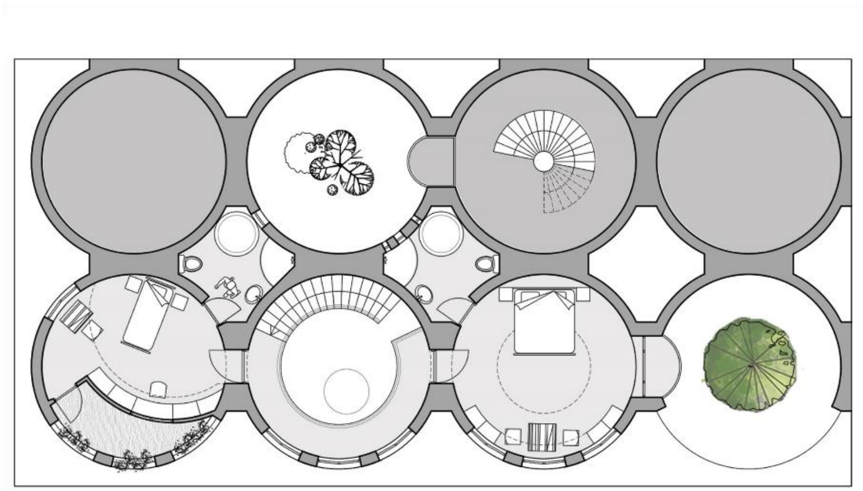


Figure 37, Public and Residential Circulation - Open Bins for Greeneries

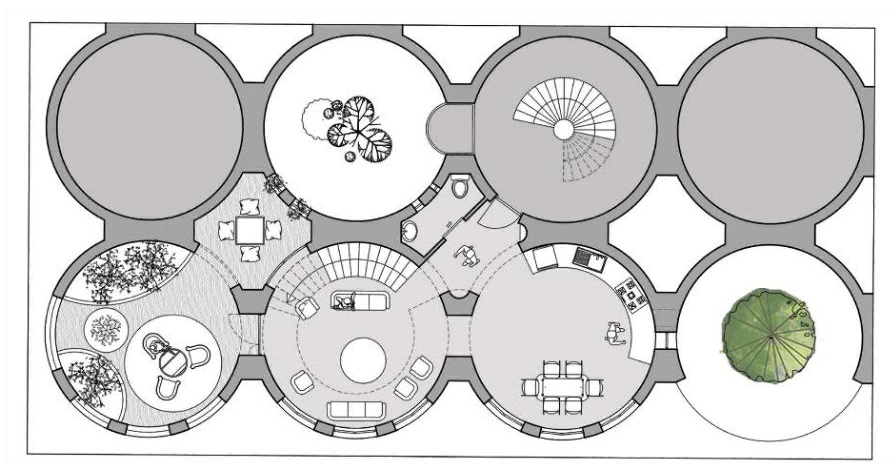
UNIT 1 - DUPLEX (1- 4 . 1-3)



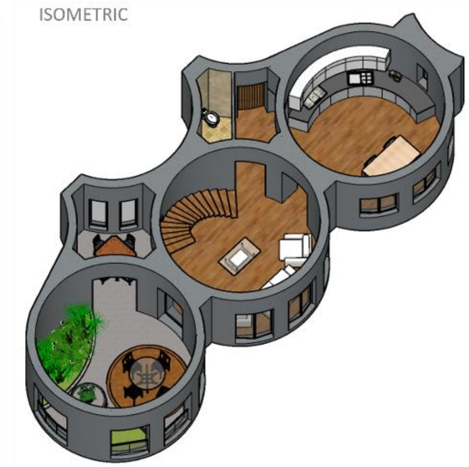


3RD FLOOR - PLAN

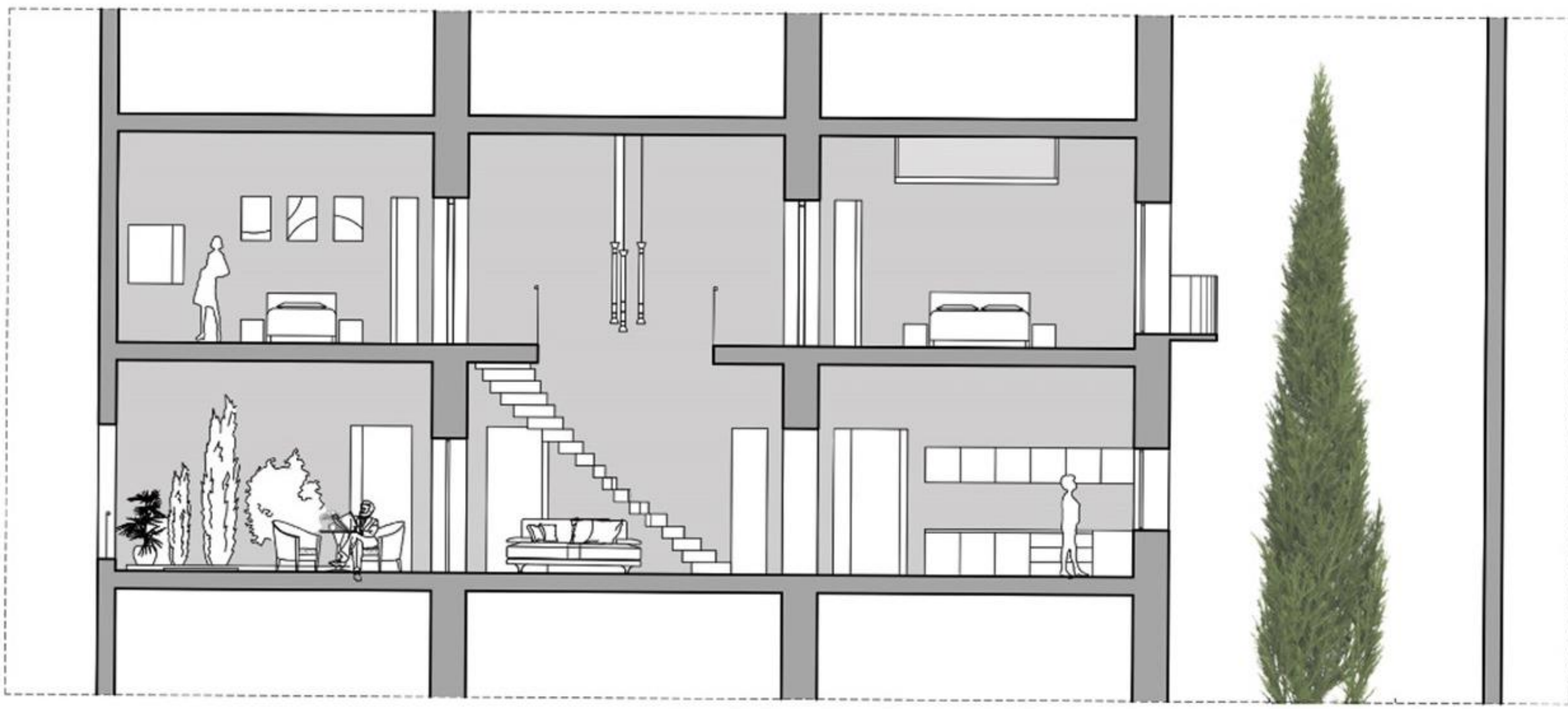
3RD FLOOR - ISOMETRIC



2ND FLOOR - PLAN

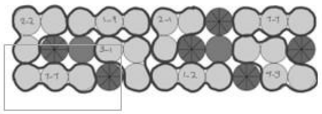


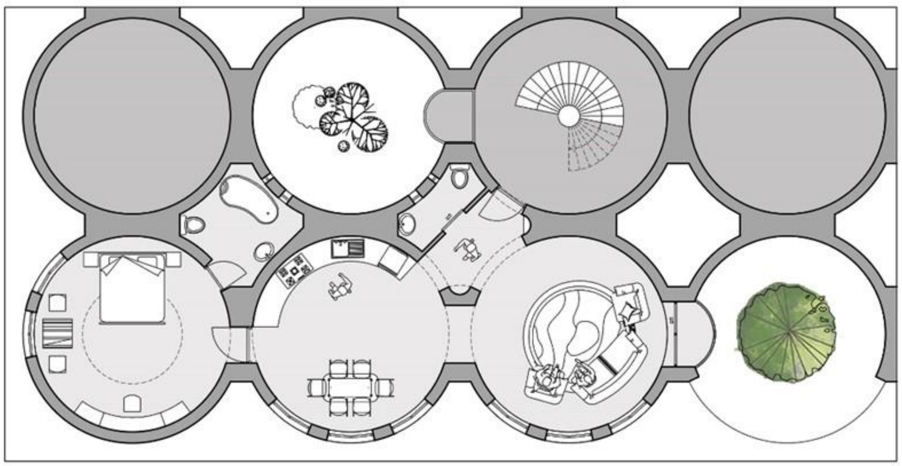
2ND FLOOR - ISOMETRIC



2ND and 3RD FLOOR - SECTION

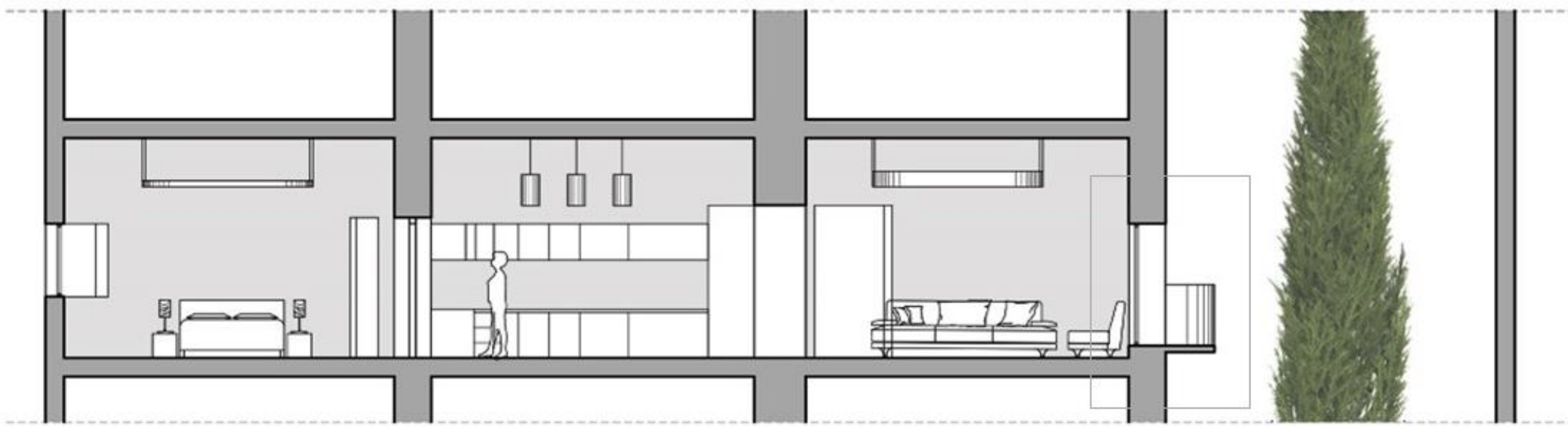
UNIT 2 (1-1)





1ST FLOOR- PLAN

1ST FLOOR- ISOMETRIC



1ST FLOOR- SECTION

Figure 39. Natural ventilation and lighting

Figure 40. Combination of outdoor and Indoor Spaces

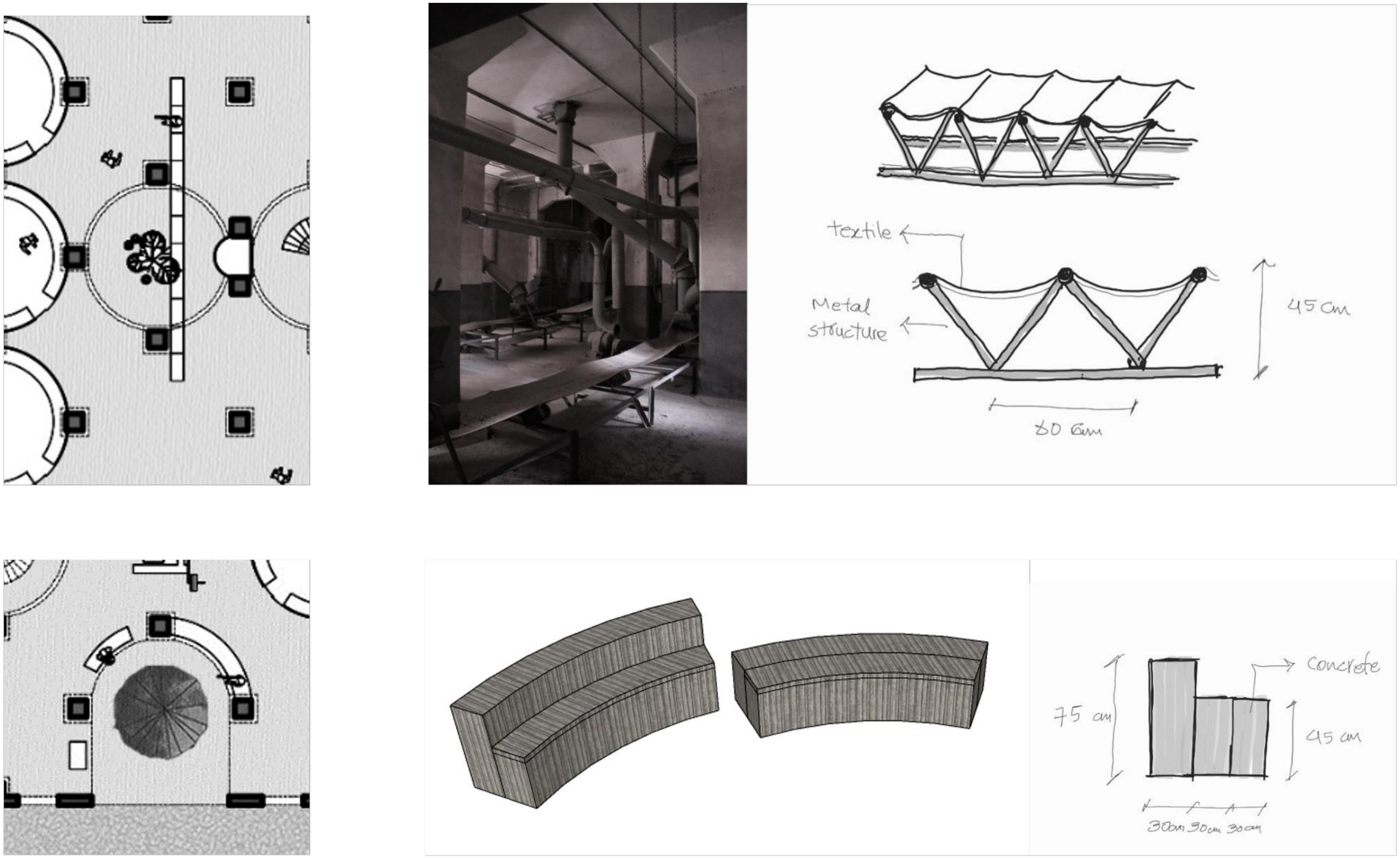


Figure 41. Furniture Design with Reused Material

Figure 42. Perspectives By Author

Figure 43.Perspectives by Author

Conclusion

Today, housing has become a critical global urban challenge, and in countries like Iran, where economic and political issues are severe, the problem is even worse. A promising solution to this situation could be the adaptive reuse of abandoned buildings, such as industrial heritage sites and structures with historical significance and architectural potential. Unfortunately, although transforming industrial sites for new uses is a common practice worldwide, this potential remains largely underutilized in Iran. The country's industrial heritage, including grain silos, is often neglected by both the government and private sectors. Despite the abundance of abandoned grain silos in Iranian cities, the idea of repurposing them for housing is largely unexplored. A notable example of this neglect is the Hafezieh grain silo in Shiraz, the first industrial building in the city, which holds significant historical value in the collective memory of Shiraz's residents. However, it has been abandoned for over a decade, despite its potential to offer a viable solution to Shiraz's housing challenges.

With this background, this thesis demonstrates how adaptive reuse can address housing provision challenges by transforming the Hafez silo building into a mixed-use housing project in a cost-efficient manner. The research identifies and categorizes the factors that contribute to enhancing quality and reducing project costs. Quality-related factors are grouped into four categories: physical and structural quality, indoor environmental quality, aesthetic and psychological quality, and functional quality. The main cost-related factors are categorized into planning and management, architectural design, installation and systems, construction, and financial planning and strategies. During the design phase, strategies for project intervention were selected based on research, case studies, and site analysis. Cost-reducing strategies include using modular design, minimizing demolition, implementing a multi-functional program, providing public spaces and amenities, and thoughtful furnishing. Similarly, five strategies were applied to increase project quality: natural ventilation and lighting, incorporating green spaces and trees, combining outdoor and indoor spaces, ensuring harmonious materiality, and strengthening the connection with the urban context. These strategies were chosen based on lessons from three similar case study projects and a thorough analysis of the site's opportunities and challenges, identified through site analysis, interviews, and observations.

Despite the complexity and scope of the topic, which made it challenging to find more precise answers within a short timeframe, this thesis aims to inspire further research and exploration into the potential for transforming industrial sites in Iran. It particularly highlights the significance of grain silo buildings, which, unfortunately, have no examples of reuse in the country.

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