graduation report.

A sense of belonging through the inhabited edges of Homs, Syria

Colophon

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Author
LFA Fokkelman

First mentor: Ir. Job Schroën
Second mentor: Dr. Alessandra Navarro

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Abstract. This graduation project explores how architecture can contribute to restoring a sense of belonging in post-conflict Homs, Syria. Following years of war and displacement, reconstruction requires more than rebuilding physical structures; it must also support social recovery and reconnect people with place. The project investigates how spatial organisation, façade design, and material strategies can foster belonging within contemporary housing.

Through a design-by-research methodology, the study combines theoretical research, contextual analysis, material exploration, and architectural design. Research into environmental psychology, neuroarchitecture, and Syrian architectural traditions identified key factors that contribute to belonging, including cultural practices, social interaction, local material expression, and spatial experience.

The traditional Syrian courtyard house was analysed as a case study to understand how architecture mediates relationships between privacy, community, climate, and everyday life. Rather than replicating historical forms, the project extracts and reinterprets these underlying principles within a contemporary housing typology. In parallel, the research explores the potential of pistachio-shell agricultural waste as a locally producible bio-composite façade material, linking housing reconstruction to local resources and economies.

The resulting architectural proposal organises housing around interconnected courtyards, galleries, and inhabited thresholds that create gradual transitions between public, collective, and private space. Combined with a material strategy based on recycled rubble, limestone, and pistachio-shell composite panels, the project demonstrates how reconstruction can address both physical and social recovery.

Ultimately, the project argues that architecture can support post-conflict recovery by creating environments that foster belonging, while responding to local cultural and material conditions.

Key words: Syria, post-reconstruction, sense of belonging, housing, local material

CONTENT

01 INTRODUCTION

Foreword. This graduation project explores how architecture can contribute to restoring a sense of belonging in post-conflict Homs through spatial thresholds, façade design, and locally grounded material systems. The project was developed through a design-by-research methodology, combining theoretical research, contextual analysis, material exploration, and architectural design.

The report is structured in four main chapters. The first chapter introduces the context, relevance, and research questions. The second chapter explains the methodological approach and theoretical framework surrounding sense of place and belonging. The third chapter presents an abstract of the research results, including an analysis of the traditional courtyard typology and a pistachio-shell bio-composite study. Finally, the fourth chapter translates these findings into the architectural proposal.

Together, the report aims to demonstrate how reconstruction can move beyond technical rebuilding and engage with the social, cultural, and material dimensions.

1.1 CONTEXT

Figure 1: boy walking with dog Beirut

1.1.1 PROBLEM STATEMENT

When Azzam Freij crosses back into Syria and finally walks through the souks of Homs again, he describes pride at being home but finds streets of ruin, scarce jobs, and only a few hours of electricity each day, making everyday life almost unrecognisable (Caleb & Pernot, 2025). This experience is no exception, but emblematic of a broader return. Since 2011, the war followed by the earthquake in 2023 has led to massive destruction and prolonged displacement, which leaves 1.87 million Syrians to return to cities that are physically and socially devastated (Jazeera, 2025). In Homs, a city in western Syria, more than half of the pre-war population has been displaced, and more than half of all homes have been left uninhabitable, with large parts of the city consisting of empty concrete frames and looted apartments (UN-Habitat, 2022). Environmental psychological research conceptualises this as an “ambiguous loss of home,” in which war and forced migration disrupt security, social ties, and continuity of place. As a result, even physical return may be insufficient to restore a sense of belonging as the foundation of home.

At the same time, Syria’s physical reconstruction faces enormous constraints: the costs of rebuilding are estimated at hundreds of billions of dollars, while sanctions, depleted foreign reserves, and shrinking government investment make conventional, import-dependent building materials unaffordable (World Bank Group, 2025). Within this context, the reuse of locally available resources, such as rubble, presents a potential pathway to reduce costs and environmental impact. In parallel, the agricultural sector, historically a backbone of Syria’s economy and still accounting for about a quarter of GDP during the conflict,

has re-emerged as a crucial safety net (Food and Agriculture Organization of the United Nations, 2017), generating organic waste by-products. One such by-product is pistachio shells, which could potentially be enhanced into building components while strengthening local agriculture-based livelihoods.

1.1.2 RELEVANCE

Home is a primary goal of architecture, yet when buildings no longer represent shared achievements, values, and continuity, they risk reinforcing disruption instead of supporting recovery (Azzouz, 2023; Relph, 1976). In a context characterised by displacement and prolonged insecurity, environments that nurture a sense of belonging become essential for people seeking to rebuild their lives in damaged neighbourhoods (Najafi & Shariff, 2011; Stedman, 2008). The central importance of this project lies in approaching this crisis of belonging as an architectural task, by exploring how the built environment can actively contribute to restoring ties between people and places in the post-conflict area of Homs.

In this context, facades are a critical architectural element, as they form the most visible and tactile interface between residents and their neighbourhoods (Humanise, 2025), mediating everyday encounters with buildings and the city. Neuro-architectural research shows that façade characteristics influence stress regulation, feelings of safety, and belonging. Furthermore, the Humanise research (2025) shows that culturally resonant facades can support a sense of belonging. However, much of this research remains context-independent and emphasizes universal perception factors rather than socially and culturally situated experiences. Accordingly, little has been said about how these findings could be applied to post-conflict situations such as Homs, where reconstruction is inextricably connected to questions of identity.

Material and economic urgencies add a second layer. Transforming waste streams from the agricultural sector into façade components could create local employment, strengthen rural-urban links, and reduce dependence on imported products. Existing bio-composite research indicates that residues from these waste streams have high potential as technically viable fillers, but offers little guidance on how to develop a feasible product for facades connected to an already existing supply chain. A notable gap persists in design-oriented frameworks that bridge the potential of bio-composites with their application in concrete, small-scale façade components and context-specific manufacturing processes.

Figure 2: The Syrian Conflict : Physical Damage and Reconstruction Assessment World Bank

1.1.3 OBJECTIVE AND RESEARCH & DESIGN QUESTIONS

The main objective of this project is to develop a housing typology that strengthens residents' sense of belonging through three dimensions of façade design. Building on this aim, the project is structured around one overarching 'project question', a set of 'research questions', and a 'design question' that address how facades through three different dimensions shape belonging, how locally grounded architecture can inform façade articulation, and how material transformation can respond to the current gap between underused agricultural by-products.

Project question: How can locally grounded housing architecture support a renewed sense of belonging in post-conflict Homs through spatial configurations, façade components, materialisation?

Research questions:
1) Which architectural factors are associated with fostering a sense of belonging?

2) What building characteristics and inhabited practices in pre-war housing in Homs are significant to Syrian cultural identity, and how can these be translated into design principles?

3) How can pistachio shell agricultural waste be transformed into a bio-composite material suitable for façade components in post-conflict housing in Homs, Syria?

Design question:
4) What spatial configurations, façade components, and materialisation can form a foundation for a housing typology that enables a sense of belonging?

Finally, the accumulated insights from theoretical, contextual, and material research converge in an architectural design.

1.1.4 SCOPE

The scope is defined by answering the questions 'what, who, where, and how'.

What?

Developing a housing typology for mid-rise residential buildings in post-conflict Homs that can be applied to representative neighbourhood conditions. The typology is intended to support residents' everyday practices, cultural values, and evolving needs by structuring spaces with different gradients of privacy with the corresponding façade elements that enable a renewed sense of belonging.

Who?

Primary users: Returning citizens and remaining residents of damaged neighbourhoods
Secondary: Local craftspeople and agricultural actors

Where?

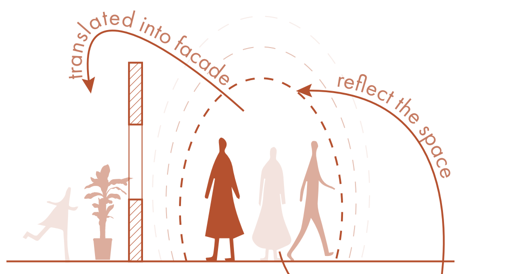
The designed typology could apply to any representative neighbourhoods with a change of function in the plinth if necessary. For this assignment, one specific site in Homs has been selected to develop the building.

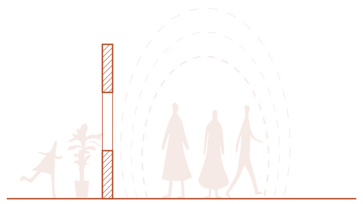
How?

A theoretical framework defines how sense of belonging relates to façades, identifying four factors that contribute to a sense of belonging, condensed from environmental psychology, façade research, and Syrian critiques.

A contextual architectural analysis applies three architectural dimensions: 1) the space a façade creates, 2) façade as the component, and 3) the building process/ adaptation to Syrian pre-war courtyard typologies to extract design principles that support belonging in Homs.

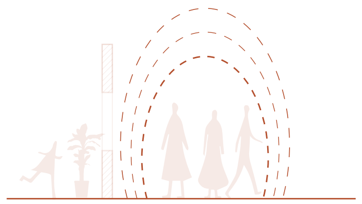
A material-based research that investigates pistachio-shell bio-composites as a feasible façade material, establishing their properties, supply chain, and manufacturing methods as the technical framework, which will inform and constrain the design phase of the project.





the 'component' itself
(object)

What does the facade look like? How are the openings, materials, and details arranged?



the 'space' it creates
(spatial)

What activities happen there (hosting, cooking, play, neighbour interaction? How does it mediate?

the way it is built & and adapted
(process)

How have people built, adapted, or personalised it over time? What traces of craft and self-building are visible?

02 APPROACH

2.1 METHODS

2.1.1 METHODOLOGY

This graduation project adopts a design-by-research methodology that iteratively links theory, contextual analysis, material research, and architectural design (figure 4). Knowledge produced in each phase feeds forward into subsequent stages, informing both the research direction and the evolving architectural design, strengthening a sense of belonging.

First, a theoretical literature review in environmental psychology, neuroarchitecture, and Syrian critiques develops a framework linking the sense of place and sense of belonging to the architectural dimension. This phase results in a set of abstract factors that foster a sense of belonging, guiding analysis and design.

Second, a context-specific analysis localises this framework to Homs. Pre-war architectural housing situations are examined across three architectural dimensions related to facades: 1) the space a façade creates, 2) façade as the component, and 3) the building process. This analysis results in a set of context-specific design principles that articulate how façades can support belonging within the social and spatial realities of Homs.

Third, a material and fabrication study addresses the material scarcity problem through pistachio-shell façade components. Through literature on bio-composites and the mechanical properties of pistachio shells combined with an analysis of the Syrian pistachio sector, different matrix–fibre combinations and manufacturing routes are explored.

Fourth, a design-oriented exploration translates the previous findings into spatial configurations, façade components, and materialisation. Using the context-specific design principles as criteria, iterative design studies test different arrangements of semi-open spaces while integrating material studies.

2.1.2 PLANNING

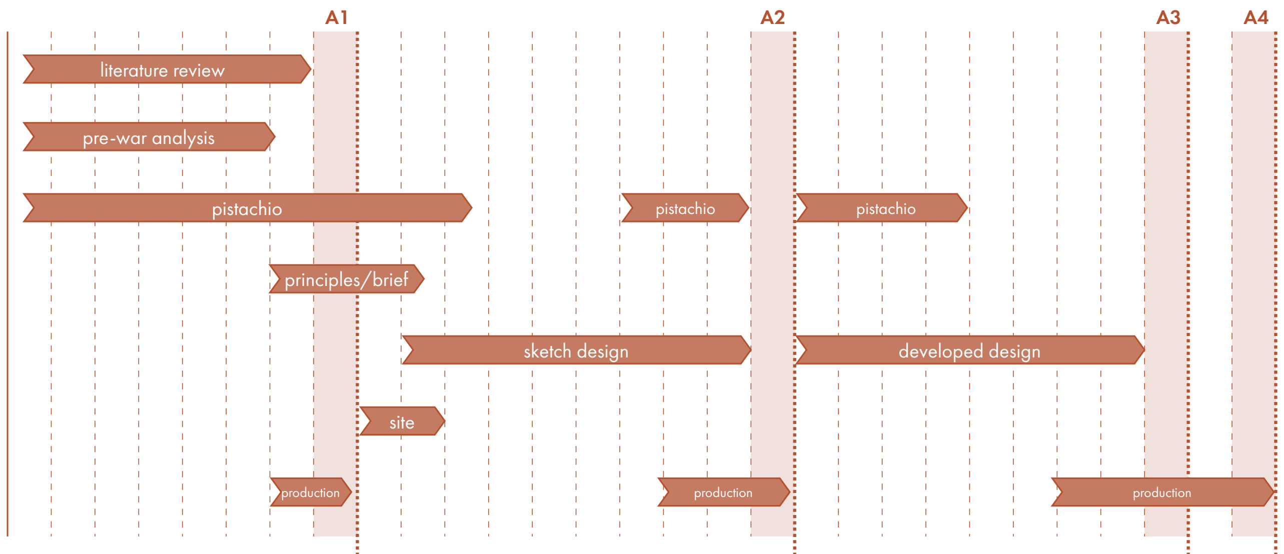


Figure 3: planning diagram

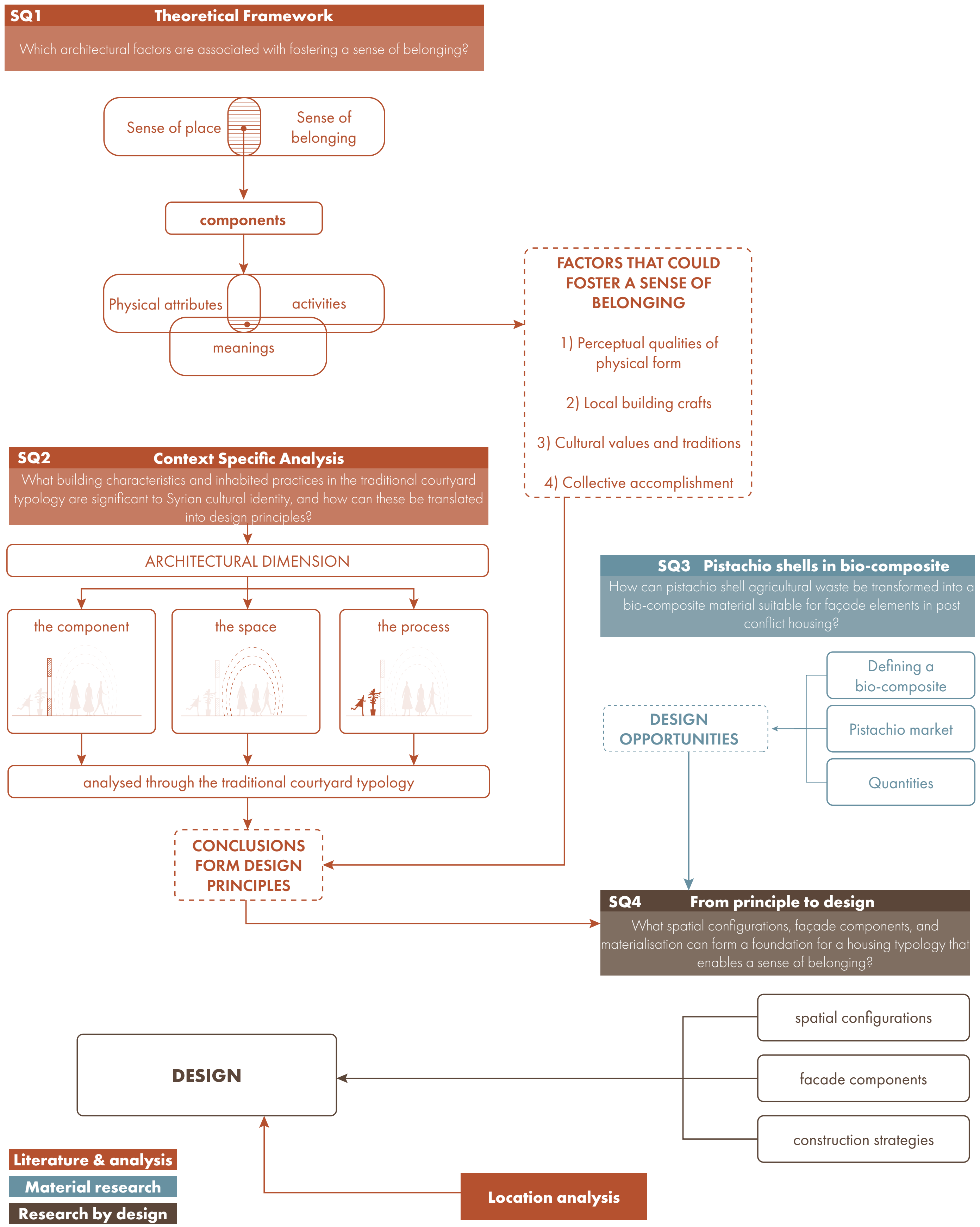


Figure 4 methodology diagram

2.2 THEORETICAL FRAMEWORK

2.2.1 SENSE OF PLACE AND RELATED CONCEPTS

Sense of place is widely used to describe how people experience, value, and feel attached to particular settings, going beyond the physical form (Najafi & Shariff, 2011). Several studies (Relph,1976; Steel, 1981; Najafi & Shariff, 2011) emphasize that this sense arises from the combination of three components: the physical attributes, the activities that take place there, and the meanings that people attach to it. This gets 'decoded' based on their roles, experiences, expectations, and motivations (Rapoport,1990). When these components intersect, places acquire a distinctive personality through which people experience belonging (figure X). When they do not, something called placelessness occurs; settings are culturally unidentifiable and emotionally thin (Relph, 1976; Hummon, 1992).

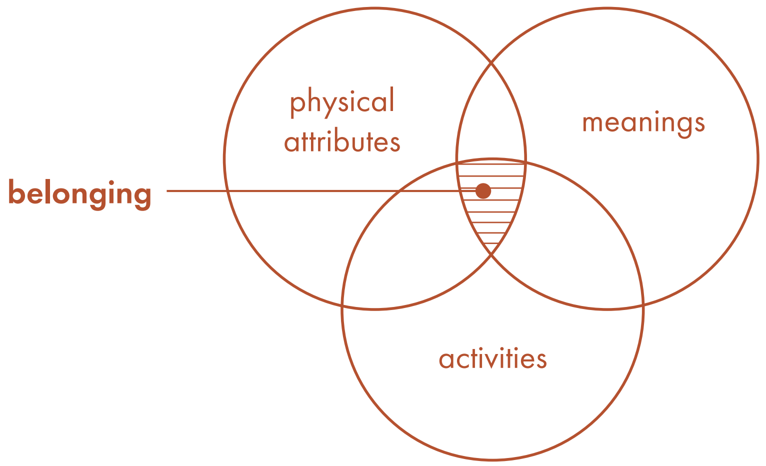


Figure 6: defining 'sense of place' based on (Najafi & Shariff, 2011)

Figure 7: the stages of 'sense of place', based on (Shamai, 1991)

Phenomenological and environmental psychology research associates a strong sense of place with feelings of security, continuity, and pleasure, and with a willingness to care for a setting (Steel, 1981; Hummon, 1992). Steele (1981), links sense of place to feelings of safety and enjoyment, and Hummon (1992) describes how identification or alienation with communities produces qualitatively different 'senses of place' even where the material environment is technically adequate. Synthesizing these perspectives, Najafi and Shariff (2011) argue that sense of place should be understood primarily as an emotional relationship that supports satisfaction, attachment, and pro-environmental attitudes toward settings

As sense of place is diffuse and difficult to measure directly, many authors treat place attachment as its evaluative or measurable dimension. Stedman (2008) describes it as how much a place means to people; it's a way of measuring the strength of the relationship between person and place. Empirical studies connect greater attachment to a place with greater psychological well-being, more environmentally friendly behaviour, and a willingness to invest time or resources in an environment, while displacement weakens this attachment (Altman & Low; Hummon, 1992).

Shamai's (1991) hierarchy of sense of place moves from simple knowledge of being in a place, through belonging, to stronger attachment, and ultimately willingness to sacrifice for a place. In this model, belonging

marks the early stage at which people feel that a place reflects who they are and that they are part of its social and spatial world, before this develops into deeper attachment and commitment. Within this conceptual framework, the thesis focuses on the sense of belonging, understood following Shamai (1991) as the stage at which people move beyond mere awareness of a place to emotional connection and identification with its symbols. This focus highlights whether rebuilt environments allow residents to re-establish this foundational connection, or whether they return physically to their neighbourhoods without recognising themselves in the spaces around them.

2.2.2 SENSE OF BELONGING THROUGH ARCHITECTURE

Within the tripartite model, explained in 2.2.1, architecture contributes primarily through the physical setting, but also mediates activities and meanings. Kim (2025), senior research lead in the Humanise campaign, argues that facades are not neutral surfaces but perceptual and emotional interfaces through which people build memories, identify with their surroundings, and decide whether a space feels like 'theirs.' Studies by Srikantharajah and Ellard (2025) link long, blank or highly reflective ground-floor facades with higher physiological arousal and more negative effects, while visually articulated and permeable facades, with depth, openings and visible signs of use, support comfort, interest, and casual social interaction (Ellard, 2020; Srikantharajah and Ellard, 2025). Additionally, Mazumder, Spiers, and Ellard (2020), report that environments with texture, variation, human-scale, and sky views evoke positive emotional responses.

Cognitive architecture research in the same evidence base includes work by Coburn, Vartanian, and Chatterjee (2020), which indicates that facades with a coherent but rich visual structure are processed more fluently and tend to be very engaging. Combined, these findings imply that certain façade qualities can support comfort, interest, and social presence, providing a foundation for stronger emotional bonds to architecture and the built environment.

However, perceptual characteristics alone are not sufficient to explain belonging. Former resident and architect Al-Sabouni (2016) argues that architecture that ignores local values and lived-experiences not only appears placeless, but also indicates that people don't feel seen or respected, which leads to social disruption. According to her, Syrians are not asking for 'copy-pasting' pre-war historical styles, but for 'our own architecture'. This means buildings that use particular 'principles', such as familiar materials and climate-responsive craftsmanship, through contemporary forms, expressing moral integrity and shared accomplishments. Every day setting will once again convey a common ethical and cultural narrative. Research into place-basedness supports this vision. Altman and Low (1992) describe how culture-related practices and narratives bind life trajectories to specific settings, while Najafi and Shariff (2011) emphasize that the perceptual characteristics only support the sense of belonging when activities and meanings are consistent with them over time. Architectural form, specifically facades, can be both a product and a medium of these relationships.

2.2.3 CONCLUDING FRAMEWORK

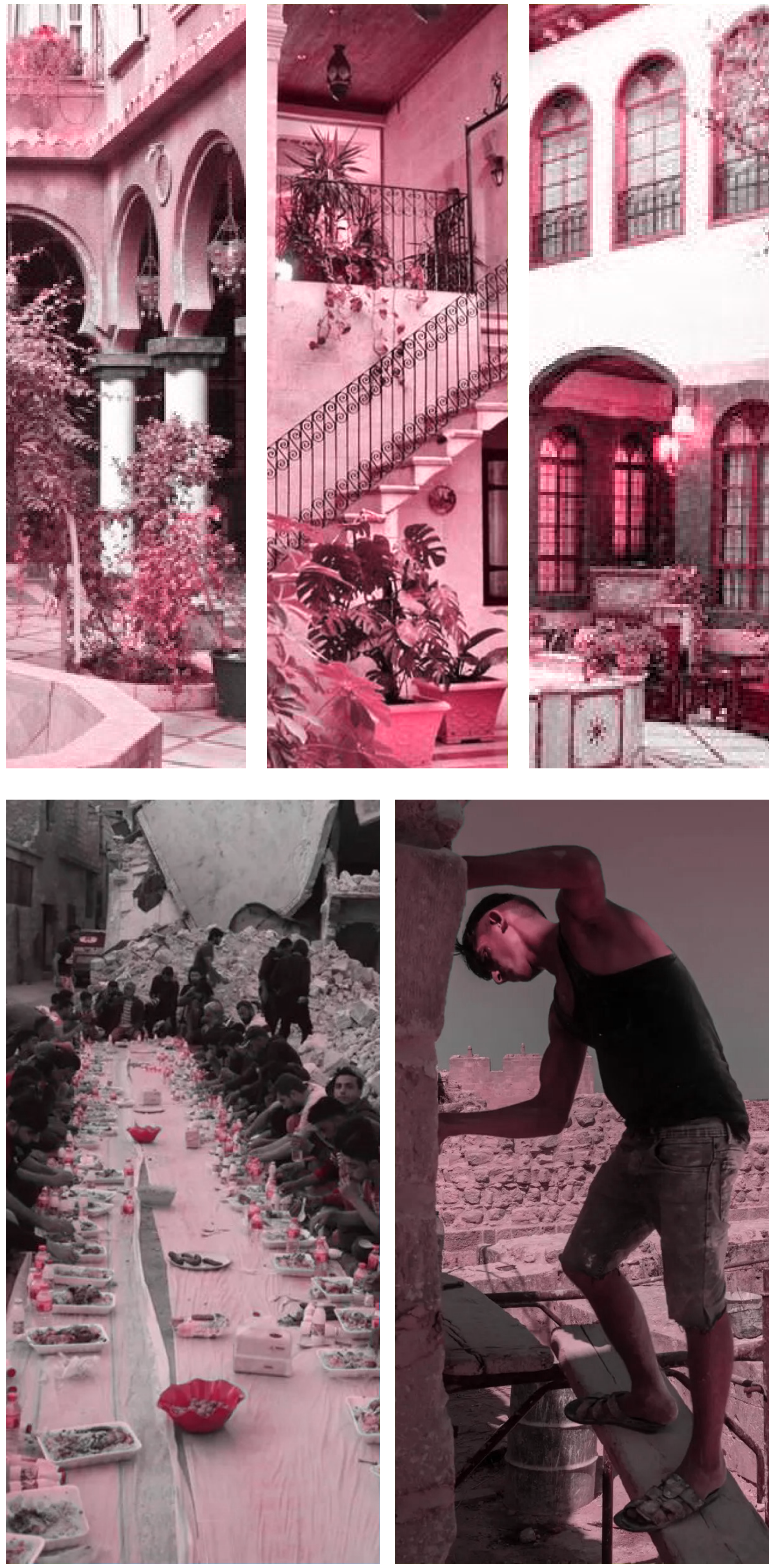
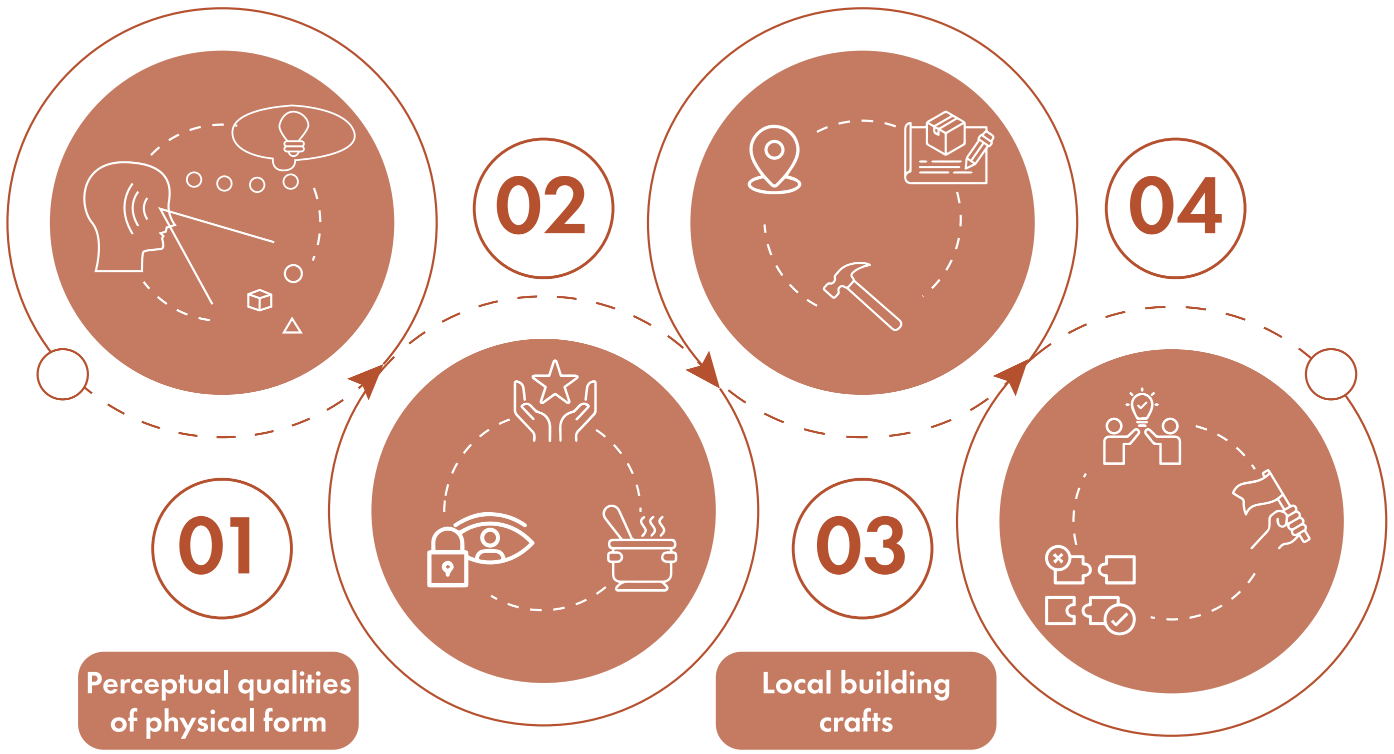


Figure 8: collection of photo's from courtyards



01 Perceptual qualities of physical form

Refers to the legibility, human scale, and organised visual complexity of buildings that support comfort, recognition and imageability.

Kim, 2025
Srikantharajah and Ellard, 2025
Mazumder, Spiers, and Ellard, 2020

02 Cultural values & traditions

Refers to shared values and practices that are anchored in a space and informs how spaces are used and interpreted.

Relph, 1976
Al-Sabouni, 2016
Altman and Low, 1992

03 Local building crafts

Refers to locally rooted materials, construction techniques and climate-responsive forms that embed vernacular knowledge.

Al-Sabouni, 2016
Azzouz, 2023
Srikantharajah and Ellard, 2025

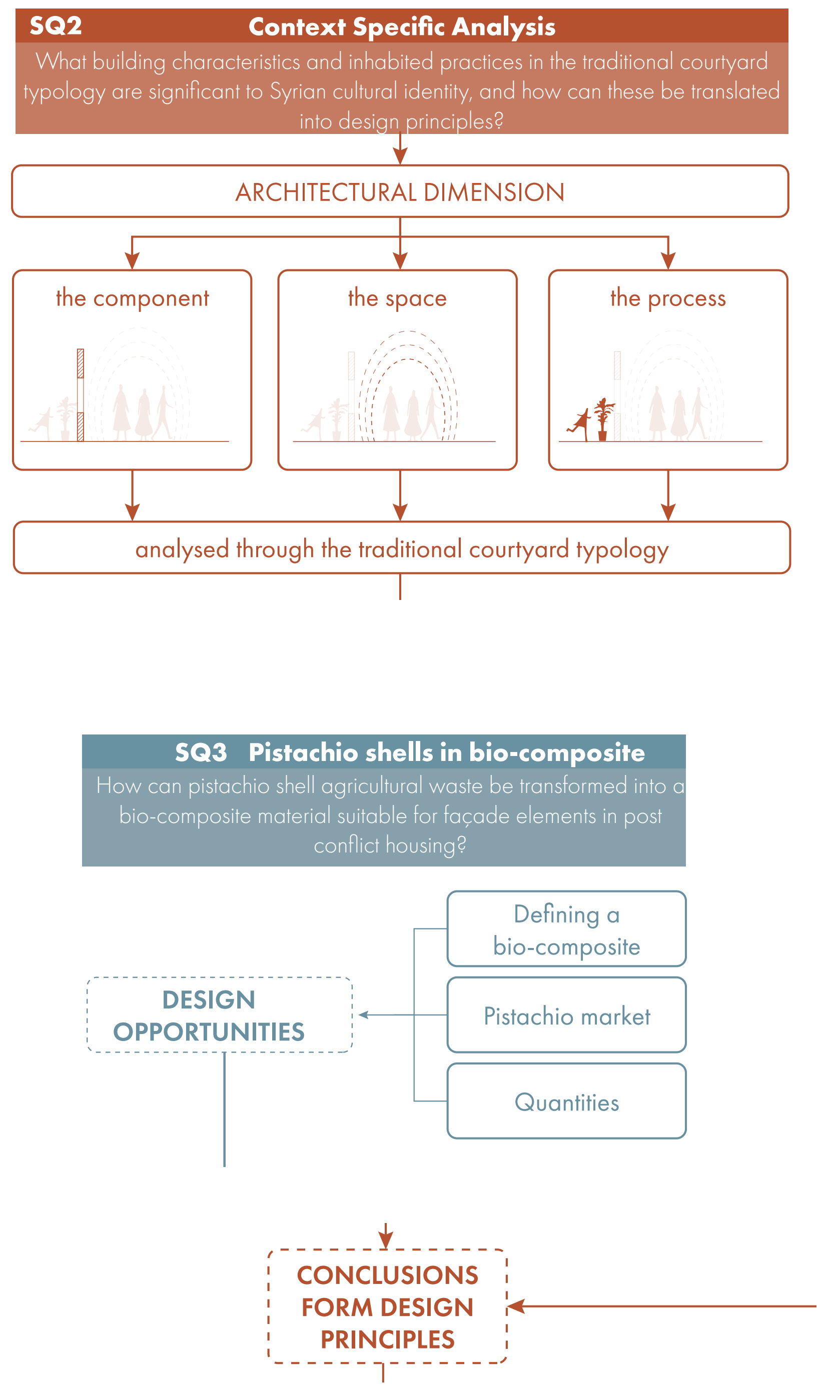
04 Collective accomplishment

Refers to the shared sense that a community has produced something of value together, which generates pride and accomplishment.

Al-Sabouni, 2016
Azzouz, 2023

Figure 9: Architectural factors of belonging based on the literature

As conclusion, four factors were selected (Figure X) that could bring back this sense of belonging according to multiple sources in the literature review.



03 RESULTS: RESEARCH

This chapter recaps the research that has been done during the project. The full pieces can be found in Appendix A & B. The research responds to the subquestions:

- What building characteristics and inhabited practices in the traditional courtyard housing are significant to Syrian cultural identity, and how can these be translated into design principles?'

- How can pistachio shell agricultural waste be transformed into a bio-composite material suitable for façade components in post-conflict housing in Homs, Syria?

The full pieces can be found in the appendix. The chapter ends with conclusion in the shape of design principles and a analysis into the city Homs and its areas.

3.1 TRADITIONAL COURTYARD HOUSING

ABSTRACT

What building characteristics and inhabited practices in the traditional courtyard housing are significant to Syrian cultural identity, and how can these be translated into design principles?

This analysis answers sub-question 3 by examining the Syrian courtyard house as a typology that combines spatial organization, material expression, and cultural practice to create belonging. Focusing only on the courtyard house, it studies the façade as a component, space, and process, and reads it through Syrian architectural critiques, studies of traditional dwellings, and oral accounts of everyday life before the war. The analysis shows that the courtyard house creates a graded relationship between privacy and collectivity, supports climate-responsive living, and records adaptation through incremental construction and local craft.

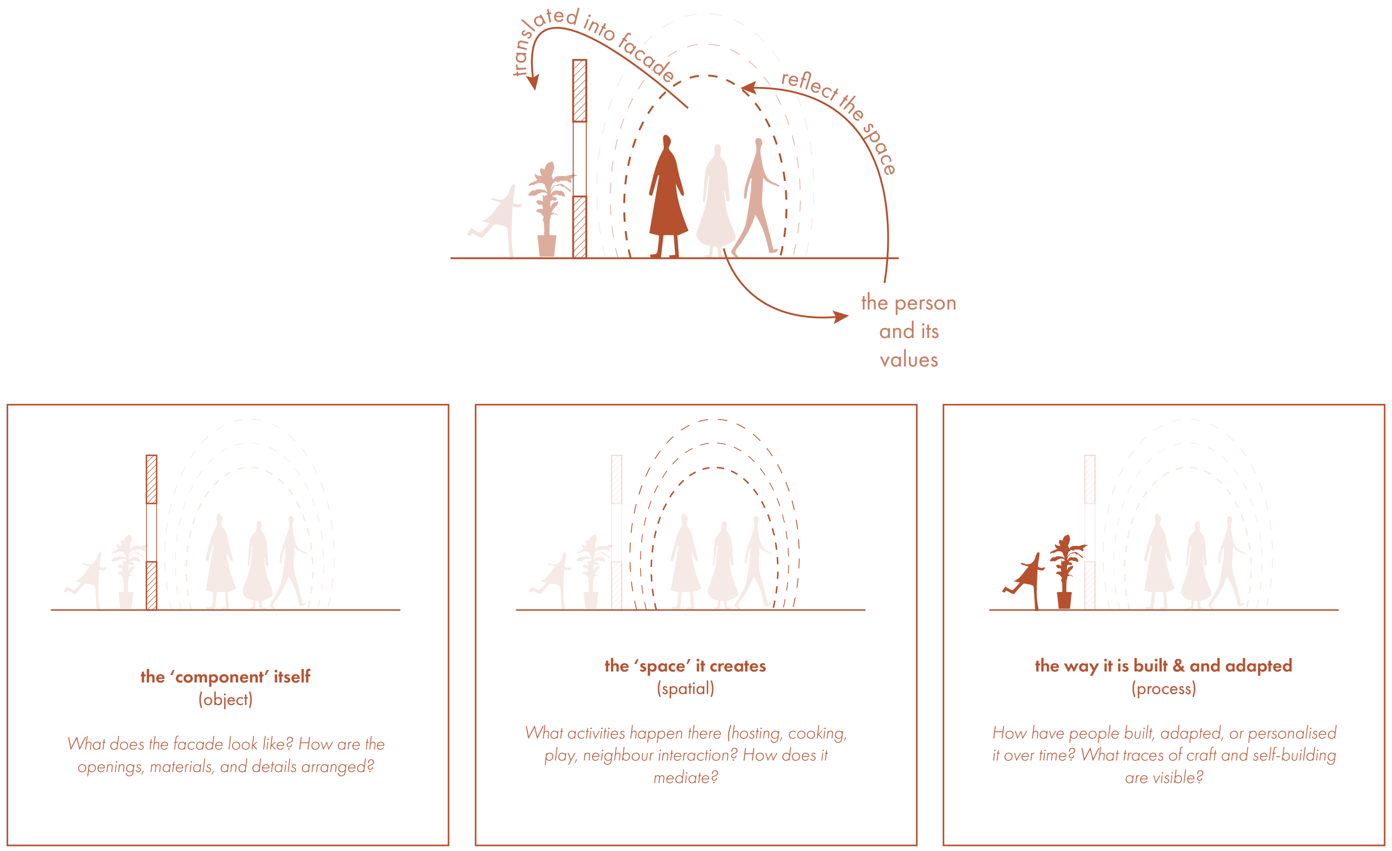


Figure 10: facade dimesions

Figure 11: courtyard house movement based on season and time of day diagram

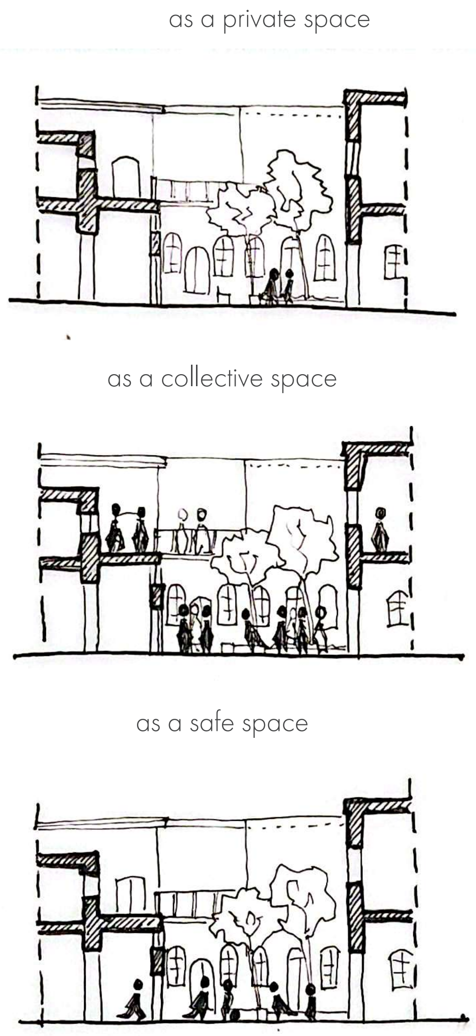


Figure 12: courtyard house social functions diagram

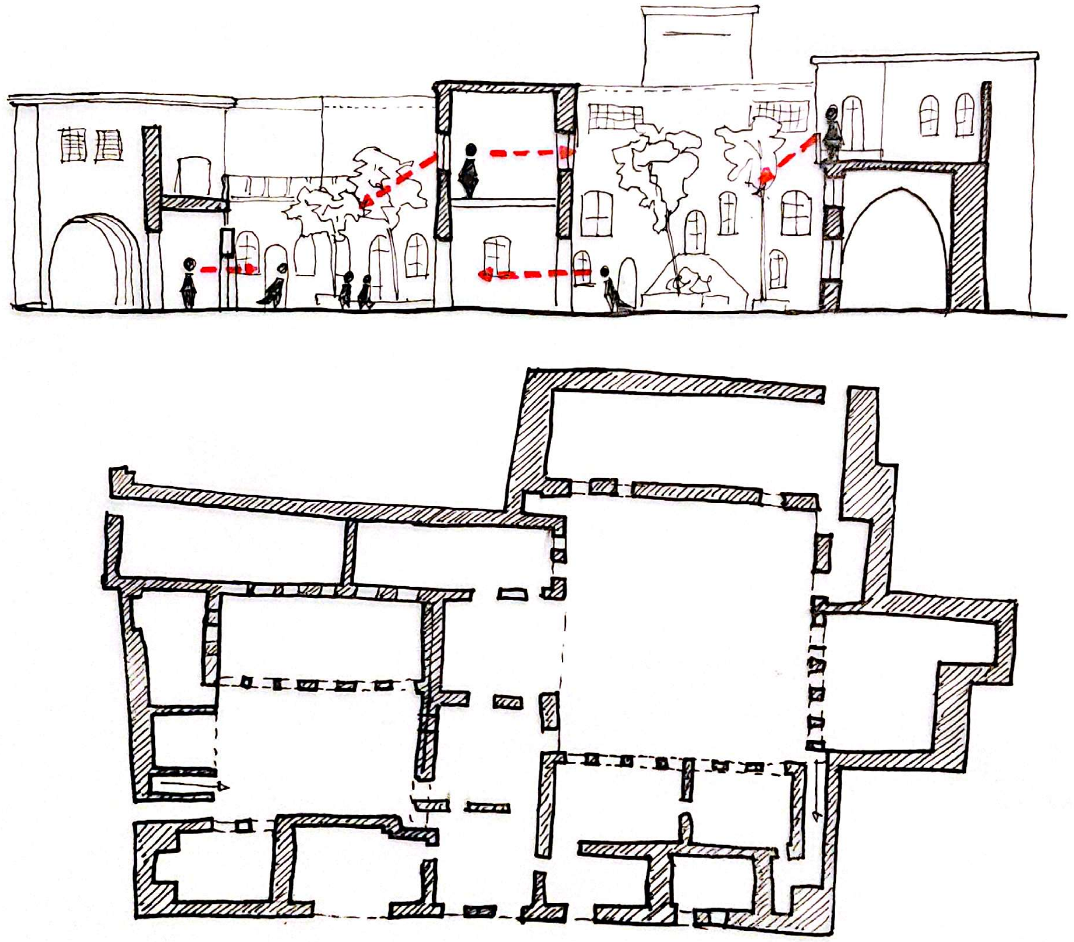


Figure 13: open view across spaces and levels diagram

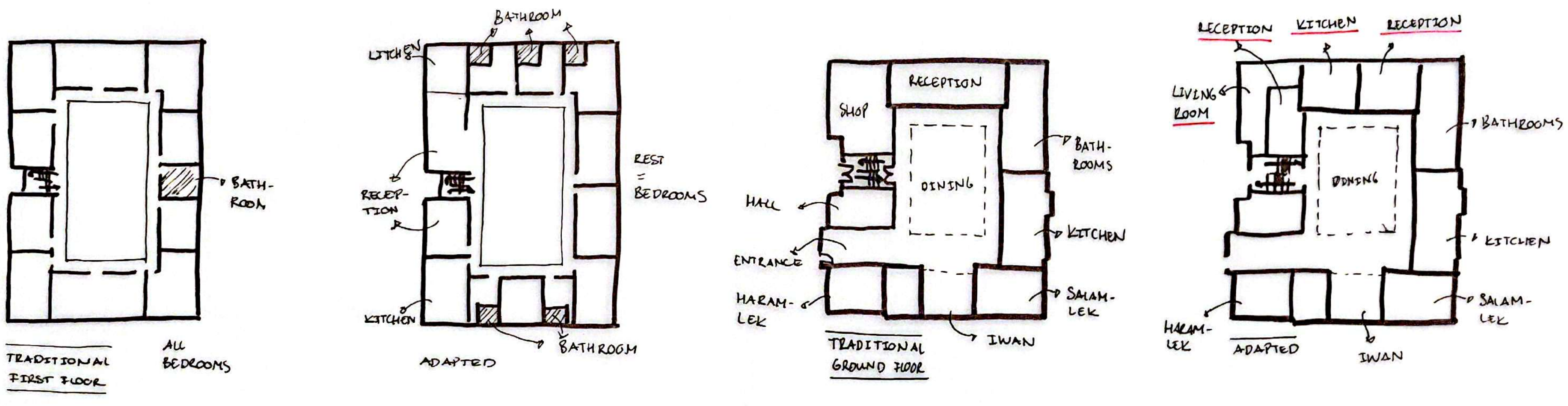


Figure 14: change in households visible in spaces

Figure 15: privacy gradient through the facades

3.2 SYRIA'S RED GOLD

ABSTRACT

How can pistachio shell agricultural waste be transformed into a bio-composite material suitable for façade components in post-conflict housing in Homs, Syria?

This paper answers sub-question 2 by exploring whether pistachio shell waste from Syria can be transformed into a bio-composite suitable for façade panels in post-conflict Homs. It argues that pistachio shells, a low-value agricultural by-product, can function as a bulk filler in a locally sourced composite system, combined with a suitable bio-based matrix. Through literature review and material selection, the study identifies pistachio shells as a technically viable material for a bio-based composite material. Furan resin emerges as the most suitable matrix for exterior façade use, while fibre reinforcement is not considered necessary for the intended application. The paper also outlines a feasible low-tech manufacturing route based on bulk compression moulding and estimates, even with assumptions based on old data, the shell output of pistachio orchards could translate into meaningful façade areas, indicating real potential for future integration into reconstruction strategies.

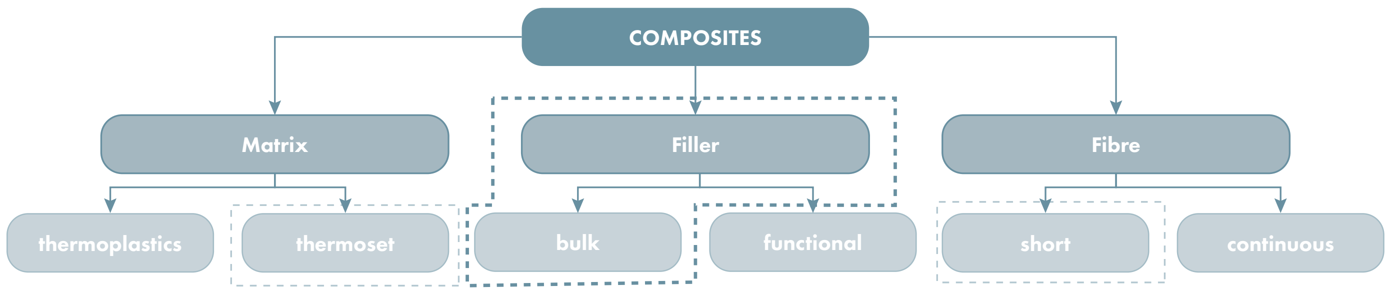


Figure 16: typical composition for polymeric composites

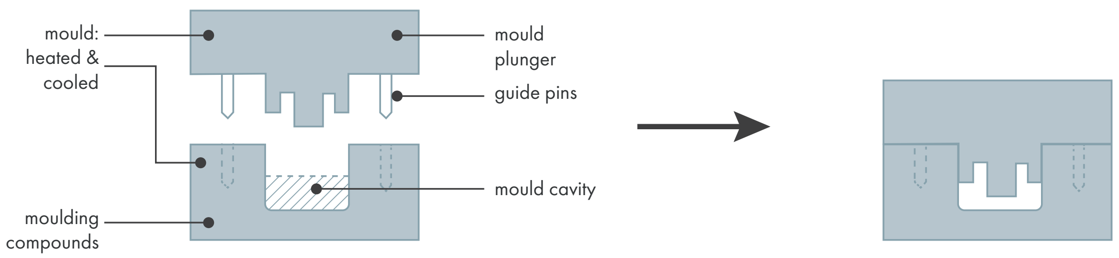


Figure 17: Compression moulding

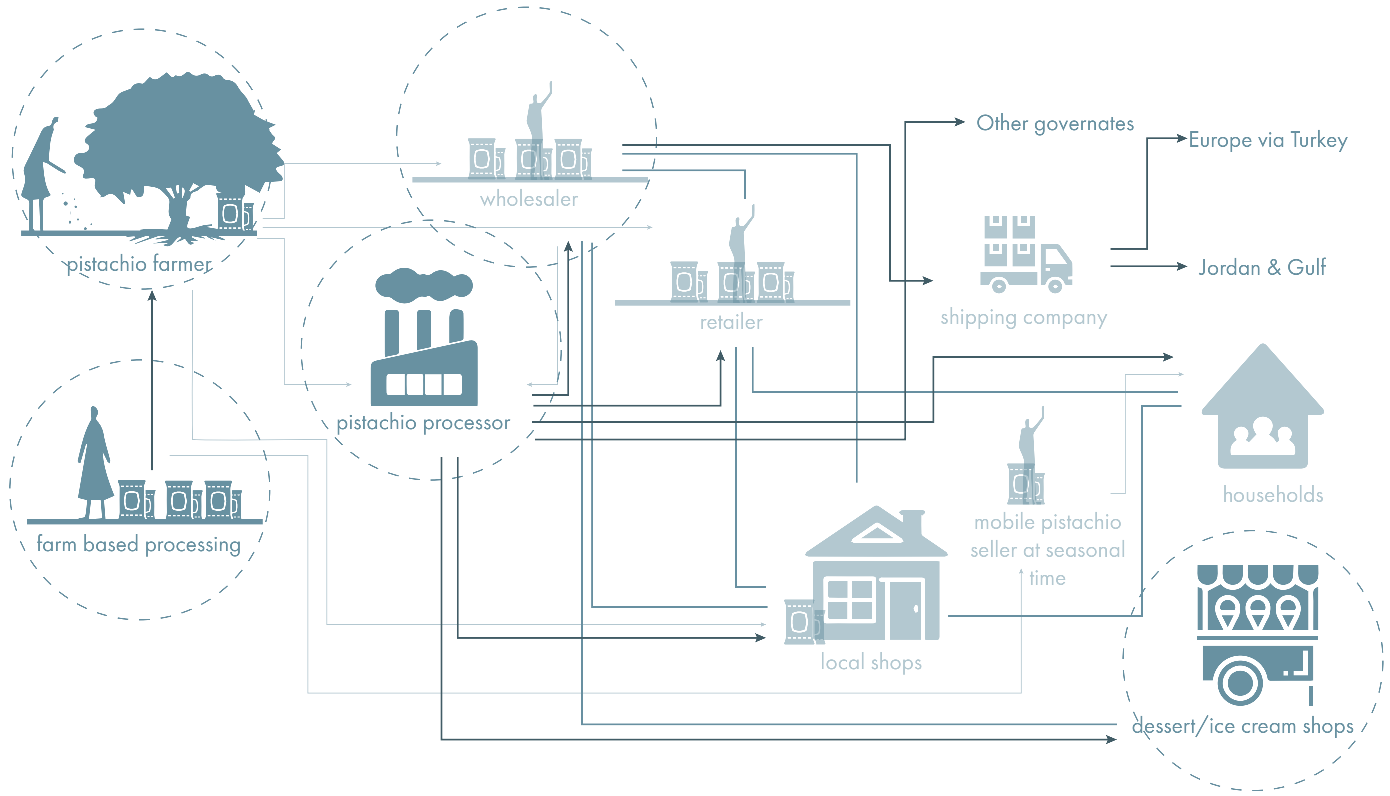
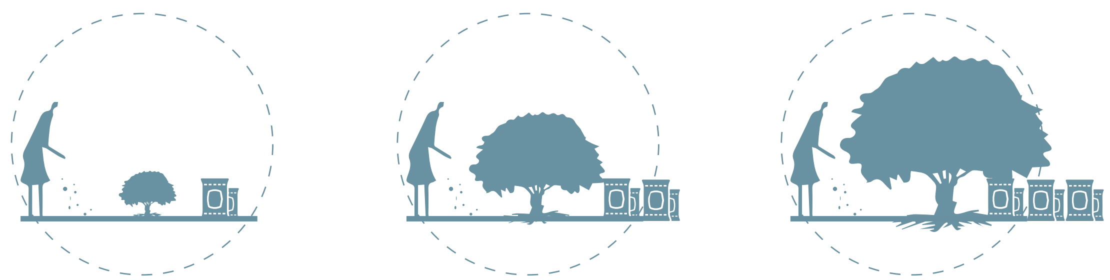


Figure 18: Mapping of pistachio (shells), based on data from (iMMAP, 2019)



	YOUNG TREE	AVERAGE TREE	MATURE TREE
PISTACHIO KG/TREE	1- 2 KG	6 - 10 KG	> 15 KG
SHELL KG/TREE	0.5 - 1 KG	3.0 - 5.0 KG	> 7.5
FACADE PANEL (M2)	0.10 - 0.20	0.6 - 1	> 1.5

Figure 19: Mapping of pistachio (shells), based on data from (iMMAP, 2019)

3.3 DESIGN PRINCIPLES

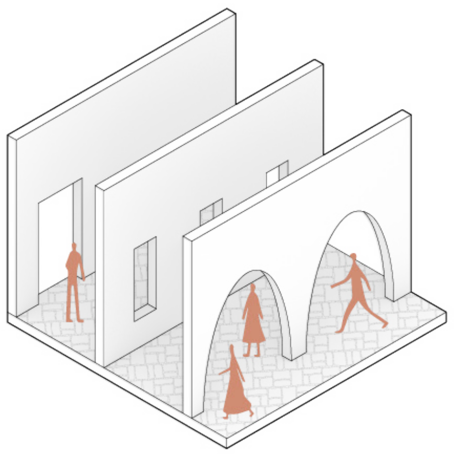
From these observations, the paper extracts design principles relevant to façade design and domestic space in the Syrian context.

SPATIAL	[3] clear public - private gradient Design some type of sequence from public to a semi-public transitional zone to a more private shared space. Residents can control who crosses which threshold and when.	[3] co-presence & supervision Arrange rooms, galleries and circulation space so people can see and hear each other across levels without being in the same room, enabling everyday watching, greeting and informal care for children and elders.	[3] [2] climate wisdom in spatial layout Shape semi-open spaces and their edges to produce shade, air movement and seasonal sun access, so outdoor life is comfortable and naturally aligned with local climate.	[3] [4] shared inward orientated space Provide a collective space that is visually protected from the 'outside' but easily reached from dwellings, echoing the role of the courtyard as a daily living room and multi functional space.
COMPONENT	[1] [3] differentiate outer & inner facade Let street facing façades be more controlled, with carefully placed openings, while inner façades can be more open, articulated and expressive, making the inside of the community visibly distinct from the outside world.	[1] [2] human scale - articulation Façades with readable rhythms of openings, galleries, and edges, and include details at eye level that are recognisable.	[1] [2] modest ornaments Creating some detail in the facade, without copy-pasting from the past	[2] facade dept as climatic- and social tool Design projections, recesses, arcades and shading devices so that the relief of the façade itself creates comfortable, usable edges for sitting, watching, and hosting, not just visual effects.
PROCESS	[4] allow change Detail façade systems so residents can add or adjust elements over time (screens, small extensions), making space for negotiated privacy and changing family needs.	[2] [4] involve local craft Use construction methods and components that can involve local masons, carpenters and metalworkers, so their skills are embedded in visible parts of the façade and residents recognise familiar techniques and materials.	[2] [4] personalisation Accept a degree of variation and "patina" so that repairs, additions and personalisation remain legible on the façade as traces of family and collective effort, rather than being systematically erased.	[3] privacy as something adjustable Provide layers (screens, shutters, graded openings) that residents can operate or modify to tune visibility and openness over time, reflecting ongoing negotiation between traditions and contemporary aspirations.

Figure 20: design principles

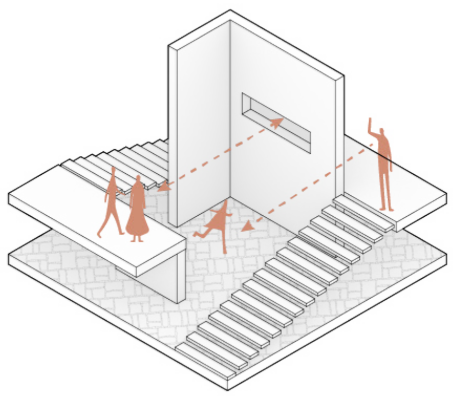
FIVE FOCUS POINTS

SPATIAL	[3] clear public - private gradient	[3] co-presence & supervision	[3] [2] climate wisdom in spatial layout	[3] [4] shared inward orientated space
COMPONENT	[1] [3] differentiate outer & inner facade	[1] [2] human scale - articulation	[1] [2] modest ornaments	[2] facade dept as climatic- and social tool
PROCESS	[4] allow change	[2] [4] involve local craft	[2] [4] personalisation	[3] privacy as something adjustable



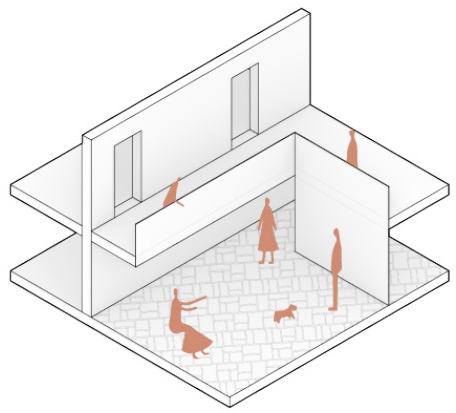
Clear public – private gradient

Design some type of sequence from public to a semi-public transitional zone to a more private shared space. Residents can control who crosses which threshold and when.



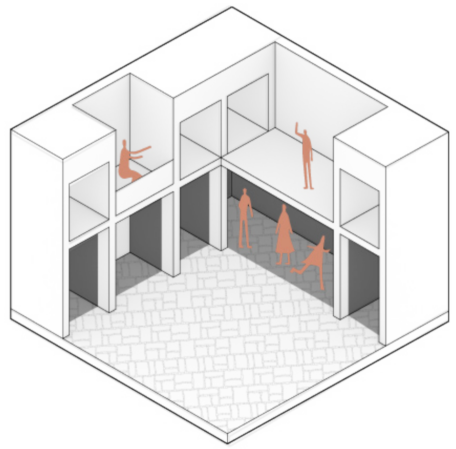
Support a structured co-presence and supervision

Arrange rooms, galleries and circulation space so people can see and hear each other across levels, enabling everyday watching, greeting and informal care for children and elders.



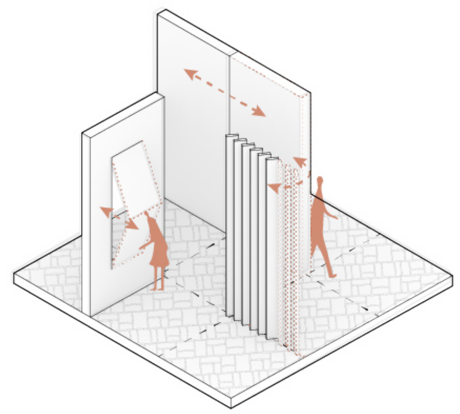
Create an inward-oriented shared outdoor room

Provide a collective space that is visually protected from the 'outside' but easily reached from dwellings, echoing the role of the courtyard as a daily living room and multi functional space.



Facade as climatic and social tool

Design projections, recesses, arcades and shading devices so that the relief of the façade itself creates comfortable, usable edges for sitting, watching, and hosting, not just visual effects.



Privacy as something adjustable

Provide layers (screens, shutters, graded openings) that residents can operate or modify to tune visibility and openness over time, reflecting ongoing negotiation between traditions and contemporary aspirations

3.4 SITE ANALYSIS

NEIGHBOURHOOD SCALE

This site was selected by translating priorities from the Homs Recovery profile into criteria that match the project's typology and recovery goals. The project is located in a severely to moderately damaged neighbourhood in Area A1, aligning with calls for integrated housing interventions in heavily affected areas while also supporting rehabilitation in less damaged zones. The plinth functions as a makerspace producing pistachio-shell building components for the dwellings above and for wider distribution across the city, linking immediate repair needs with long-term reconstruction.

The site also meets three key criteria from the profile. First, it lies in an area with high return rates, where residents are already reoccupying partially damaged housing, identified as a major recovery pattern. Second, it is close to orchards and the northern industrial belt, enabling access to pistachio-shell resources and connecting the project to local construction and labour networks. Third, the neighbourhood retains moderate to high urban functionality, with most infrastructure and primary roads operational, supporting viable return and everyday life.

Situated within the wider A1–B recovery corridor, the project contributes simultaneously to housing repair, the local construction value chain, and livelihoods for returnees and IDPs.

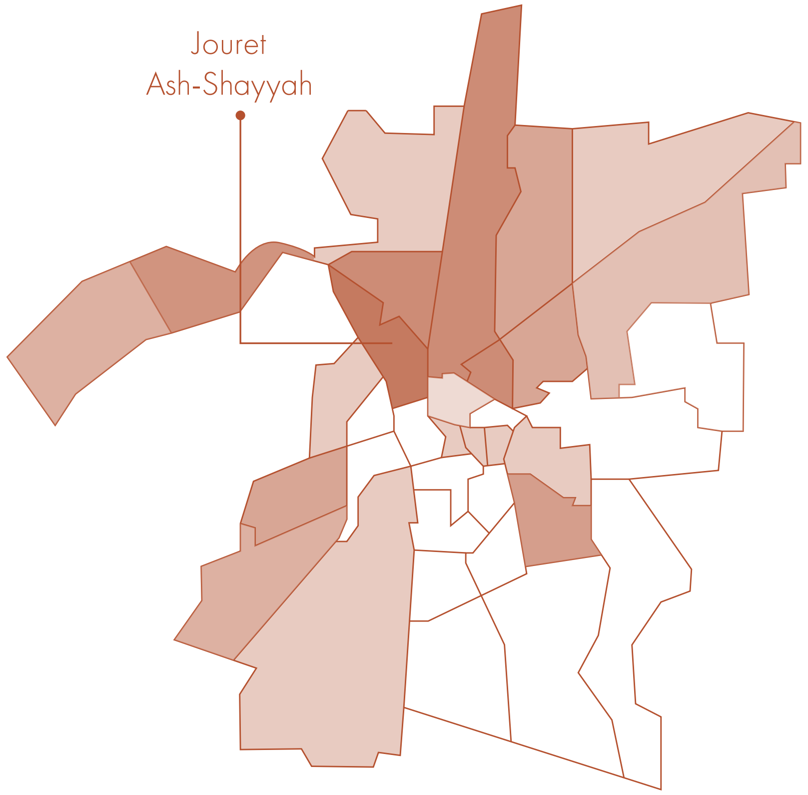
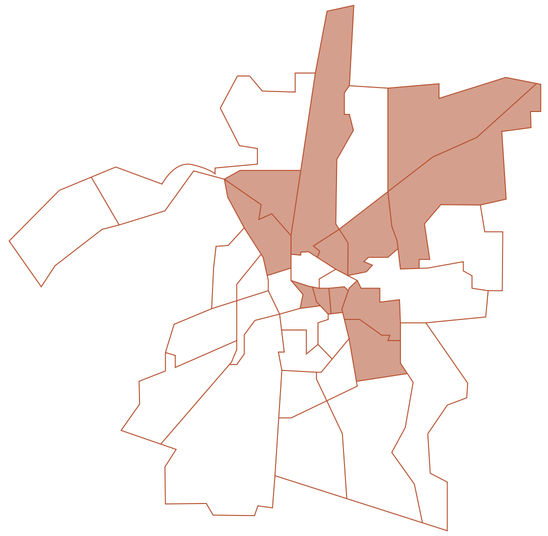
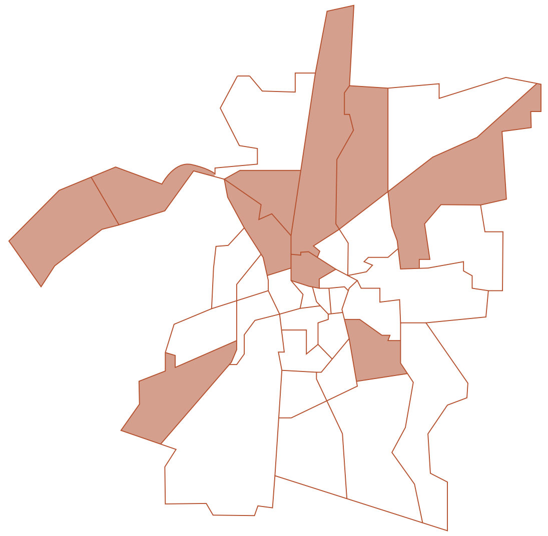


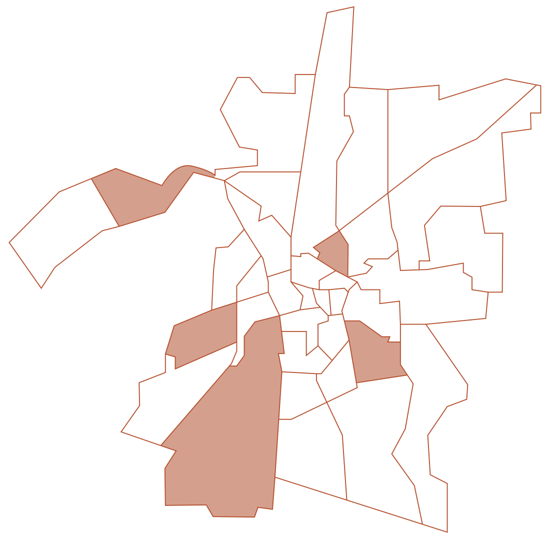
Figure 21: chosen area



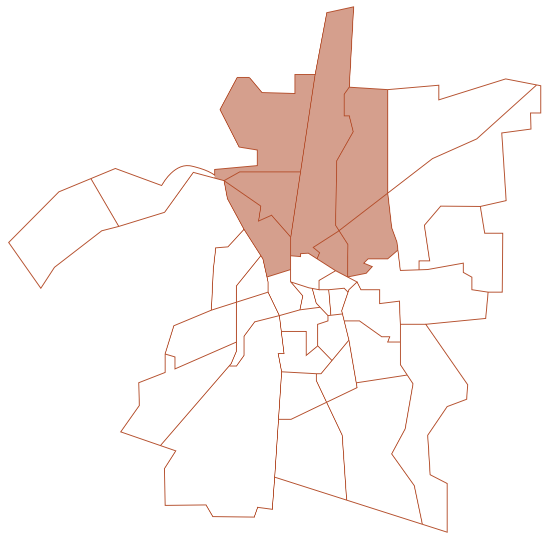
severly damaged



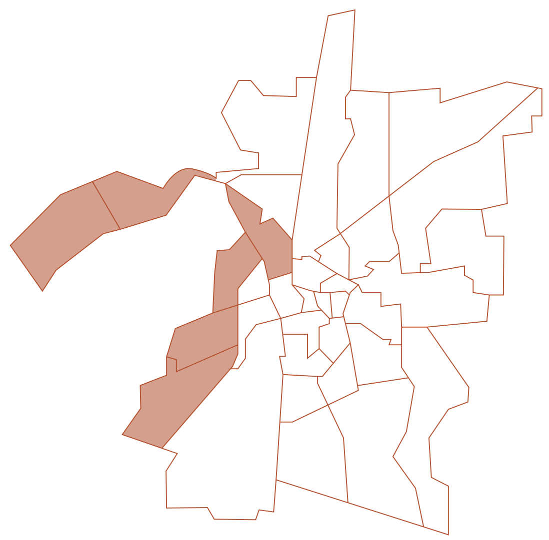
high return



middle to high functionality



Area A1:



close to orchard

AREA ANALYSIS: JOURET ASH-SHAYYAH

The restoration of this area's economic activities is strongly linked to the restoration of its residential fabric and the return of its SMEs. Priority intervention should focus on the rehabilitation of main commercial streets along with adjacent residential buildings, infrastructure, social and administrative services.

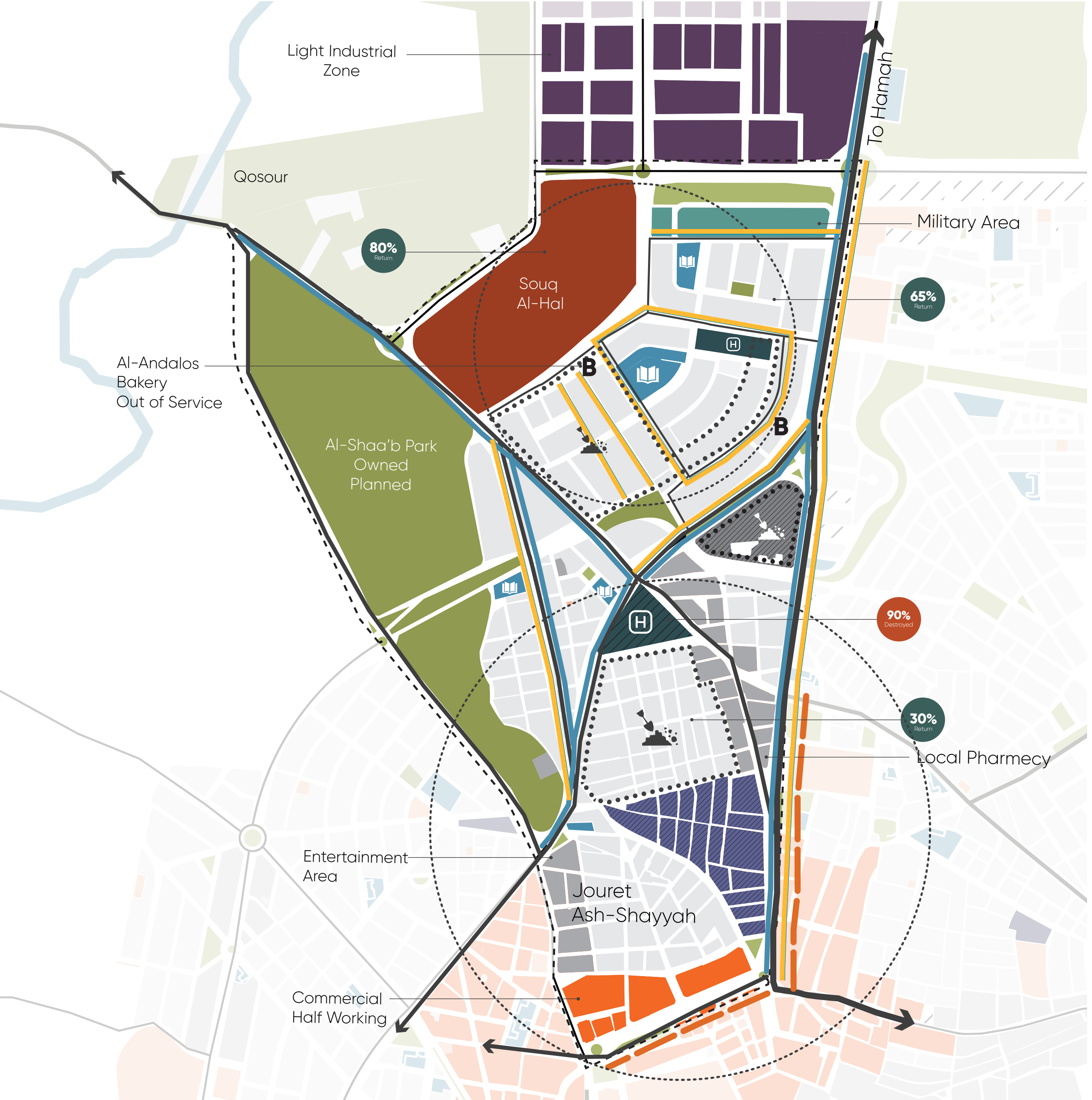


Figure 22: vision map by Humane Habitat

04 RESULTS: FROM RESEARCH TO DESIGN

This chapter addresses the final design-oriented sub-question: What spatial configurations, façade components, and materialisation can form a foundation for a housing typology that fosters a sense of belonging? The question is answered through the design process (Appendix C), which develops studies of spatial organisation, façade systems, and materials strategies into the final architectural proposal.

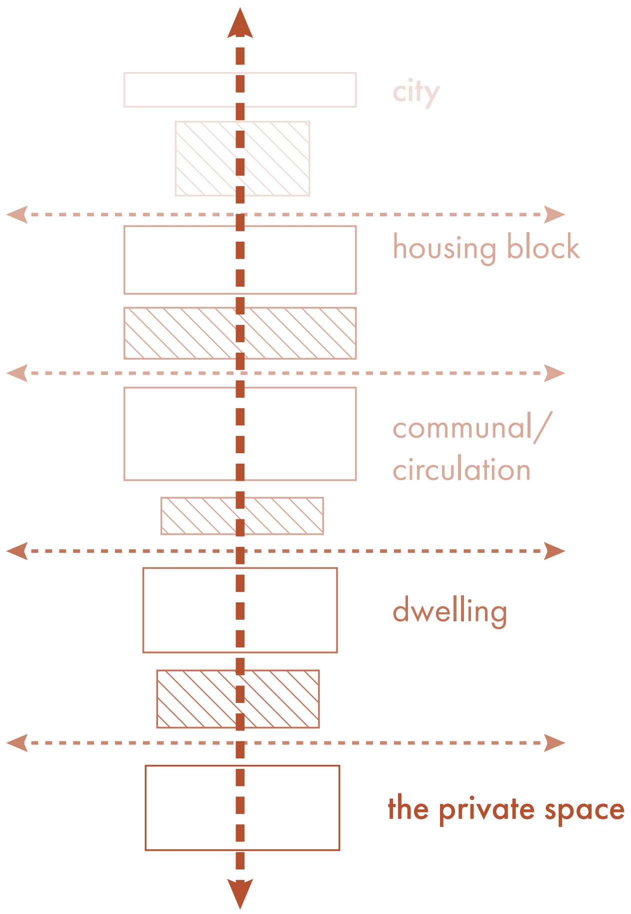
CONCEPT DEVELOPMENT

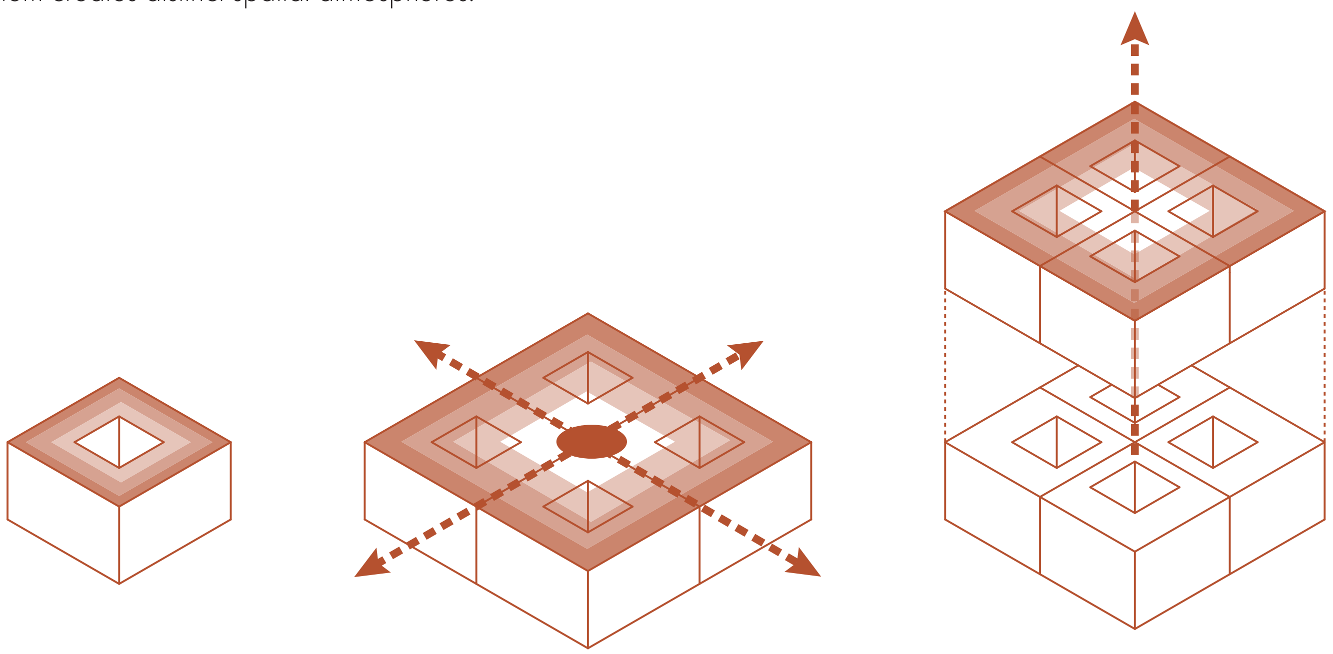
BUILDING TYPOLOGY DEVELOPMENT

The traditional courtyard typology proved highly effective in creating climate-responsive and cohesive environments. However, due to urbanisation, this typology has largely disappeared from the contemporary city. Rather than replicating the historical courtyard house, this project reinterprets its underlying principles within a contemporary architectural language.

Central to this interpretation is the concept of thresholds. Instead of separating space into rigid public and private categories, the project creates a sequence of intermediate conditions through galleries, courtyards, facades and circulation spaces. The spatial concept starts from a simple question: What happens if the courtyard is no longer a single element, but multiplied into a system?

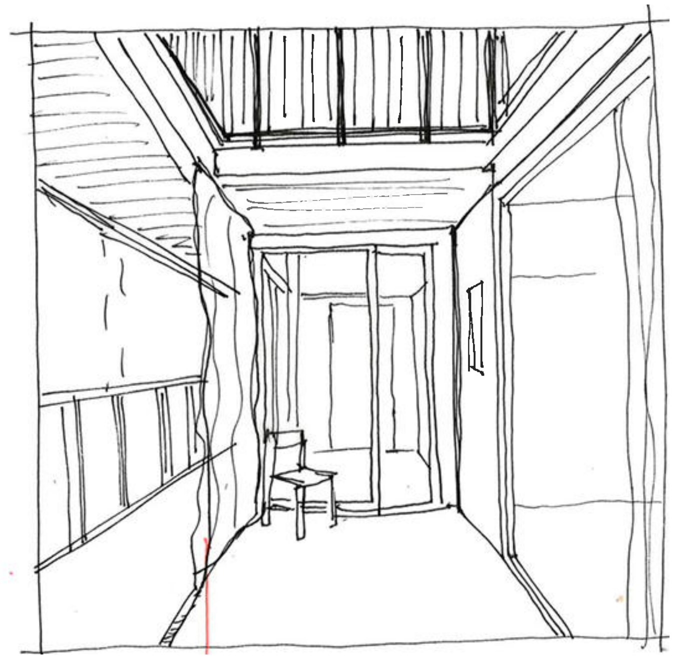
By repeating and connecting simplified courtyard volumes, the building generates gradients of privacy, collectivity, openness, and enclosure. Each position within this system creates distinct spatial atmospheres.



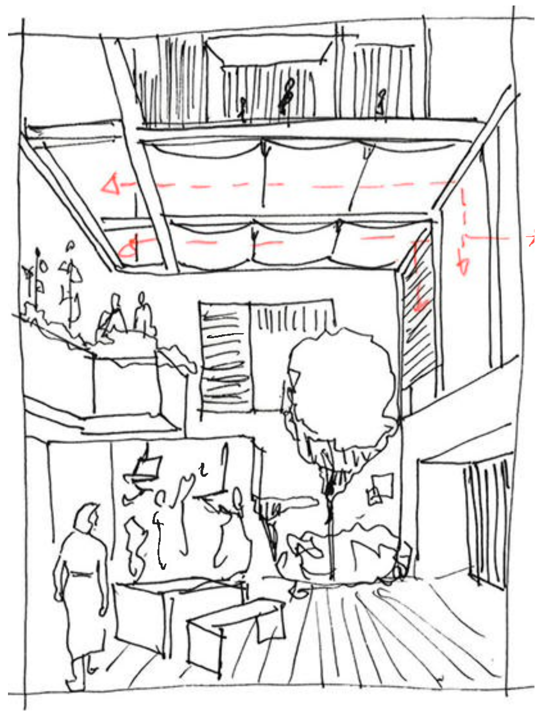


BRIEF COMMUNAL SPACE

Instead of assigning fixed functions from the start, the design focuses on defining atmospheres, meaning, spatial qualities defined by layout and facade that guide how spaces are used and experienced.



1. Galleries are designed as inhabited thresholds rather than purely functional circulation: A walkway up to the door, seating edges, planting, and informal appropriation between neighbours.

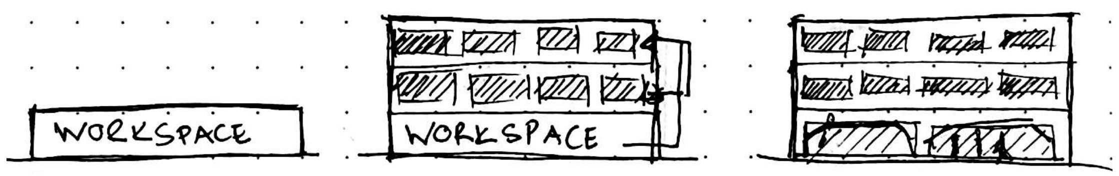


2. The courtyards (including the other communal space shattered in the building) create different communal atmospheres. The more open courtyards operate as active collective spaces for gathering, play, and shared daily activities,

3. while more enclosed courtyards provide quieter spaces for retreat and informal conversations. Together, they establish a gradual transition from public to collective to private space.

PLINTH VS COURTYARD ORGANISATION

PHASING

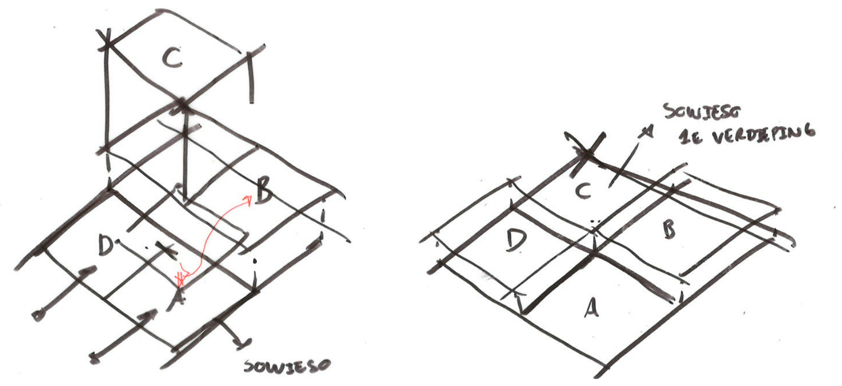


A. Foundational structure: Starts as workspaces for the material development.

B. Vertical expansion with material made in plinth.

C. Function plinth changed into other 'active functions' like restaurants and shops

VERTICAL ORGANISATION VARIANTS

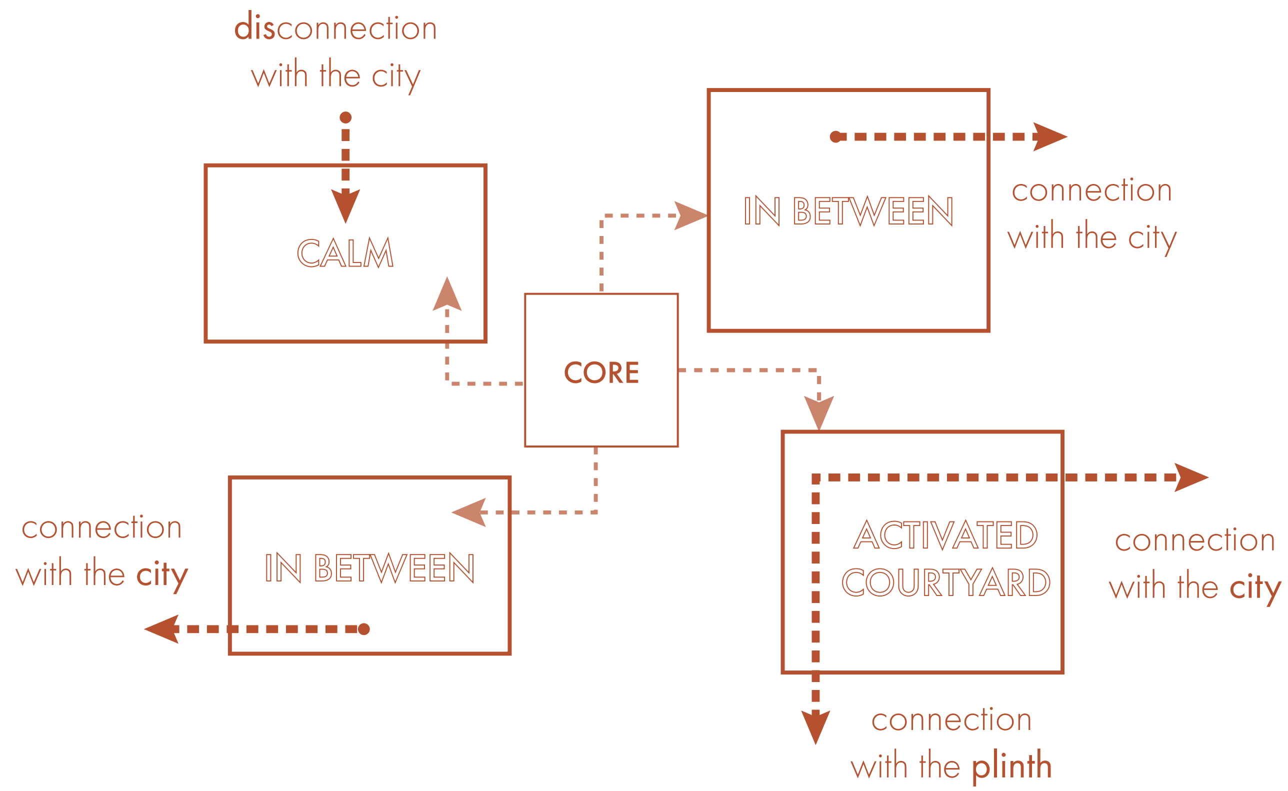


This spatial hierarchy has been adjusted to its urban context. On the east side, facing the main road and the mosque, the building forms an activated plinth that establishes the project's most public edge. During construction, this plinth functions as a workspace for producing façade panels and other building materials. After completion, it transforms into shops and restaurants, maintaining an active connection between the building and the street, while also activating the street.

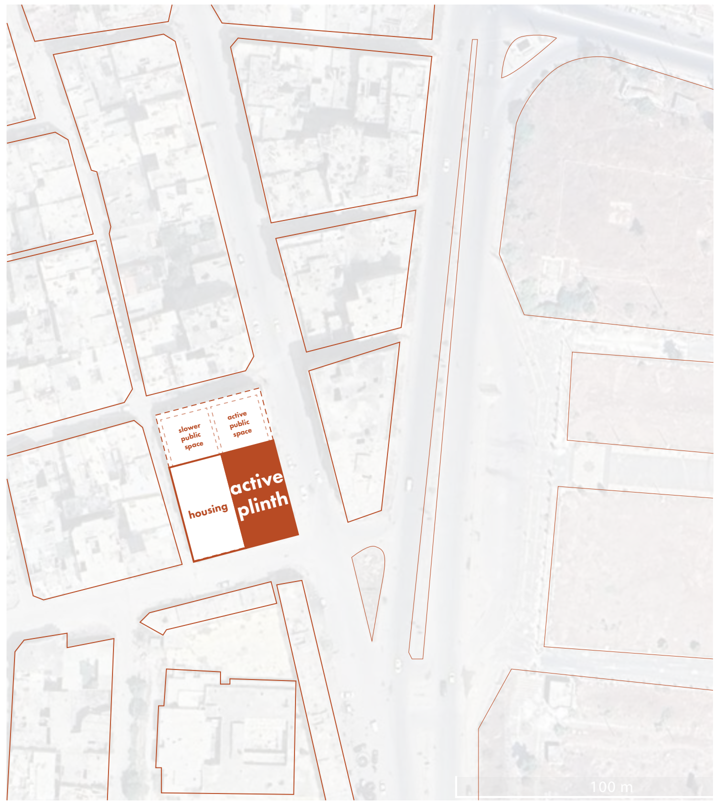
On the west side, the building becomes more inward-focused, with housing organized around courtyards. Here, the spatial sequence shifts toward more private conditions.

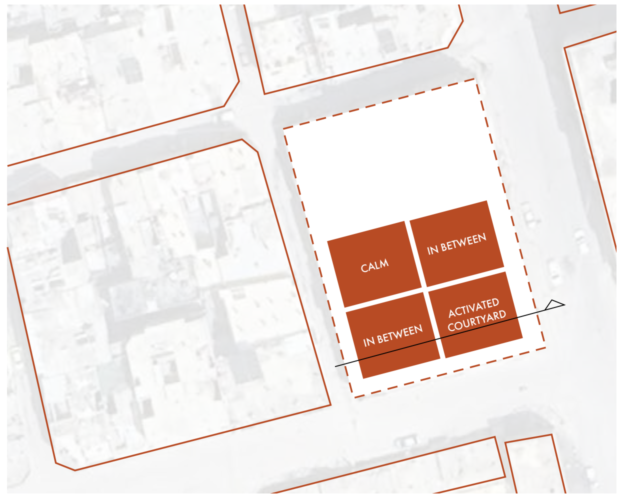
To maintain privacy while still benefiting from the liveliness of the street, the courtyards along the main road are elevated above the plinth. This creates a physical and visual threshold: the activity of the city remains present, but is filtered and distanced, allowing residents to engage with it on their own terms.

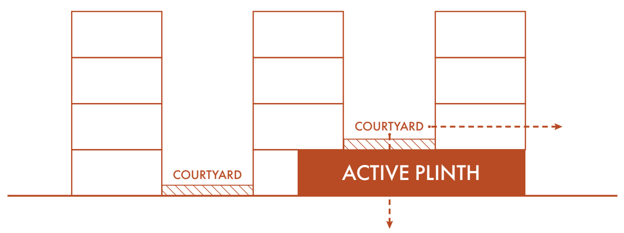
COURTYARD ORGANISATION



COURTYARDS IN RELATION TO CONTEXT

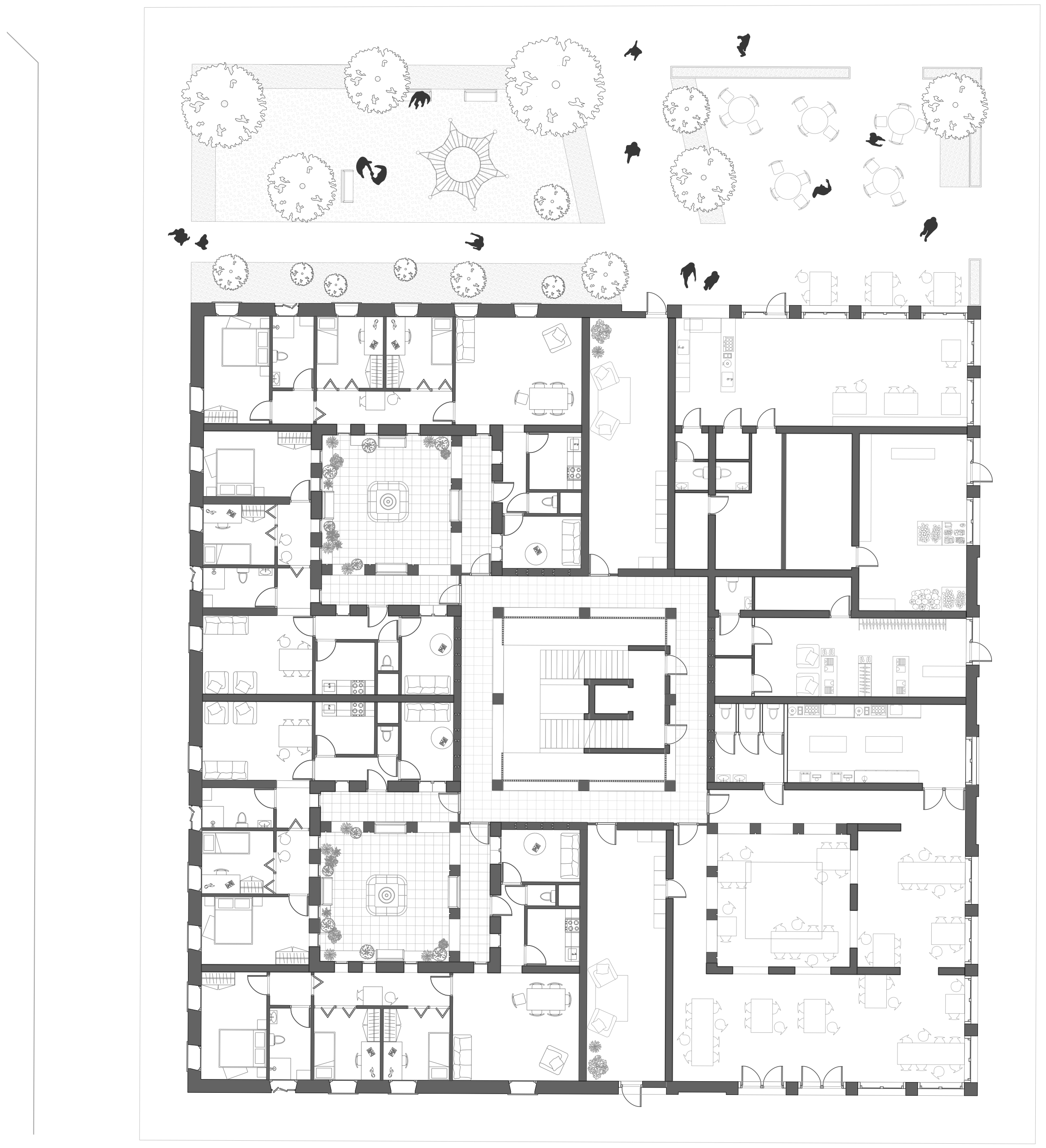






URBAN CONTEXT

Access to the building is organised through a sequence of thresholds. Entry occurs through hallways positioned away from the busy street, creating a buffer between the public city and the semi-private interior of the block.

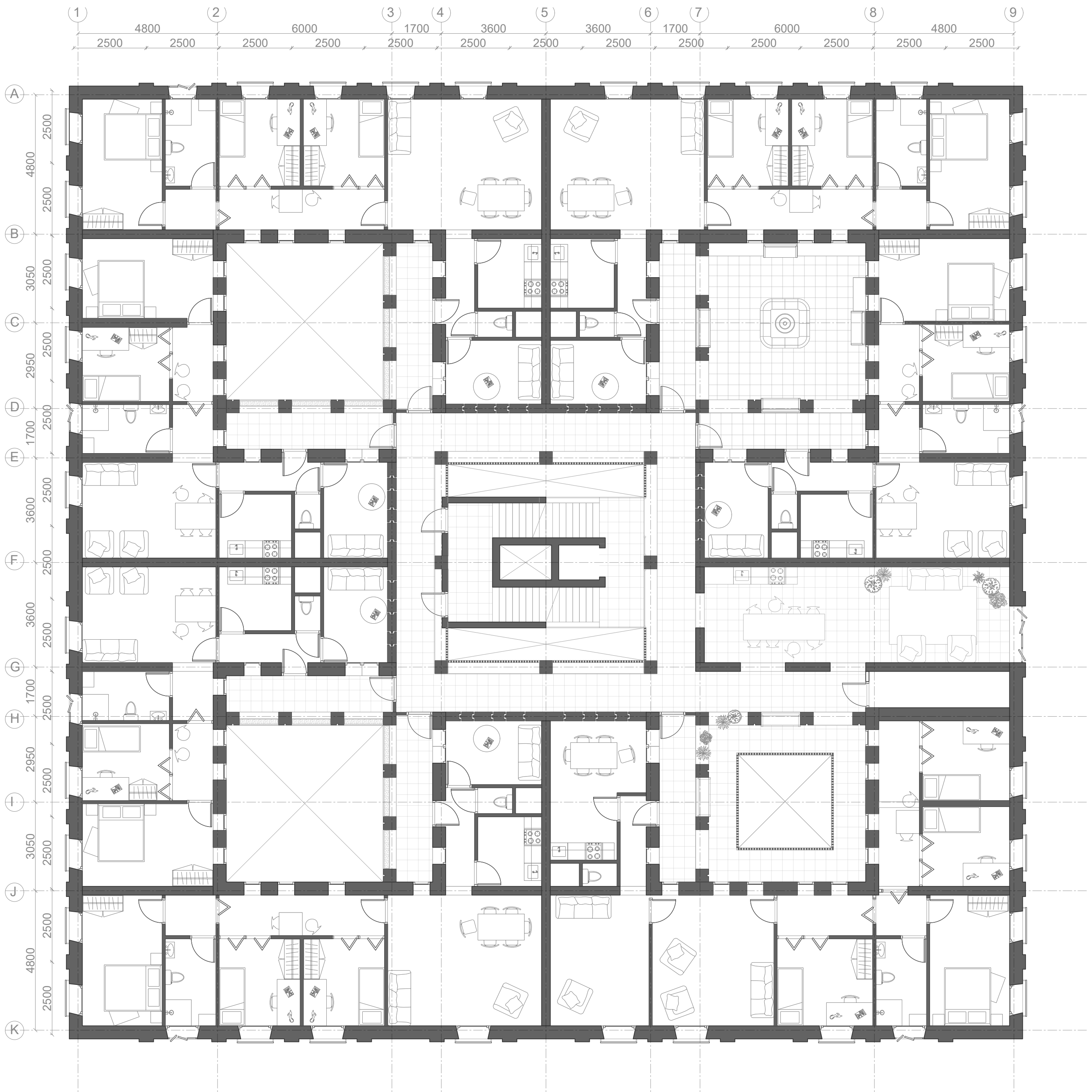


GROUND FLOOR

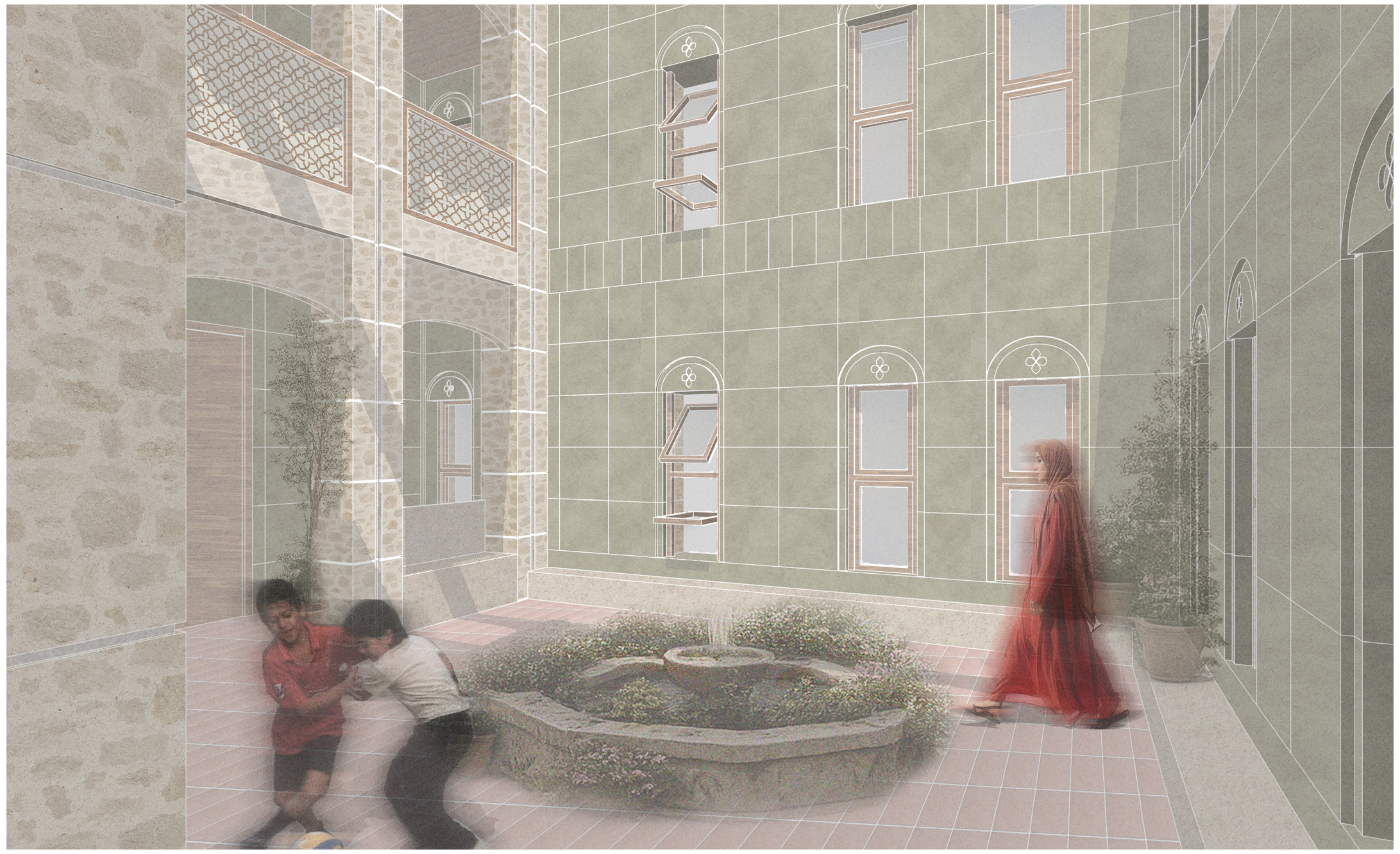
COURTYARD TO STAIRCASE

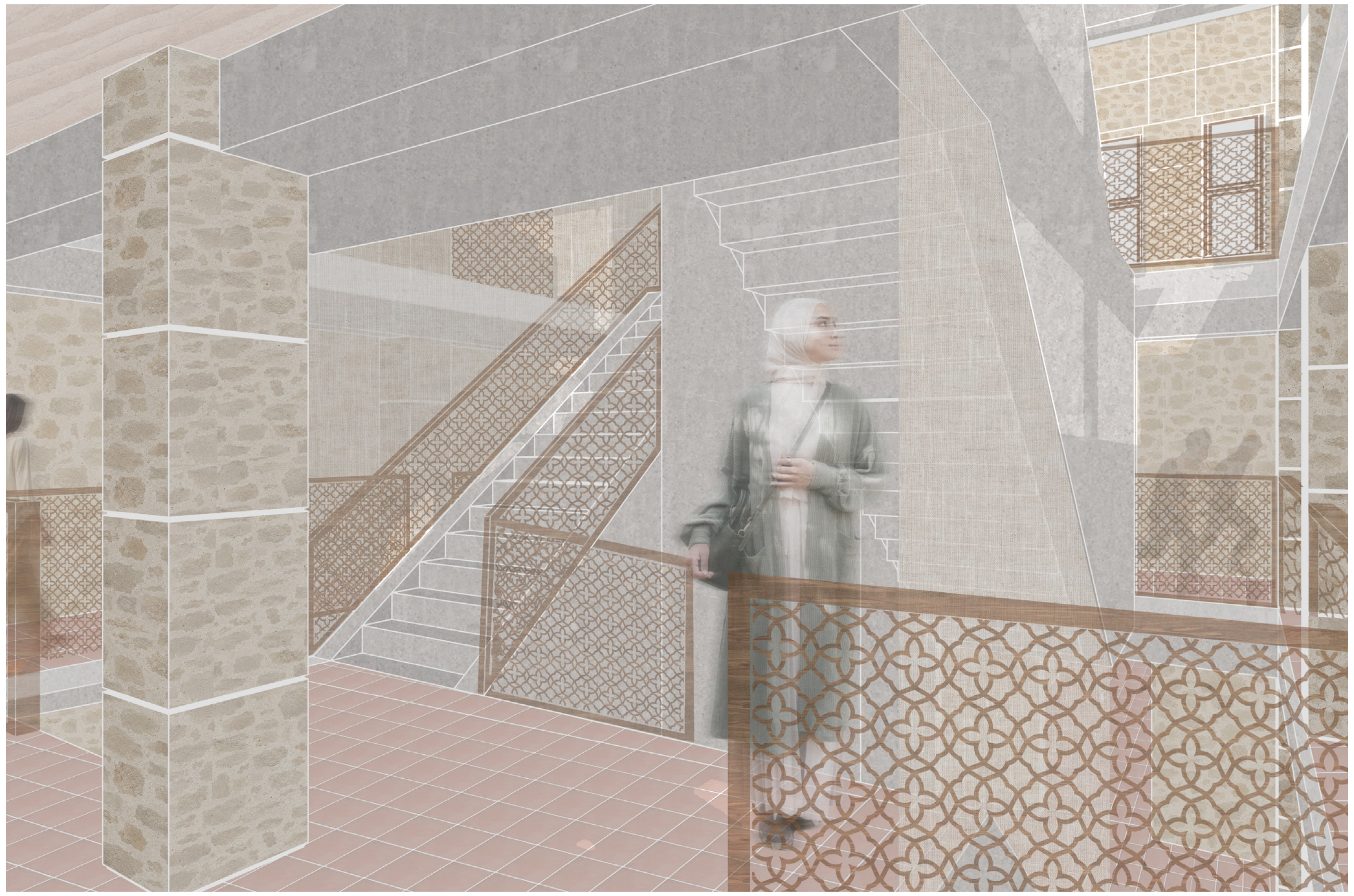
FLOORPLAN 1:100

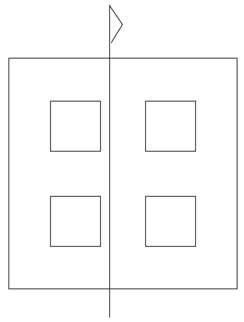
The courtyards are the social heart of the building. They are places where children can play, and neighbours can meet. At the same time, they are protected from the city. Front doors are never directly visible from the main circulation routes. The gallery structure extends into the courtyards and partly hides the entrances.



FIRST FLOOR



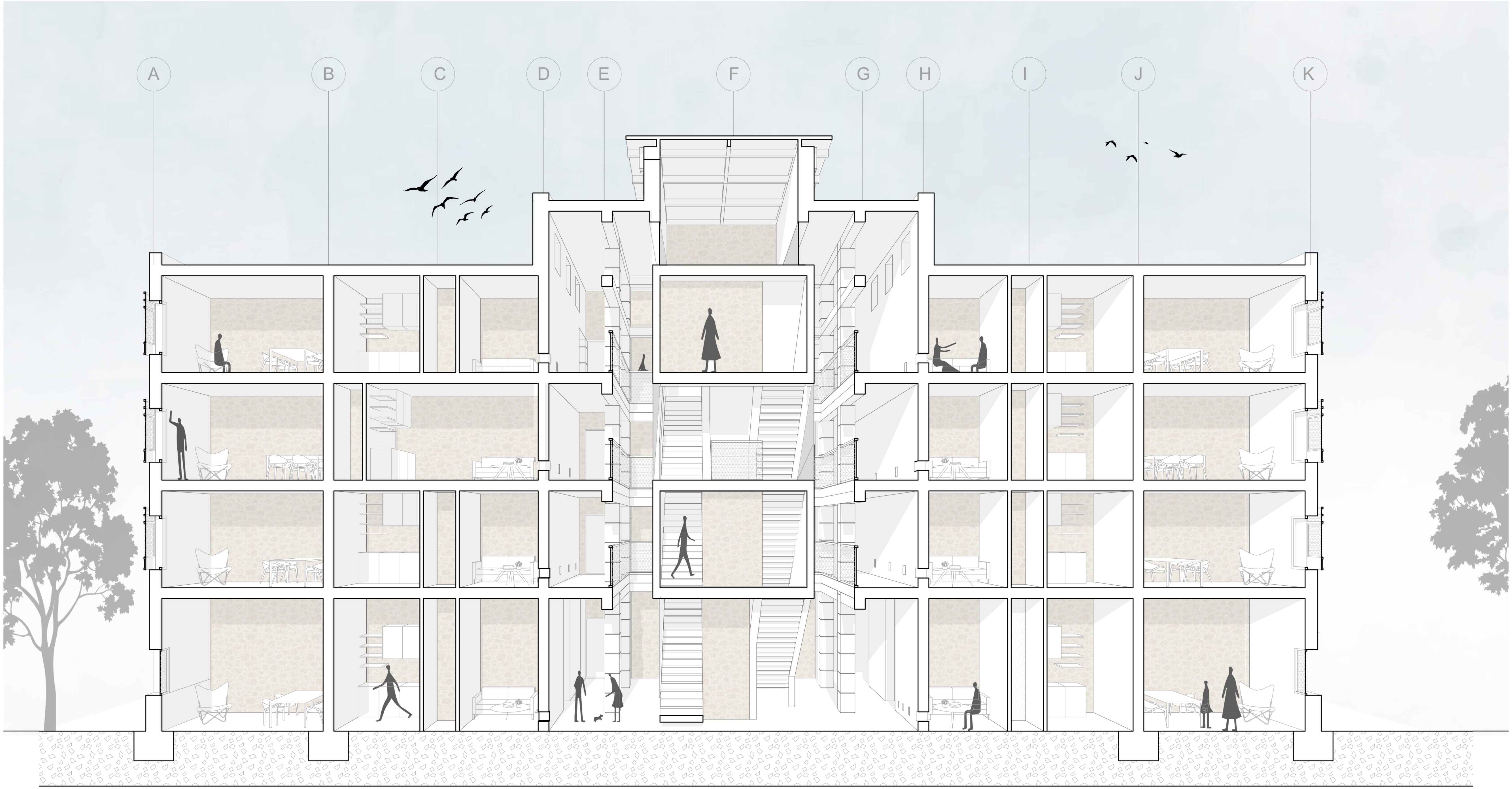




CIRCULATION: CORE OF THE BUILDING

SECTION 1:100

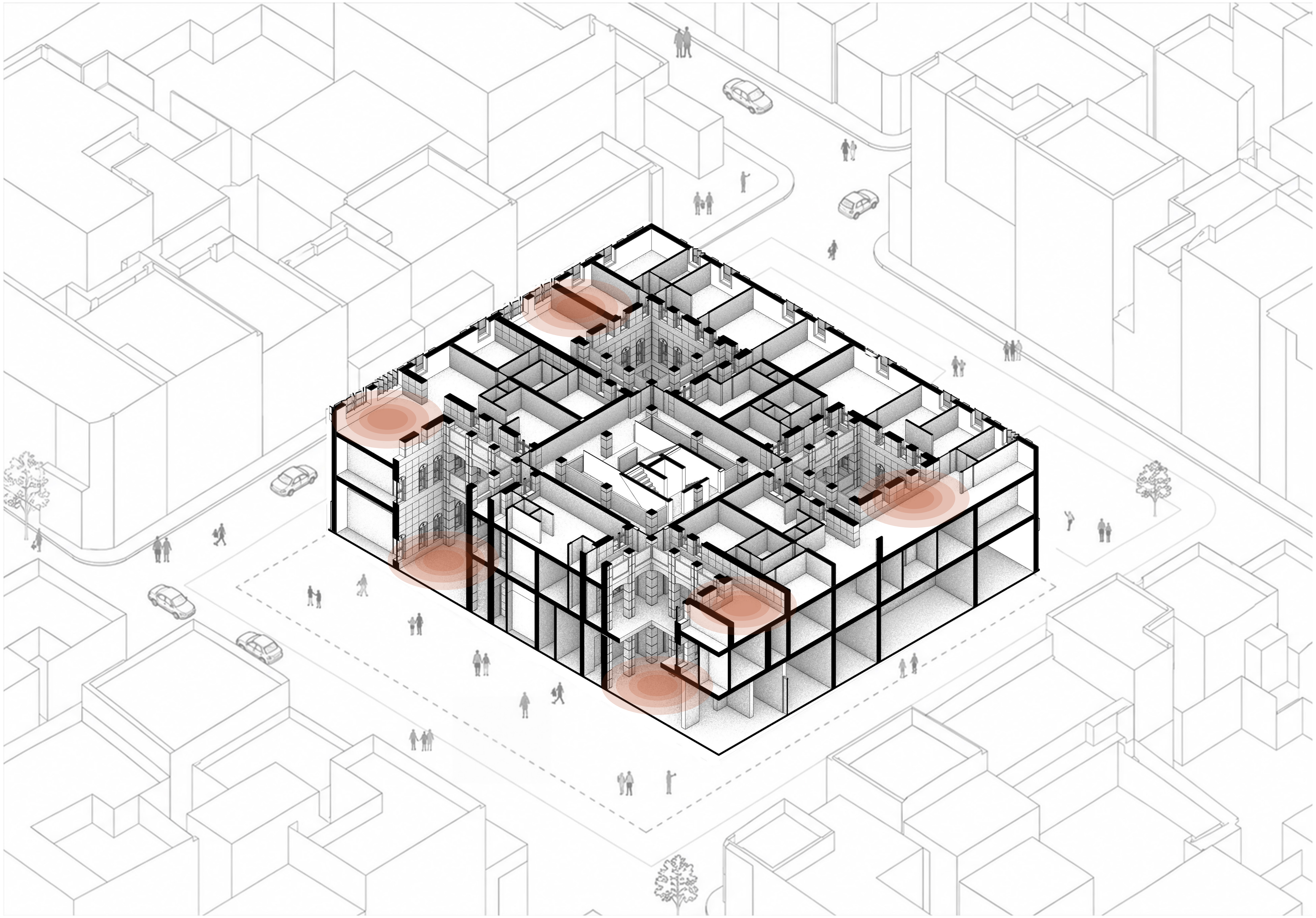
At the centre of the building, the staircase connects the different floors. Rather than serving only as a circulation route, it becomes an important transition space. The columns around the staircase and elevator create a sequence of open and more enclosed views, making movement through the building more comfortable.



OUTSIDE SPACES

AXONOMETRIC DRAWING

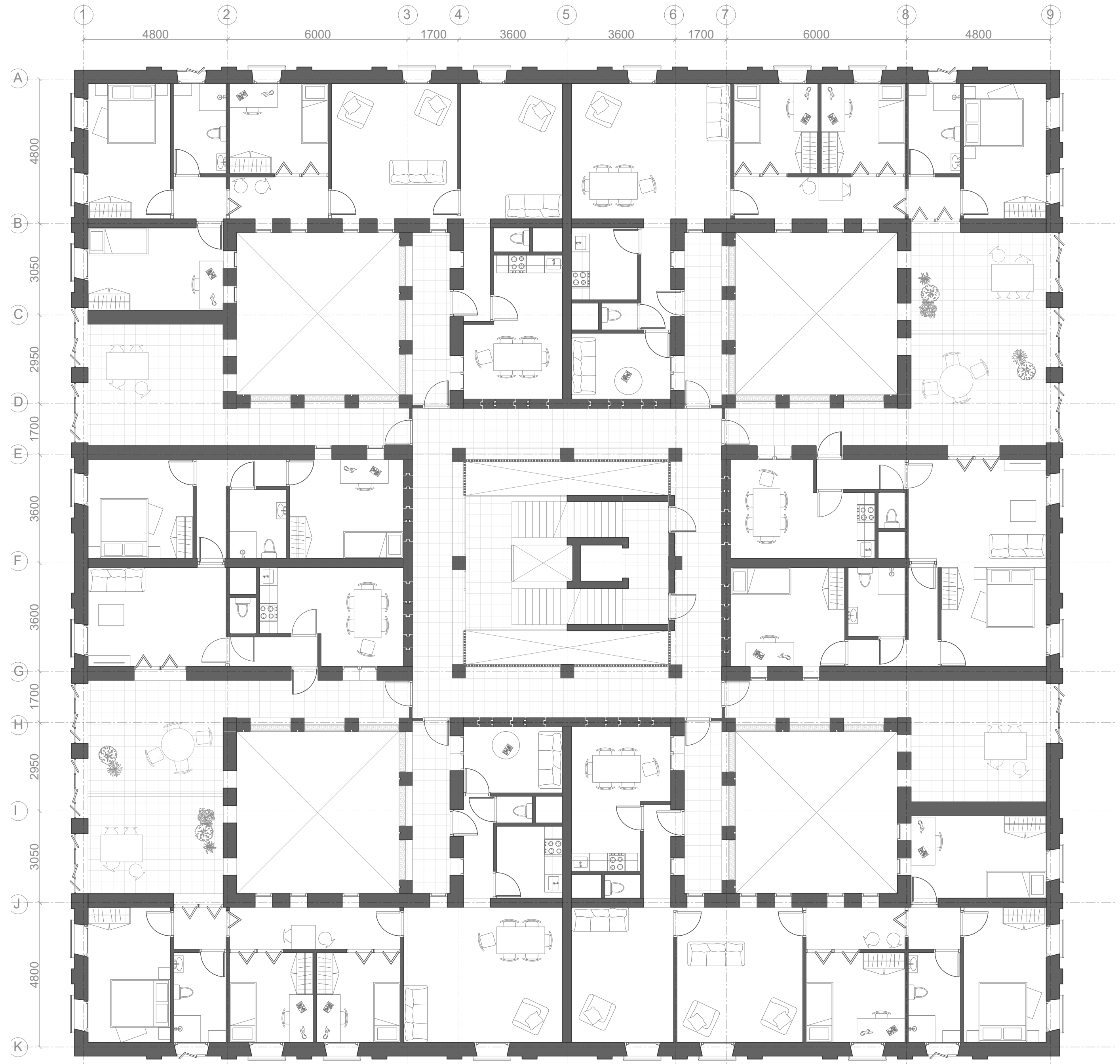
The building contains different communal spaces: courtyards, patio's, communal roof.



PRIVATE PATIO'S

FLOORPLAN 1:100

On the second floor, each home has its own private patio. They allow residents to spend time outdoors while remaining within the privacy of their own building block. At the same time, they provide views towards both the courtyards and the surrounding neighbourhood.

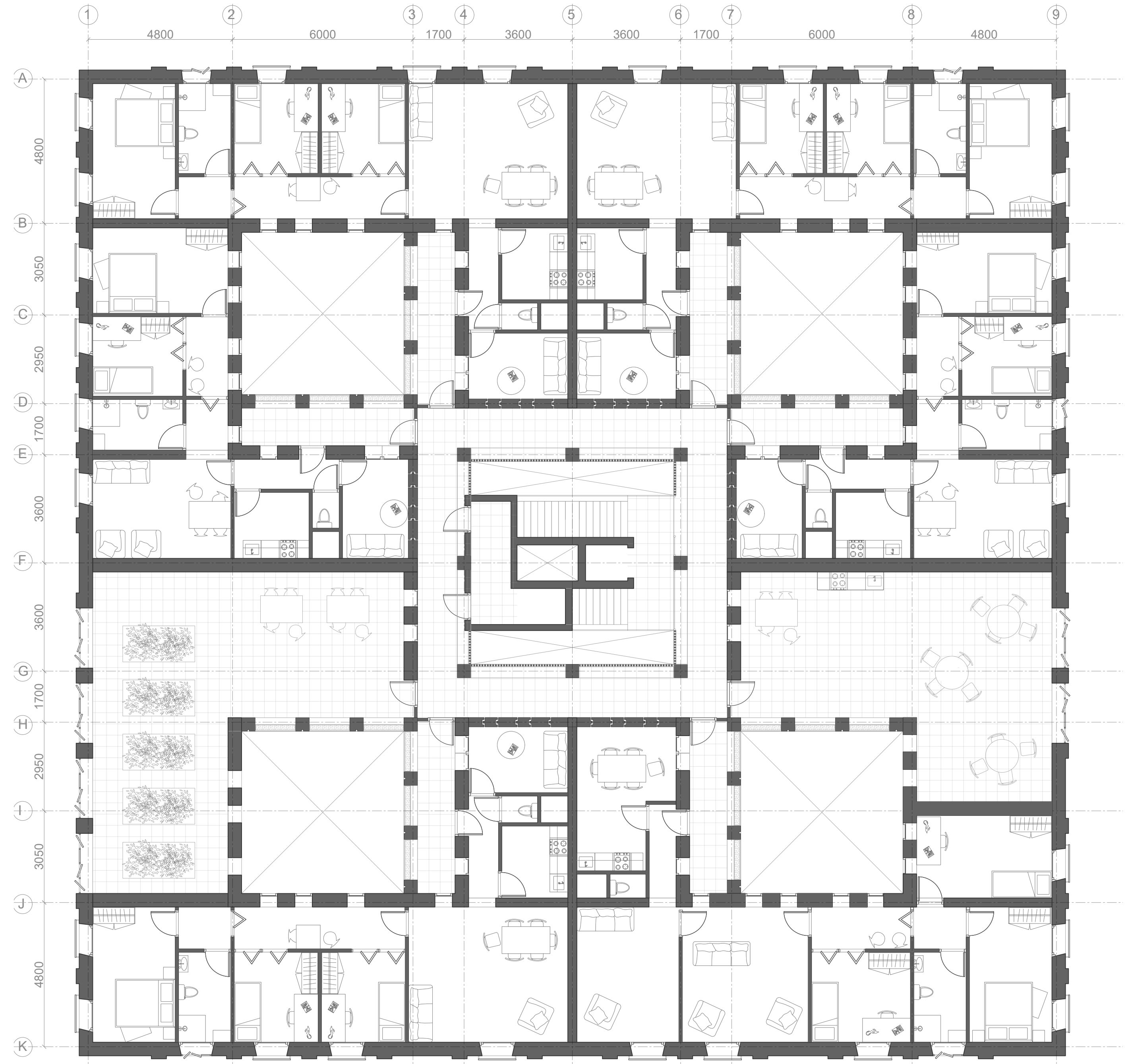


SECOND FLOOR

COMMUNAL ROOF

FLOORPLAN 1:100

On the roof, two communal patios provide the most shared outdoor spaces in the building. One includes a communal kitchen, while the other serves as a shared garden. These spaces encourage residents from different parts of the building to meet each other.



THIRD FLOOR

PRIVATE PATIO

VISUAL

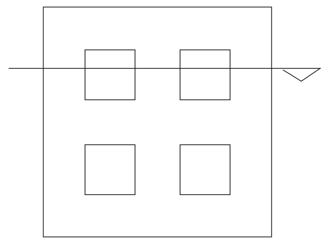
Inhabited edges, Homs
Extreme graduation - AR4EA010

COMMUNAL ROOF GARDEN

VISUAL

ALL THESE SPACES COMING TOGETHER

SECTION 1:100



Galleries extend from the circulation cores into the courtyards and connect the dwellings across multiple levels.

CONCEPT OF THE DWELLING

ZOOM IN FLOORPLAN 1:100

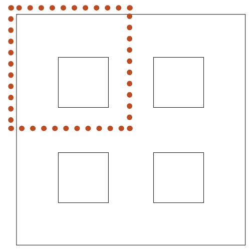
Zooming in on a single apartment, the concept of thresholds continues within the dwelling itself.

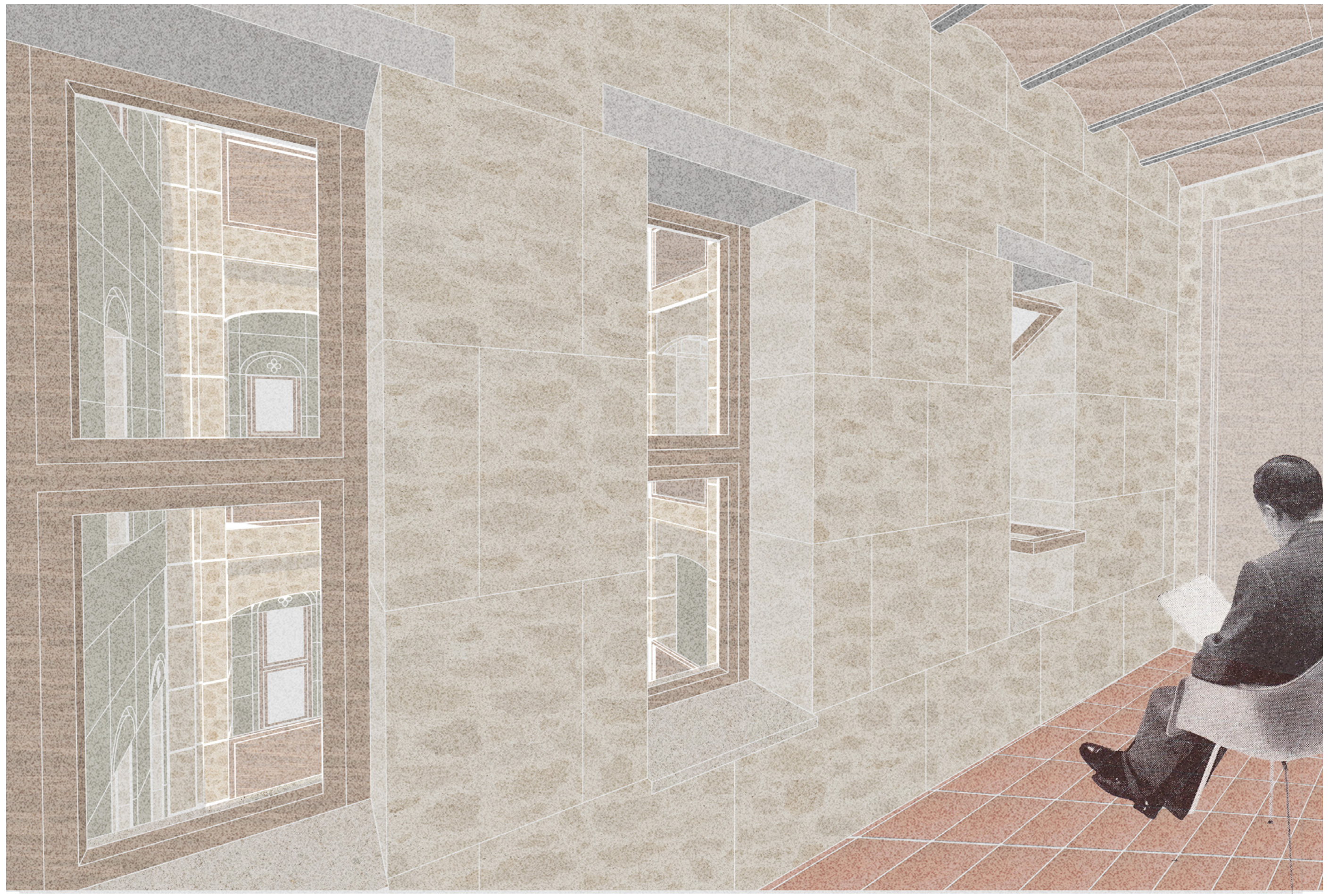
Although there are several dwelling types, they all follow the same spatial principles of privacy.

STEP 1

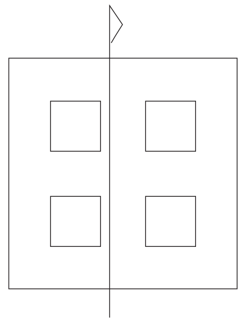
STEP 2

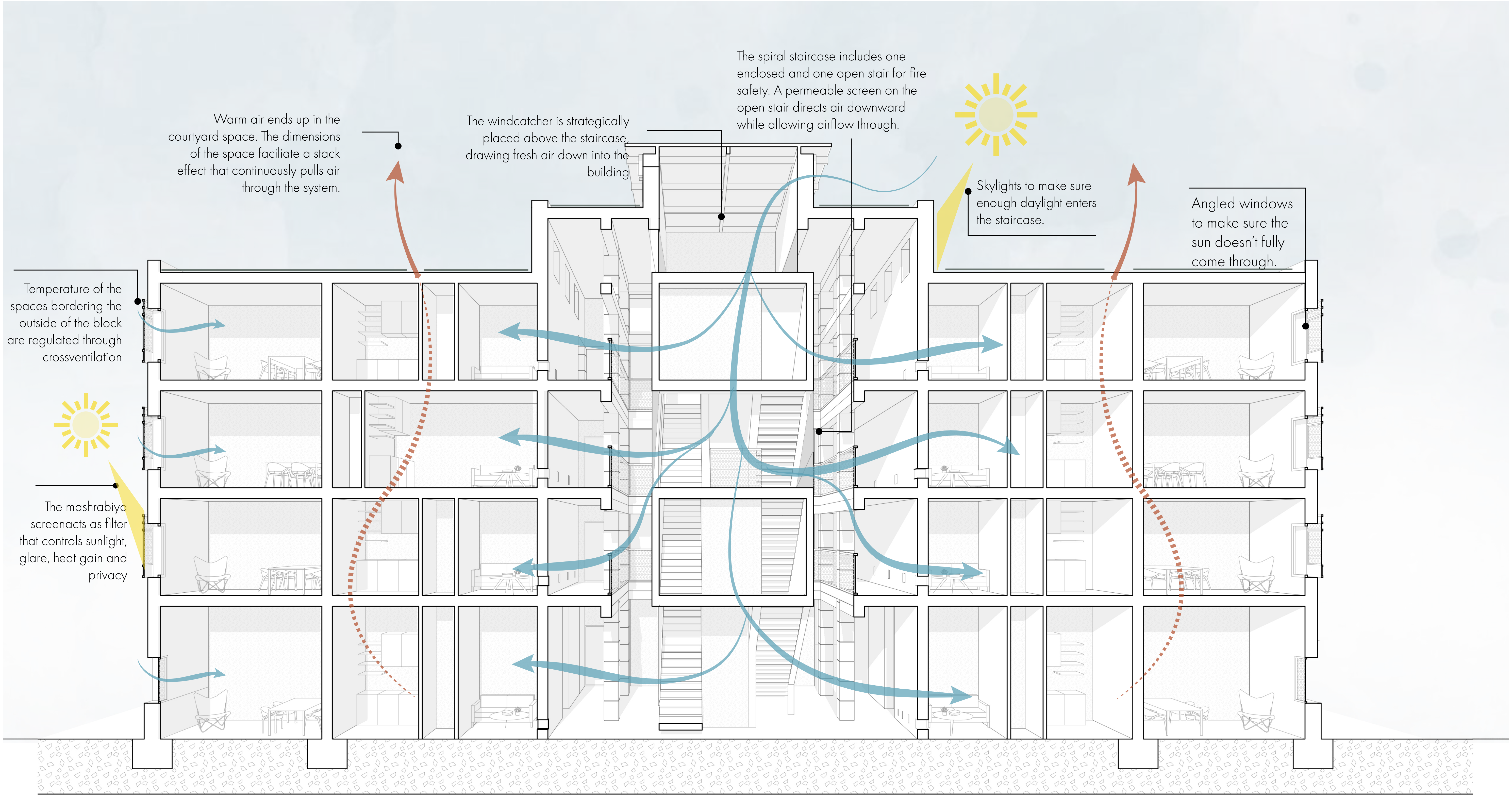
STEP 3





CLIMATE SECTION





CLIMATE EXPLANATION

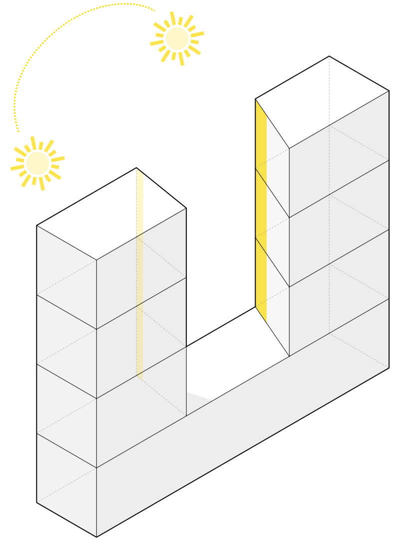
The courtyard typology is not only a spatial concept, but also acts as a climate-responsive system. It creates a microclimate that improves thermal comfort by reducing heat in summer and providing shelter from cold winds in winter.

Ventilation. Fresh air enters from the outer edges of the building, moves through the dwellings, and is drawn into the courtyards. As the air warms, it rises, creating a stack effect that continuously pulls air through the system. In this way, the courtyards function as natural air reservoirs, supporting passive ventilation across the entire block. The sections of the dwelling positioned more inwards are ventilated by the windcatcher.

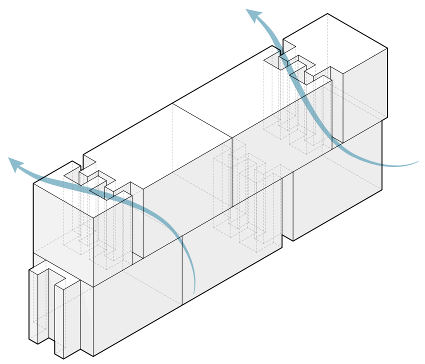
Water. Water is caught on the roof and flows down the column to the courtyard, where it reaches the fountain. In summer, water evaporates, further enhancing cooling, and in winter, the fountain refills.

Sun/mashrabiya. The screen is designed as a contemporary reinterpretation of the traditional mashrabiya for the Syrian climate. It functions as a filter that controls sunlight, glare, heat gain, and privacy. The perforation density changes across the screen: larger openings at the top help release accumulated heat and bring deeper daylight inside, while smaller openings below increase privacy and reduce low-angle glare. The depth between the screen and facade creates shadow, softens daylight, and improves interior comfort.

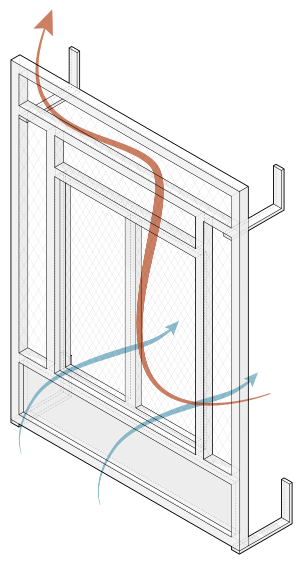
ANGLED WALLS



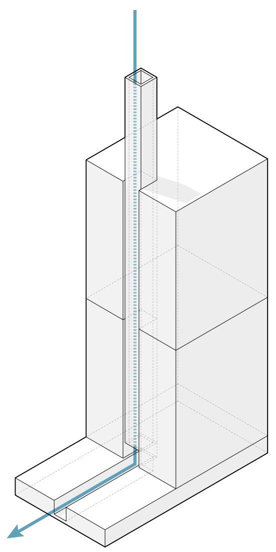
VENTILATION



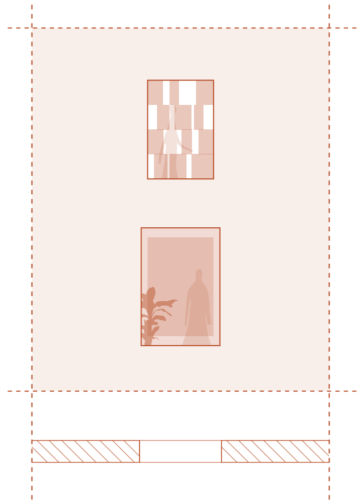
SUNLIGHT VS PRIVACY



WATER

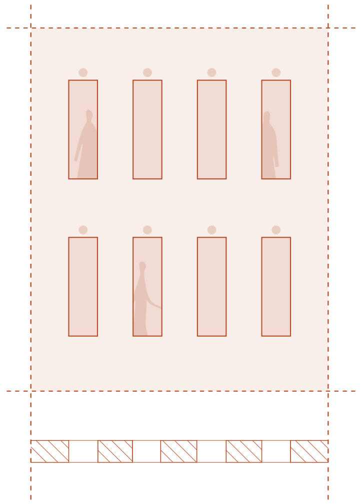


FACADE CONCEPTS



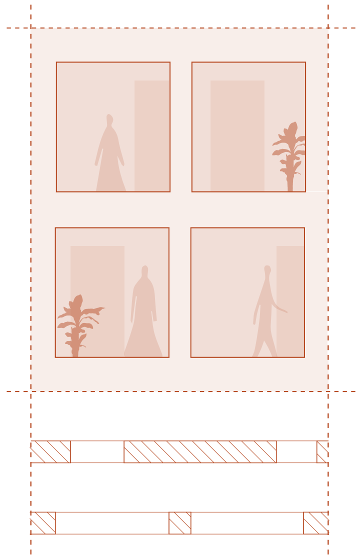
EXTERIOR

First threshold between the city and the dwelling. It reads as **calm and robus**t towards the street, with **controlled openings** that hint at life inside without exposing it.



COURTYARD FACADE

Quiet and intimate. Simpler in form but richer in texture and detail. A lot of **small openings**, providing light but also privacy, **filtered views**. A horizontal line flowing 'bench', marking the courtyard space.

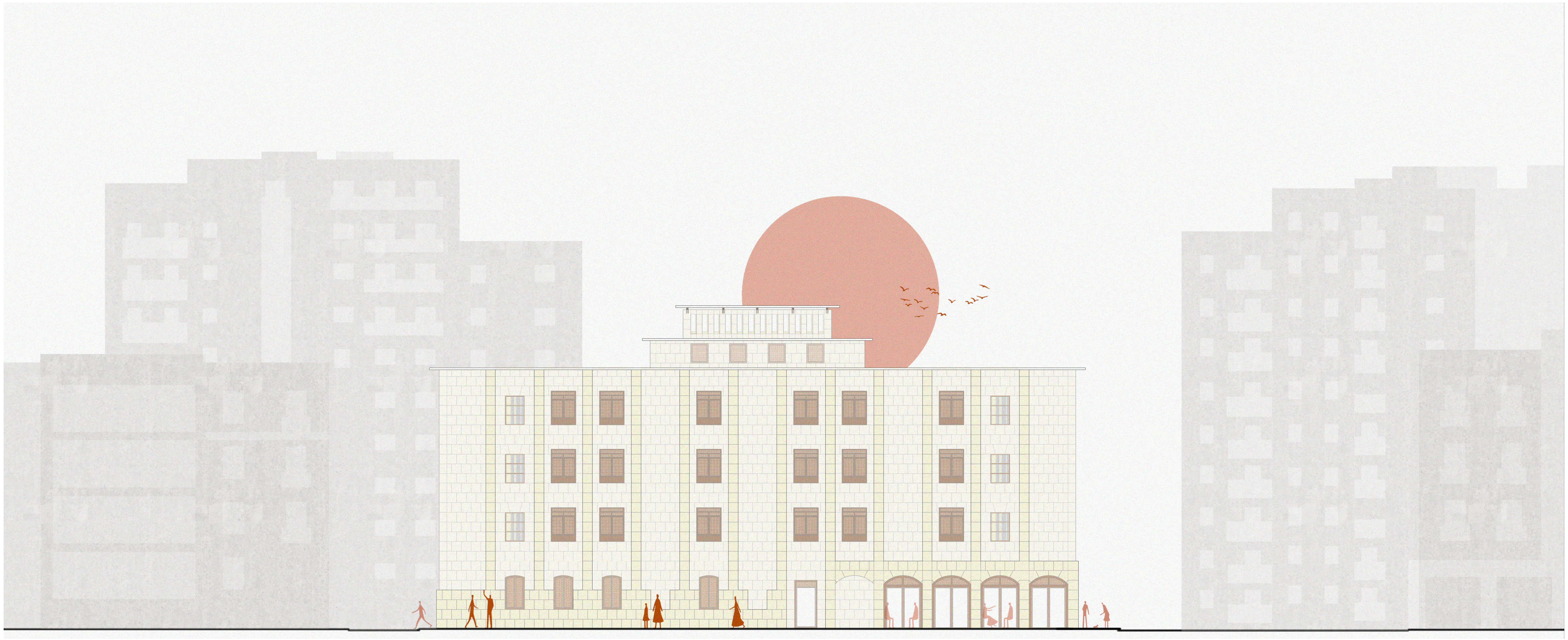


GALLERY

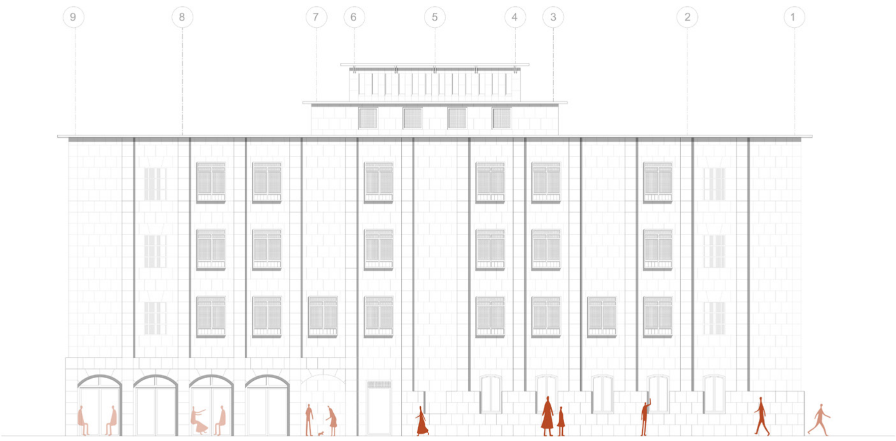
A social filter. Deep openings turn the gallery into a vertical street where people can lean, sit, talk or watch children playing below. The façade is more **expressive in shape** but calm in material, making everyday encounters visible while keeping a clear distinction from the more private dwelling skin behind.

EXTERIOR FACADES (1:100)

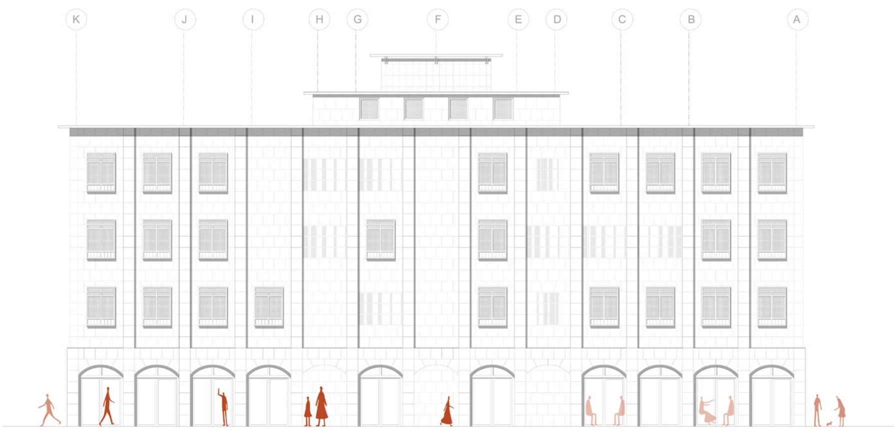
SOUTH FACADE



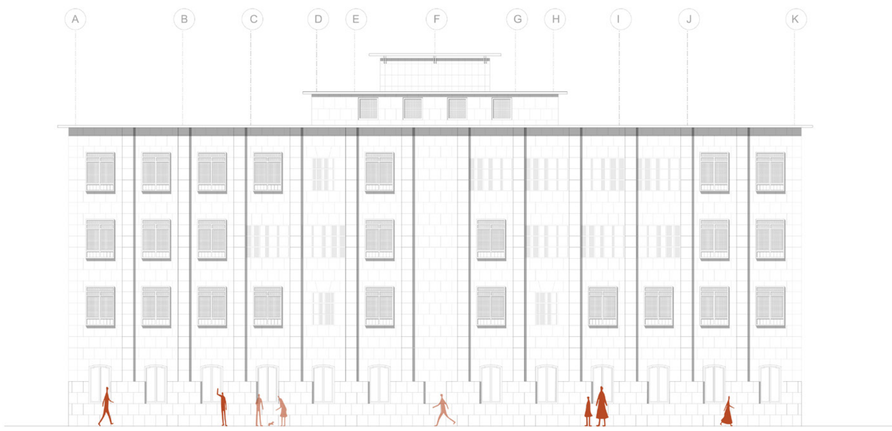
NORTH FACADE



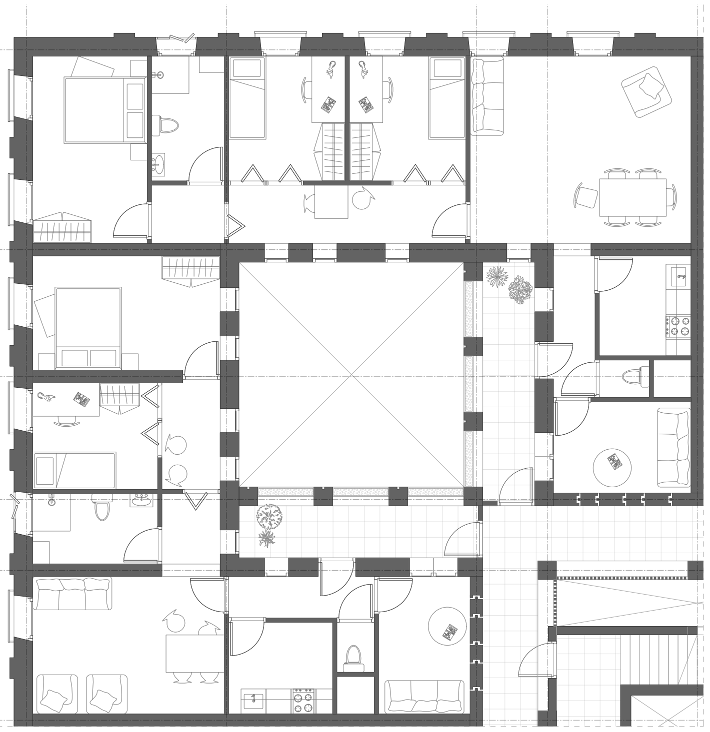
EAST FACADE



WEST FACADE



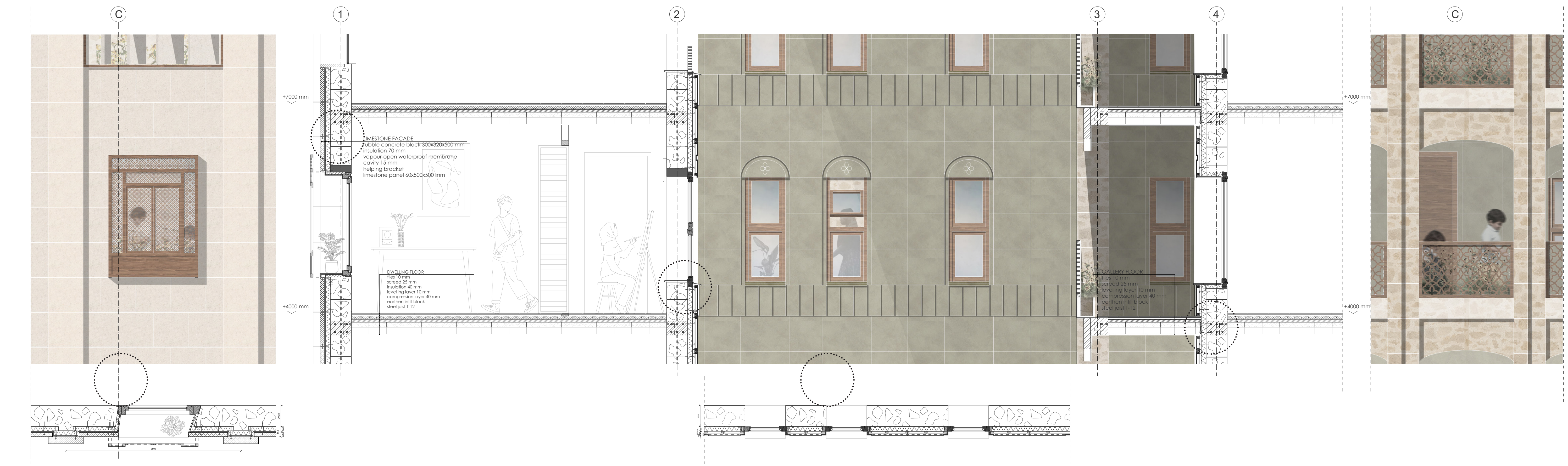
FACADE FRAGMENTS



EXTERIOR FACADE

COURTYARD FACADE

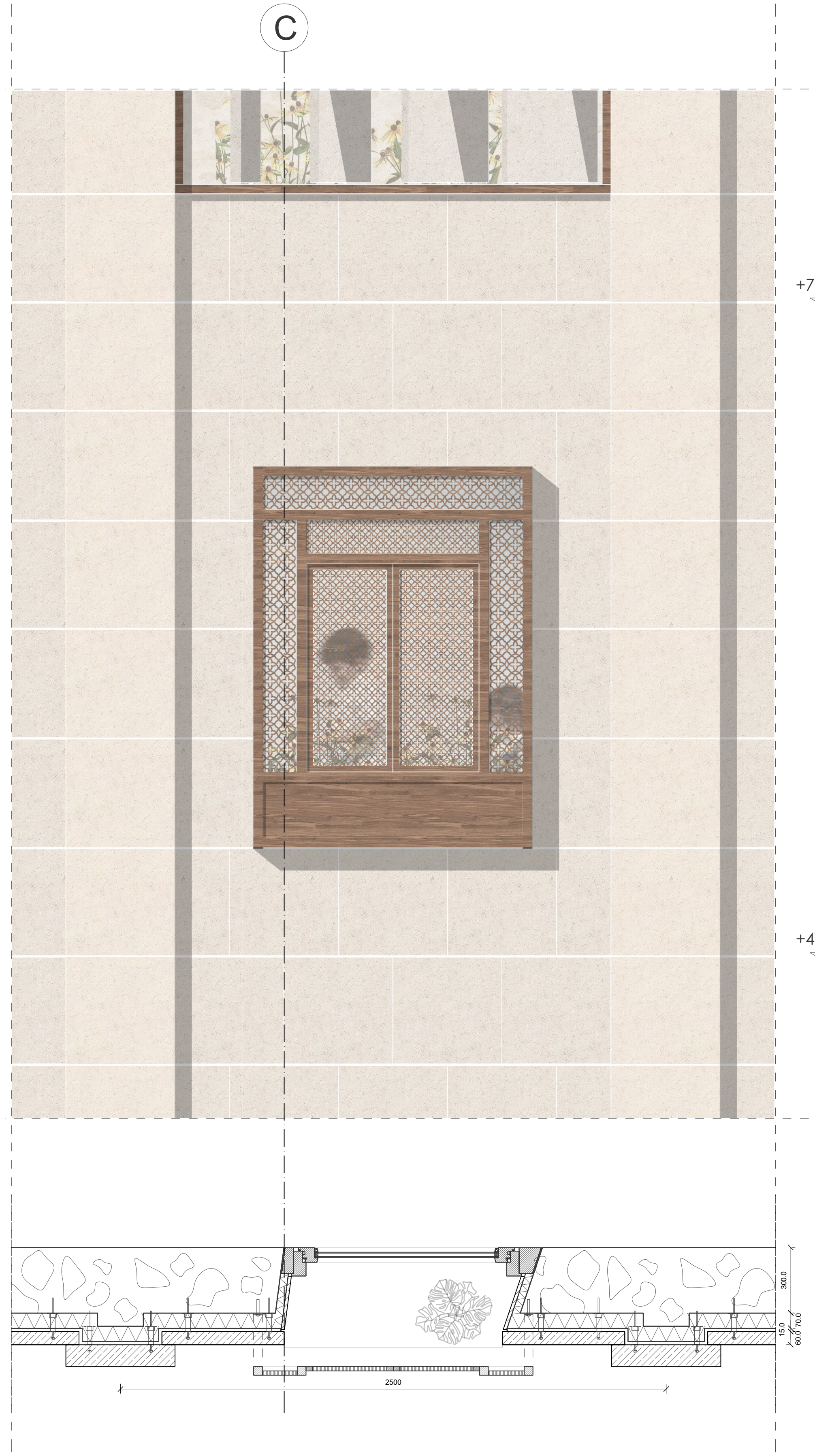
GALLERY FACADE

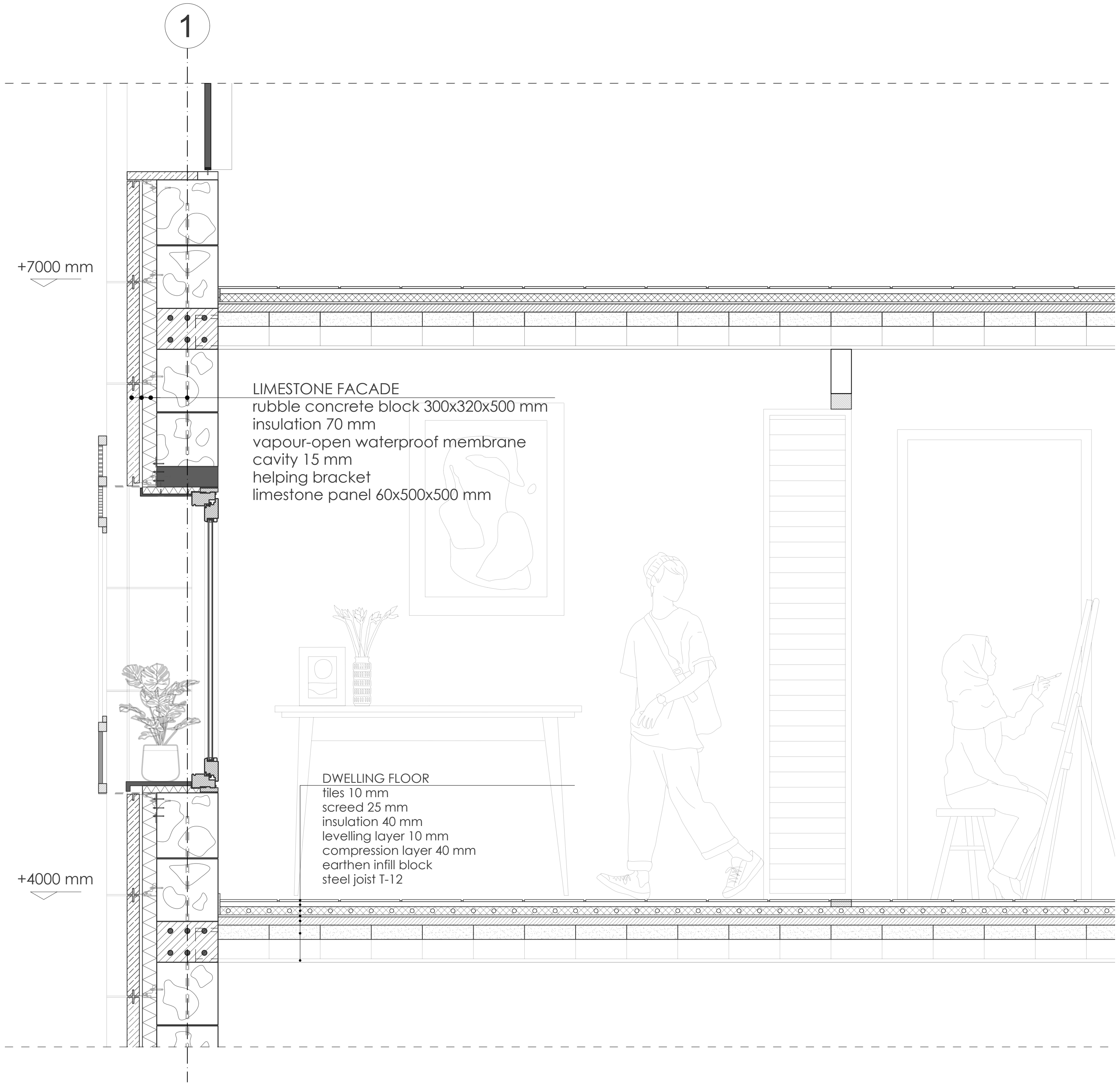


FACADE FRAGMENTS

EXTERIOR FACADE

I do not reveal everything at once. I hold the dust of the street and the stories behind my walls. Through narrow openings, laughter escapes before faces appear. I stand between the city and home, welcoming without exposing.





FACADE FRAGMENTS

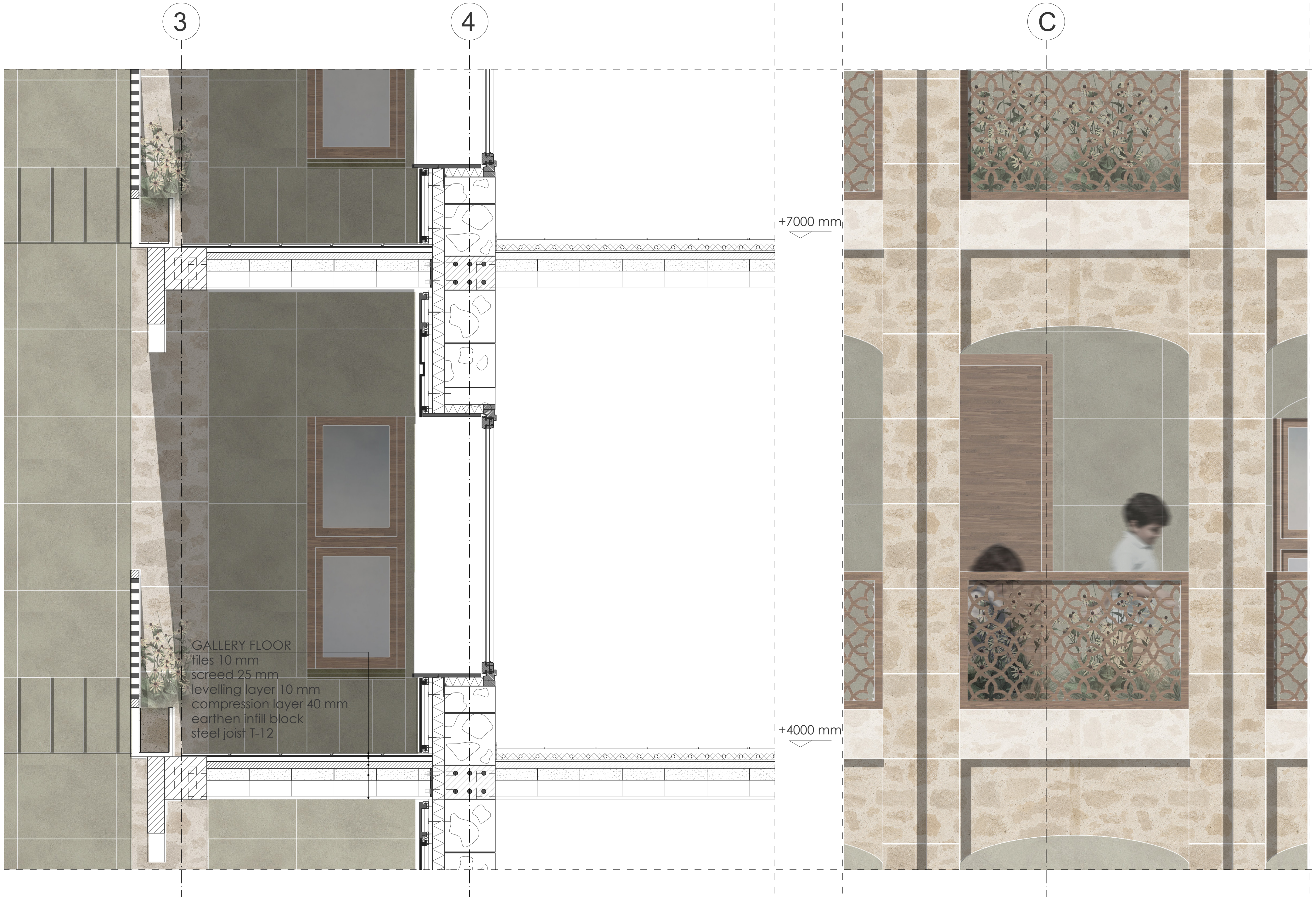
COURTYARD FACADE

Every morning, I wake with the sound of footsteps and distant voices. Children race past my shadows while neighbours linger at my edge. I catch fragments of conversation and carry them across the air. Here, life unfolds slowly, and strangers become familiar.

FACADE FRAGMENTS

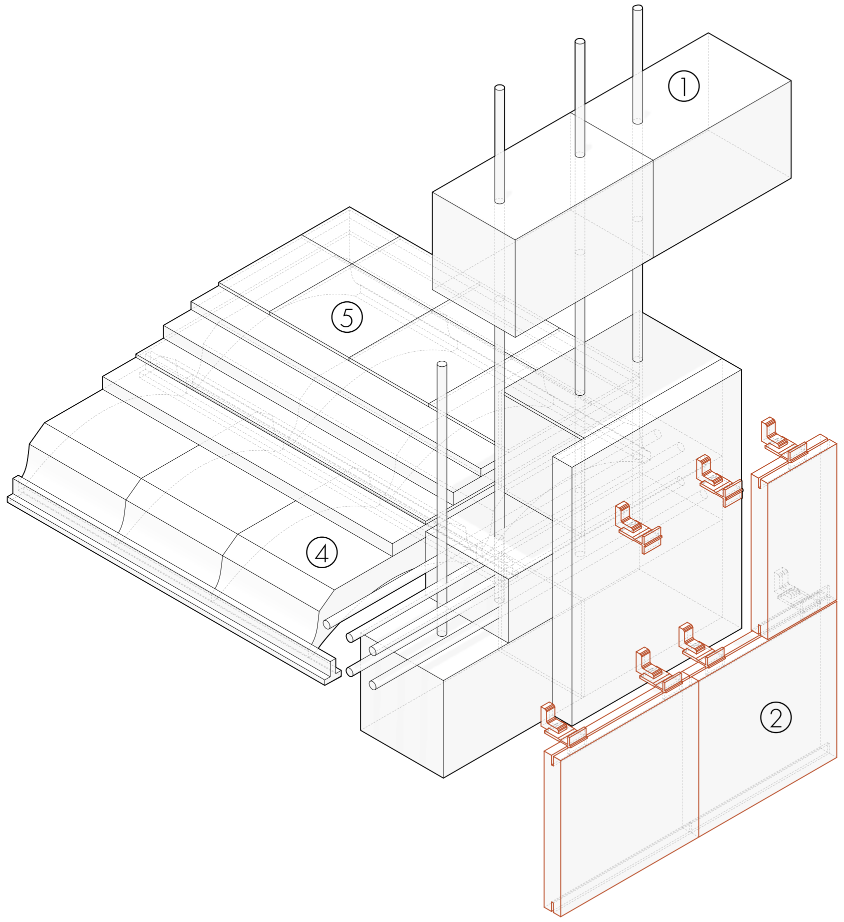
GALLERY FACADE

I am the place where returning home begins. A greeting, a shared cup of tea, a child leaning over the railing. I hold the moments too small to be planned yet too important to forget. Between one door and the next, a community takes shape.

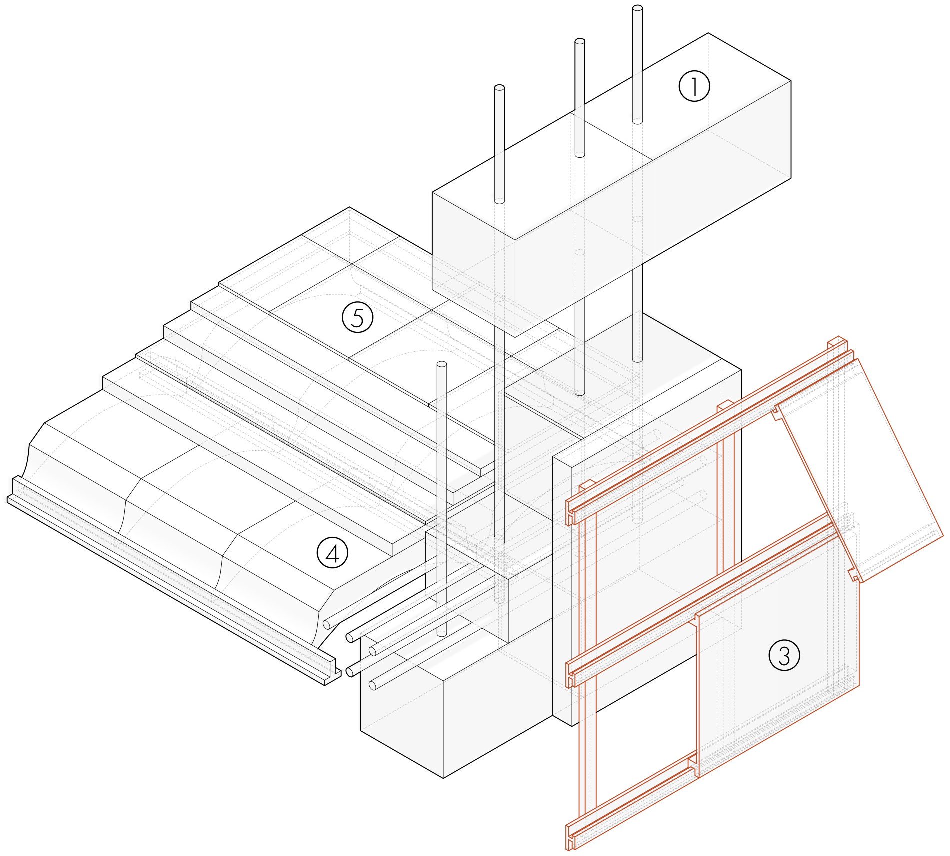


MAIN MATERIAL USE

EXTERIOR FACADE



COURTYARD FACADE



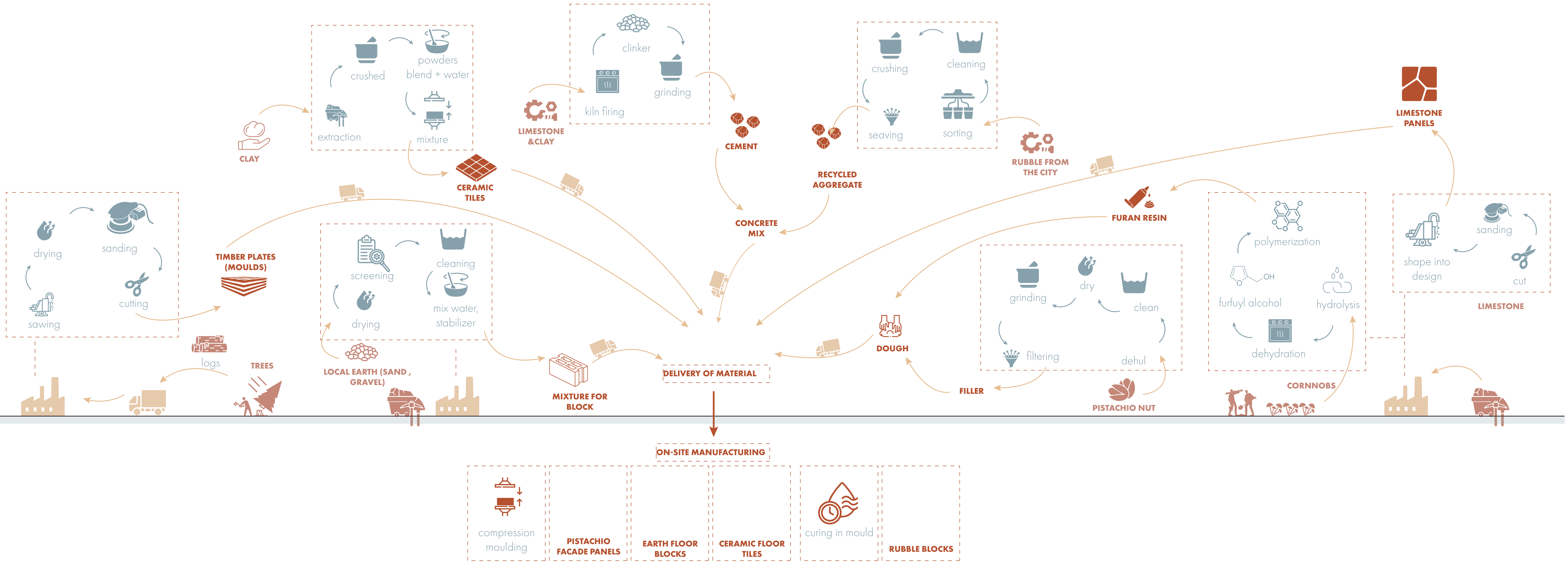
1. Rubble concrete with reinforcement
2. Limestone panels
3. Bio-composite pistachio panels
4. Earth floor blocks
5. Ceramic floortiles

My project proposes a material strategy that responds directly to Syria's contemporary scarcity by combining reuse and local sourcing. The load-bearing structure is conceived as a recycled-rubble composite: crushed debris is mixed with cement, cast in wooden moulds, and then cut into units, turning the city's remaining ruins into a structural resource rather than waste (reference: harquitectes, appendix X).

The façade strategy distinguishes between the building's outer and inner atmospheres. The exterior façade is composed of limestone panels, drawing on Syria's long stone-building tradition and on the regional availability of limestone.

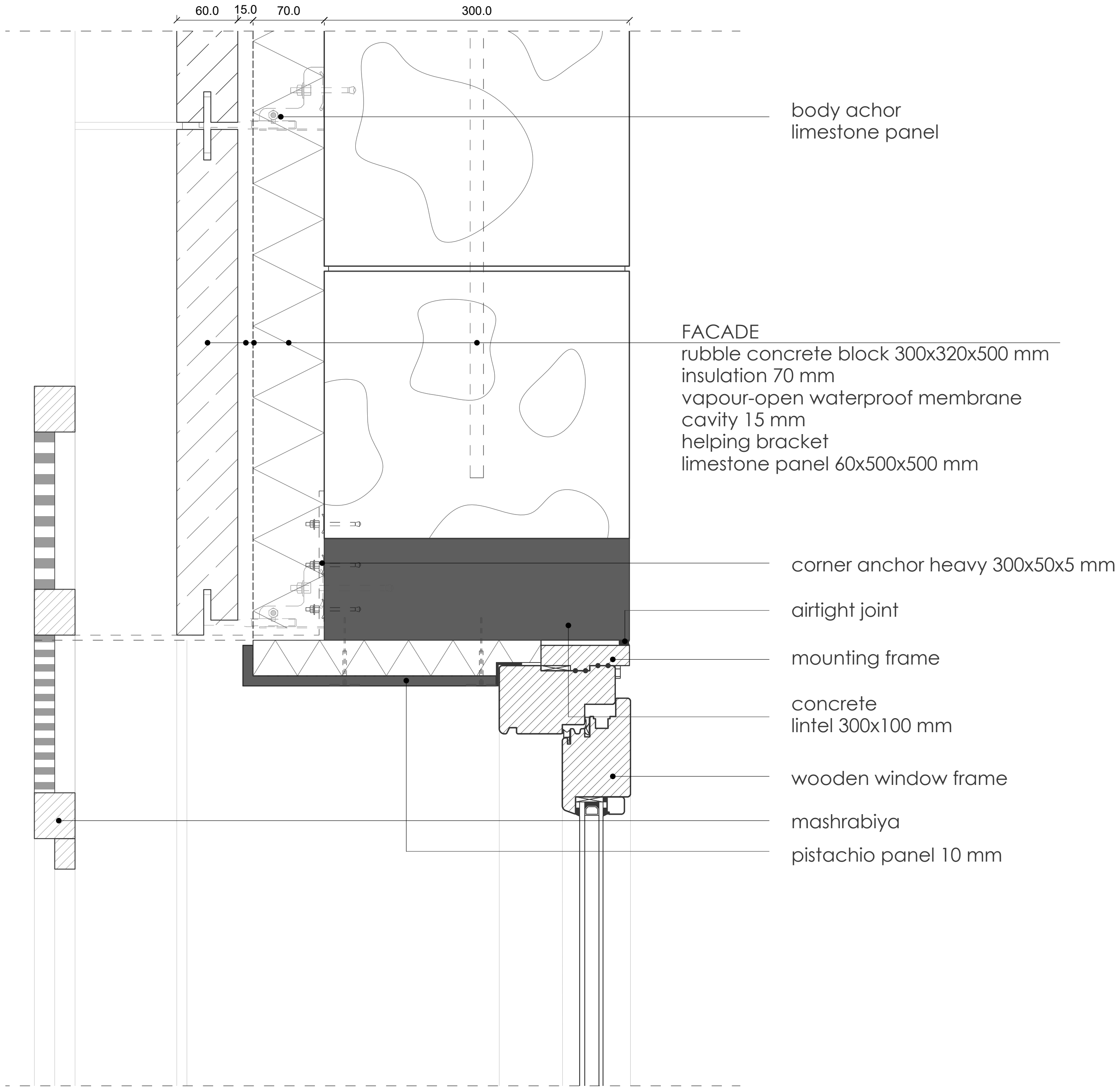
The courtyard façades use bio-composite panels made from pistachio-shell waste to create a lighter and softer domestic atmosphere and a locally producible construction system. The floor system combines vaulted construction with earthen blocks mixed with cement and supported by steel T-profiles, allowing a hybrid structure that is both rooted in context but structurally feasible. The floors are covered with ceramic tiles, continuing the long tradition of clay-based material use. In this way, the project seeks to create a familiar architectural atmosphere through contemporary methods, linking the memory of material with structural resilience and construction feasibility.

MATERIAL SOURCING & MANUFACTURING

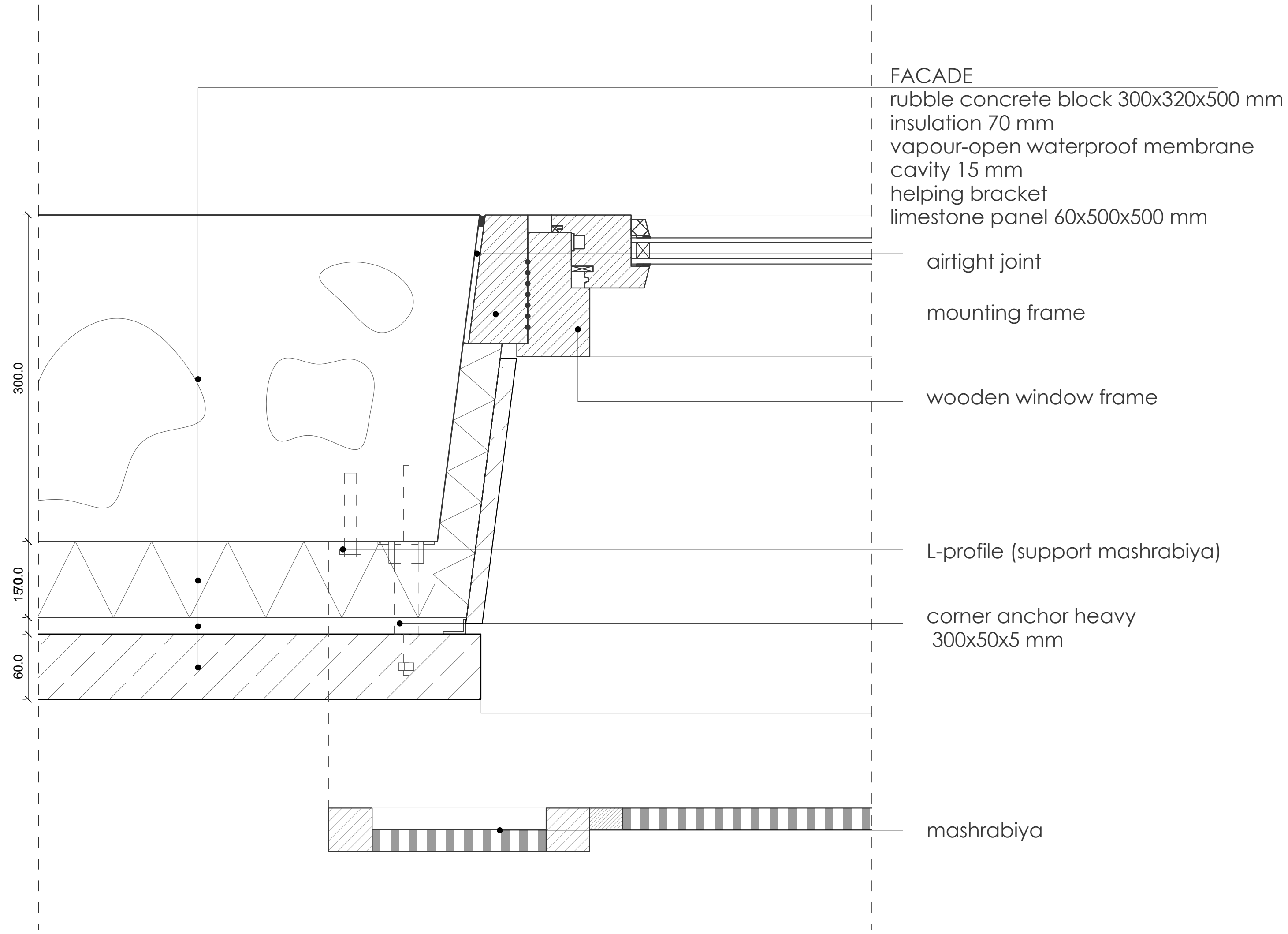


DETAILING

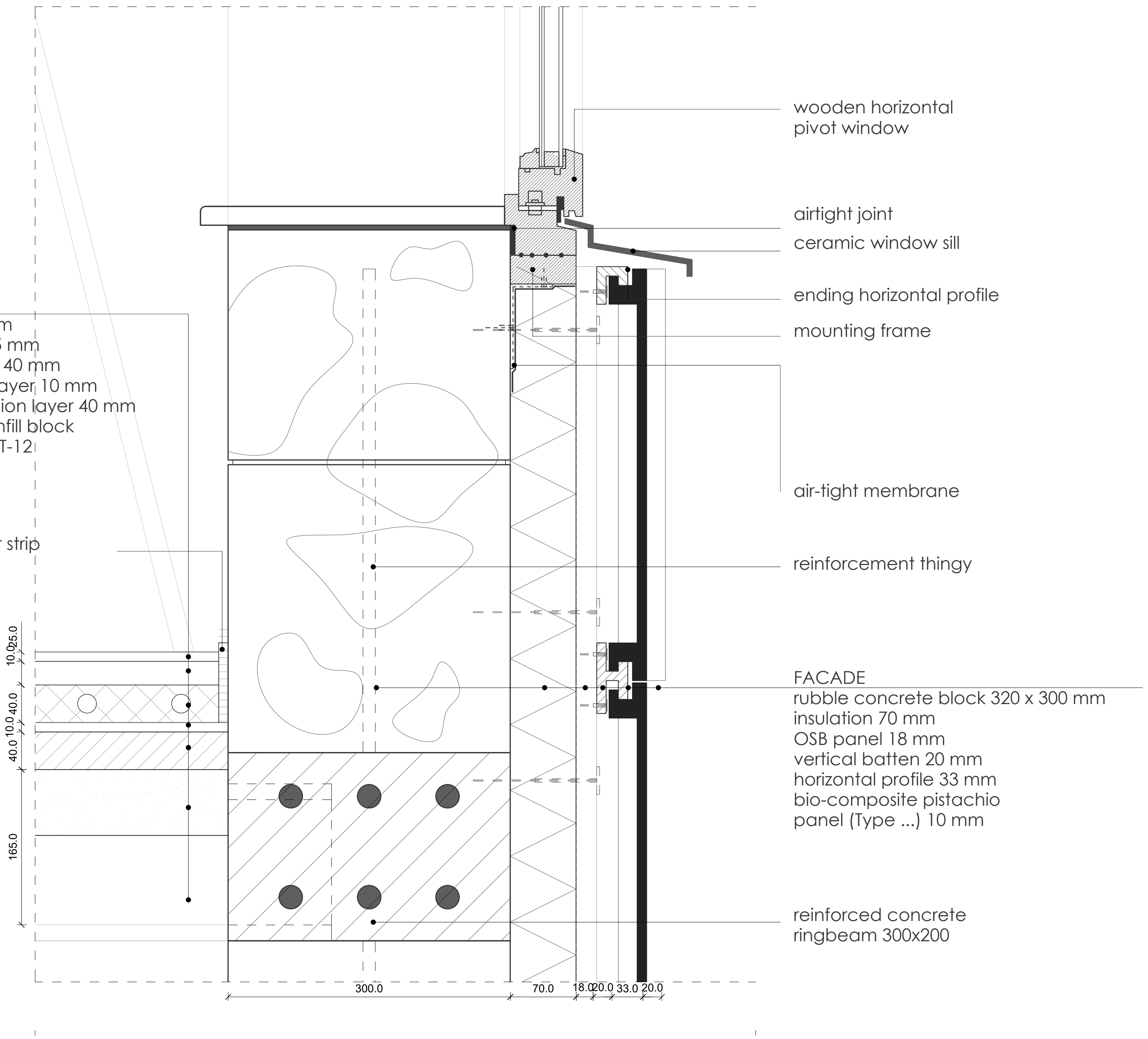
DETAIL 1 - LIMESTONE FACADE VERTICAL



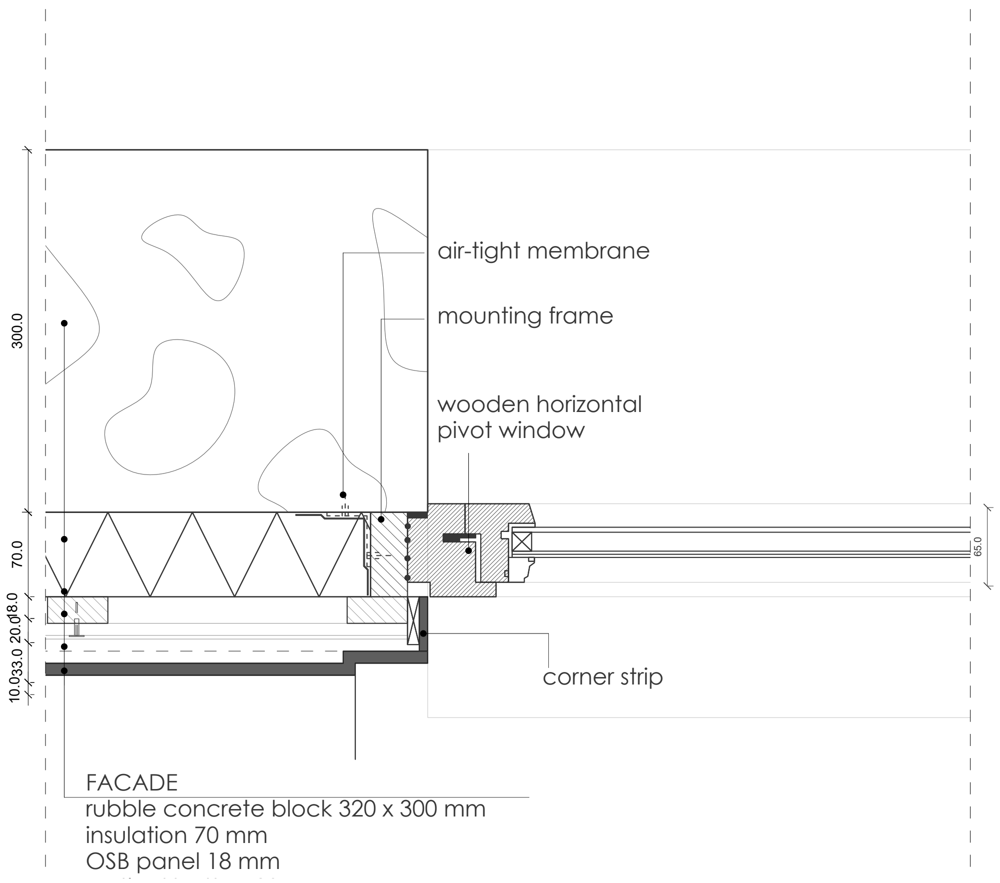
DETAIL 2- LIMESTONE FACADE HORIZONTAL



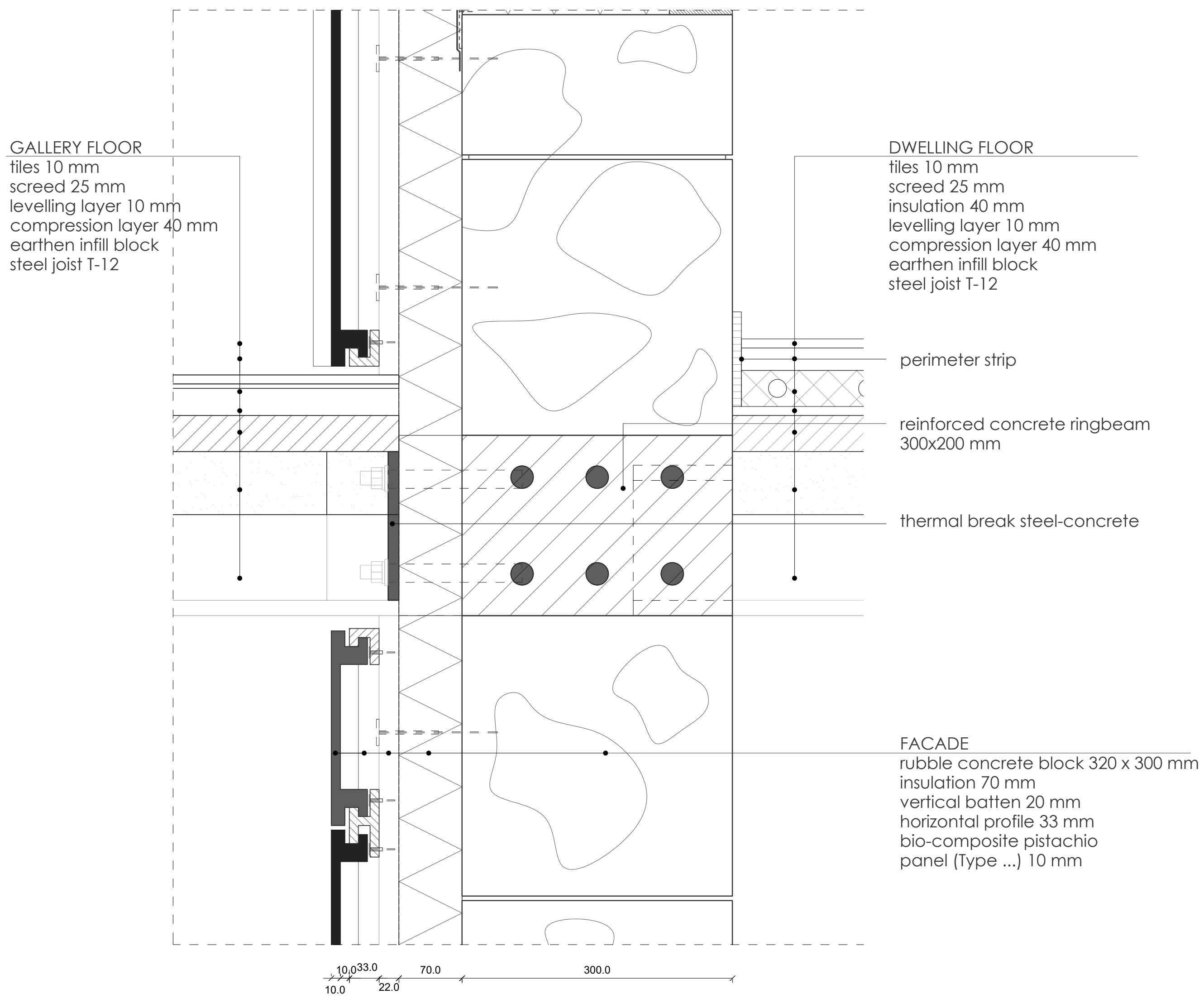
DETAIL 3 - PISTACHIO BIO-COMPOSITE FACADE VERTICAL



DETAIL 4- PISTACHIO BIO-COMPOSITE FACADE HORIZONTAL

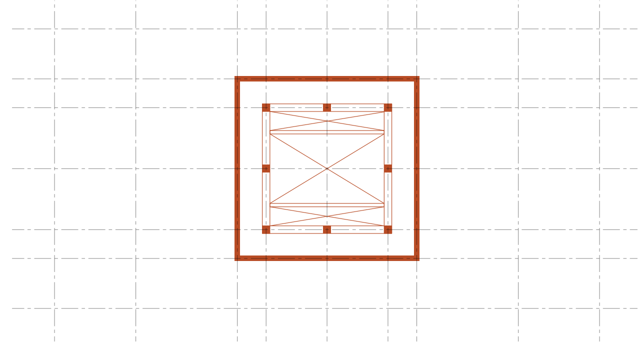


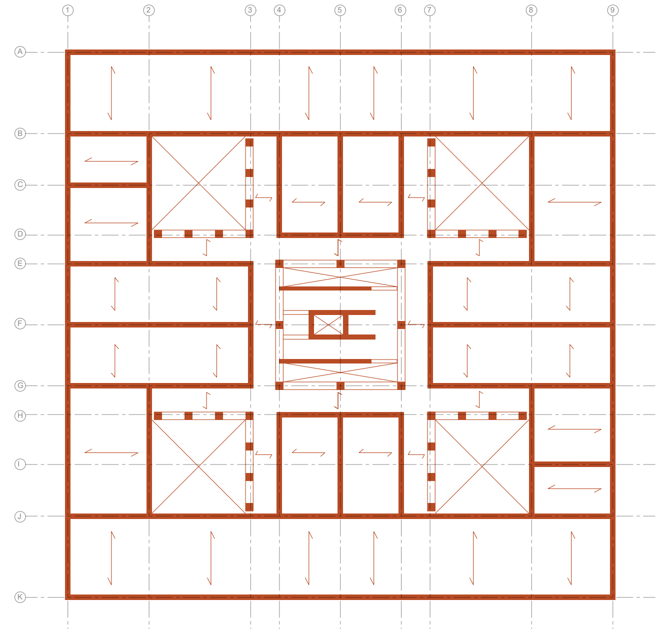
DETAIL 5 - GALLERY VERTICAL



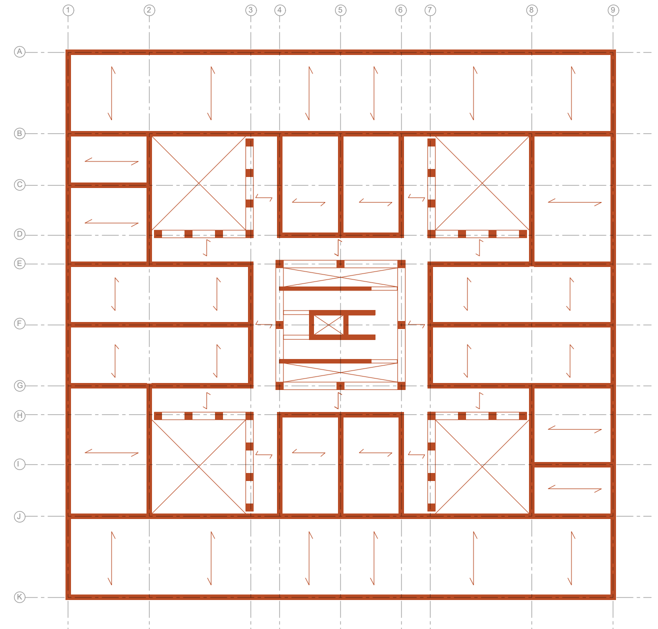
LOAD-BEARING STRUCTURE CONCEPT

Floors span from facade to facade, to facilite maximum flexibility in the floorplan for future use.

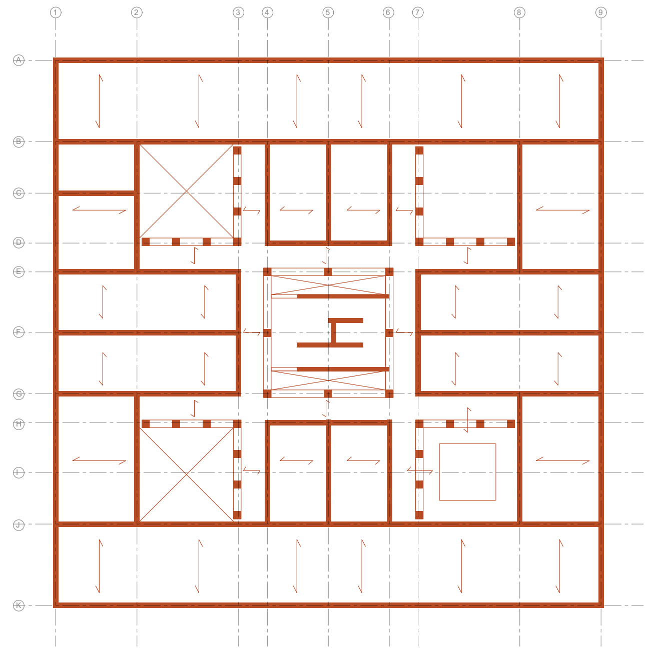




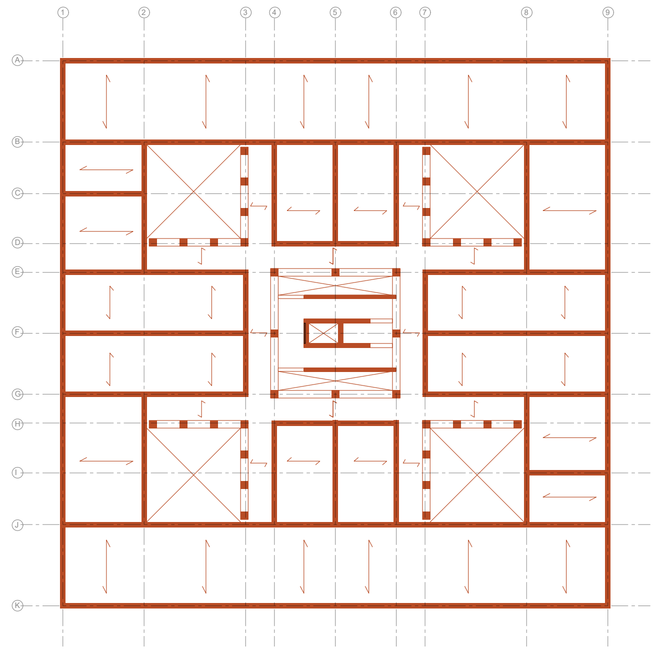
FIRST FLOOR



THIRD FLOOR



GROUND FLOOR



SECOND FLOOR

MODEL 1:100

MATERIAL SAMPLES

LOADBEARING BLOCKS: RUBBLE MIXED WITH CEMENT

Made with two different cement: limecement and fast cement. Combined with 3 different grain sizes of the rubble.

05 CONCLUSION, DISCUSION & REFLECTION

5.1 CONCLUSION

Since the outbreak of the Syrian civil war in 2011, millions of Syrians have been displaced, and large parts of cities such as Homs have been physically destroyed. Although many residents are now returning, reconstruction remains challenged by damaged infrastructure, economic instability, and a disrupted social fabric. In this context, rebuilding housing is not only a matter of replacing buildings, but also of restoring relationships between people, community, and place. This graduation project investigates how locally grounded architecture can support a renewed sense of belonging in post-conflict Homs, Syria, by designing spatial thresholds through floorplan configurations, façade systems, and material strategies. The research approached reconstruction not only as a technical challenge, but also as a social and cultural process.

The first part of the research examined the relationship between architecture and belonging through environmental psychology, neuroarchitecture, and Syrian critiques. The findings show that belonging emerges through the interaction between certain perceptual qualities of the built environment, cultural practices, local material expression, and collective accomplishment. Facades are understood as interfaces mediating these interactions.

To localise this theoretical framework, the project analysed the traditional Syrian courtyard house through three façade-related dimensions: façade as a component, creating space, and the process of building. This study demonstrates that courtyard houses are not only significant because of its historical image alone, but because of the way it shapes the relationships between privacy and community, climate, visibility and protection.

The courtyard emerged as an inward-oriented social room that enables shared life while maintaining cultural expectations of modesty and privacy. Rather than replicating historical forms, the project extracted underlying spatial and social principles from the courtyard typology and reinterpreted them within a contemporary housing block. This resulted in a design approach centred on intermediate spaces, galleries, courtyards, and inhabited facades that enable different forms of social interaction and retreat.

The research also explored how pistachio shell agricultural waste could be transformed into a bio-composite material for façade components in post-conflict housing. Combined with furan resin and low-tech compression moulding techniques, pistachio shells demonstrated potential as a locally producible material system that reduces dependence on imported construction products. This linked material experimentation to broader questions of reconstruction, local economies, and resource scarcity in Syria.

These findings informed the final architectural proposal, which organises housing around interconnected courtyards and thresholds that mediate transitions between the city, collective life, and the dwelling. Different spatial atmospheres are created through variations in openness, enclosure, and material expression. The material strategy combines reused rubble, limestone, and pistachio-shell composite panels to create a construction approach rooted in local resources and cultural memory.

Ultimately, the project concludes that architecture can contribute to restoring belonging in post-conflict contexts when reconstruction moves beyond purely functional or economic concerns and instead engages with the social, spatial, and material conditions that shape everyday life. By combining context-specific spatial principles with locally grounded material systems, the project proposes a housing typology that responds not only to the need for shelter but also to the need for continuity, identity, and collective recovery in Homs. The significance of this approach lies not in recreating a nostalgic image of pre-war Syria, but in reinterpreting underlying social and spatial principles in a contemporary way.

5.2 DISCUSSION

This project positions architecture as an active participant in post-conflict recovery. It challenges reconstruction approaches that prioritise speed, full efficiency, and standardisation, while neglecting the social and cultural dimensions of everyday life. It argues that belonging should be a bigger concern in post-conflict reconstruction. In many post-conflict situations, rebuilding risks produce environments that are technically sufficient, but emotionally distant, resulting in alienation rather than creating a place to heal. This proposal advocates for context-sensitive architecture that reconnects residents with their homes.

At the same time, the project has clear limitations. The material research stays theoretical and requires extensive prototyping and testing before it can be applied in construction. Questions regarding design limitations and the current situation in Syria remain unanswered. Furthermore, measuring the social impact of architecture on the sense of belonging is intrinsically difficult, particularly in the context characterised by trauma. Architecture is not the only solution. Nevertheless, the project suggests that architecture can still contribute meaningfully to post-conflict recovery by creating locally embedded environments that support a sense of belonging.

5.3 REFLECTION

The graduation project was developed using a 'design-by-research' methodology, in which theoretical research, contextual analysis, material exploration, and architectural design were continuously interwoven. Throughout the whole process, the interaction between research and design became increasingly reciprocal. Findings from literature, material studies, and spatial analysis repeatedly influenced design decisions, while the emerging design also revealed gaps within the research itself.

One of the most valuable aspects of this graduation process was learning to work with an unfamiliar and uncertain context across different disciplines simultaneously. This required balancing abstract and theoretical concepts, such as belonging and sense of place, with very concrete architectural decisions related to thresholds, climate systems, and façade details. Translating these conceptual ideas about identity into spatial and material strategies was both very challenging but essential to the project.

The contextual analysis of Syrian courtyard housing proved to be essential to the development of the design. Initially, there was a risk that local architecture would be used as an aesthetic reference (just copying the details). However, research provided a deeper understanding of the Syrian culture and its underlying social, spatial, and climatic logic. This contributed to a contemporary reinterpretation of pre-war Syrian architecture.

The project would have benefited from greater direct involvement with Syrian residents and communities. Conversations with people who have experienced displacement could have provided additional insights, thereby grounding this proposal not only through literature but also in lived experience.

04 APPENDICES

APPENDIX A - SYRIA'S RED GOLD

ABSTRACT

This paper explores whether pistachio shell waste from Syria can be transformed into a bio-composite suitable for façade panels in post-conflict Homs. It argues that pistachio shells, a low-value agricultural by-product, can function as a bulk filler in a locally sourced composite system, combined with a suitable bio-based matrix. Through literature review and material selection, the study identifies pistachio shells as technically viable due to their lignocellulosic composition, density, and potential to improve stiffness and dimensional stability. Furan resin emerges as the most suitable matrix for exterior façade use, while fibre reinforcement is not considered necessary for the intended application. The paper also outlines a feasible low-tech manufacturing route based on bulk compression moulding and estimates that existing pistachio production could yield substantial façade area. Although experimental validation is still needed, the findings suggest a promising circular strategy linking rural agricultural waste, local production, and urban reconstruction.

Keywords: bio-composite, pistachio shells, Syria, façade panels

Figure 1: Syria produced up to 80,000 tonnes of pistachios a year before the start of the conflict in 2011. PHOTO: AFP https://www.straitstimes.com/world/middle-east/syria-pistachio-farmers-return-to-orchards-after-years-of-war

1. INTRODUCTION

Since 2011, the war followed by the earthquake in 2023 has led to massive destruction and prolonged displacement, which leaves 1.87 million Syrians to return to cities that are physically and socially devastated (Jazeera, 2025). In Homs, a city in western Syria, more than half of the pre-war population has been displaced, and more than half of all homes have been left uninhabitable, with large parts of the city consisting of empty concrete frames and looted apartments (UN-Habitat, 2022).

Syria's physical reconstruction faces enormous constraints: the costs of rebuilding are estimated at hundreds of billions of dollars, while sanctions, depleted foreign reserves, and shrinking government investment make conventional, import-dependent building materials unaffordable (World Bank Group, 2025). However, the agricultural sector, historically a backbone of Syria's economy and still accounting for about a quarter of GDP during the conflict, has re-emerged as a crucial safety net (Food and Agriculture Organization of the United Nations, 2017),

generating organic waste by-products. One such by-product is pistachio shells, which could potentially be enhanced into building components that support housing repair while strengthening local agriculture-based livelihoods.

Bio-composites offer a potential solution that could contribute. In 1908, the bio-composite first appeared in an effort to combine lignocellulosic fibres with bio-based resins (Jawaid & Abdul Khalil, 2011). Since the 1980s, driven by the search for low-carbon, resource-efficient alternatives to conventional materials, the development of partially or fully bio-based composites has gained momentum (Riedel et al., 2001).

Bio-based composites usually contain three different components: a matrix, fibres, and fillers, whose types and proportions have to be adapted to specific applications. The incorporation of locally available waste streams, such as agricultural residues (Neuhaus, 2024) carbon footprint and can reduce the costs of the composite (Rodríguez et al., 2018). When planned and created with care, such materials can reduce dependence on imported resources, lower embodied impacts, and create new roles for rural producers and urban workshops in reconstruction.

This paper investigates how agricultural waste in the form of pistachio shells from Syria can be converted into a bio-composite material suitable for façade panels in post-conflict situations. It argues that pistachio shells, currently seen as a low-value by-product of a strategic cash crop, can serve as a bulk filler within a bio-composite system. This has to be supplemented by a selected matrix and possibly fibre reinforcement to produce a viable façade cladding material (or other function? Not specifically cladding?).

The research question guiding this work is: How can pistachio shell agricultural waste be transformed into a bio-composite material suitable for façade panels in post-conflict Homs, Syria?

To answer this question, the paper aims to achieve five objectives. First, it builds a theoretical framework around bio-composites by reviewing academic literature on the roles of the matrix, fibres, and fillers. Second, it maps pistachio cultivation and shell waste pathways in Syria, identifying potential points in the production chain where shells can be collected for use. Third, it applies comparative material-selection criteria to evaluates candidate matrices and natural fibres and selects combinations that are both technically compatible with pistachio shells and realistically available through regional supply chains. Fourth, it outlines feasible manufacturing routes for turning shells, resin, and fibres into façade-scale components, with particular attention to a process that could be implemented in small-scale or community workshops. Finally, it estimates material quantities from orchard to façade area, to understand how pistachio-shell bio-composites might be scaled up.

2. UNDERSTANDING BIO-COMPOSITES

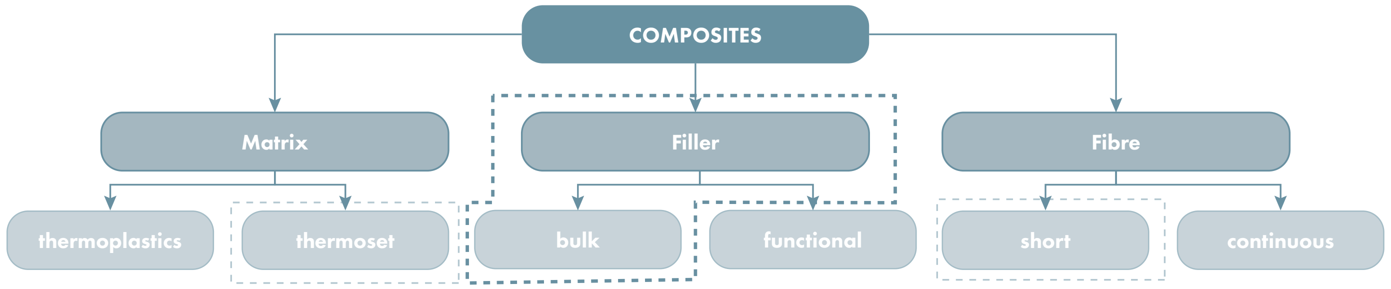


Figure 2: typical composition for polymeric composites

2.1 DEFINING BIO-COMPOSITES

A bio-composite contains ingredients that are partially or fully derived from bio-based matter (Neuhaus, 2024). Typically, the composite is composed of three main components: fibres, the matrix, and fillers. The functional and mechanical properties can be influenced by the specific choice and proportions of each component. The constituents in a composite build a lasting chemical and/or mechanical bond (Murawski et al., 2019). The quality of the bond often determines not only the strength but also the durability of a composite.
To create a good bio-composite, these three components are necessary, so research will be done on all three components, but the main focus will be on the filler.

2.2 FIBRES

In the context of bio-composites, 'fibre' refers to fibrous fillers, which are added to the composite, assuring reinforcement and improving the material's properties, such as tensile and bending strength. The most common fibres in composite materials are glass fibre and carbon fibre. In a bio-composite, these could be replaced by fibres sourced from animals or plants. The focus of this paper is not on fibres. Still, without fibres, no compatible bio-composite, so some research has to be provided on the use of natural fibres in composites.

Natural fibres were first introduced as reinforcement when bio-composites began to be further developed. These natural fibres are sourced from seeds, fruit, grasses, or extracted from stalky parts of plants by something called retting. This involves breaking down the fibril structure into separate strands and the degradation of other separate strands and the degradation of other organic matter (Ramesh et al., 2017).

Composite materials can be distinguished depending on the reinforcement system used. Unidirectional composites have a reinforcement all oriented in the same direction, while multidirectional composites have fibres randomly orientated (Kula et. al., 2013). Additionally, composites can contain either continuous or non-continuous fibres as reinforcement. The length and layout of the fibres can be predetermined based on the natural state and occurrence of the particular fibre (Neuhaus, 2024). Figure X shows that continuous fibres can be organized in three different ways. These types can influence how the composite material behaves.

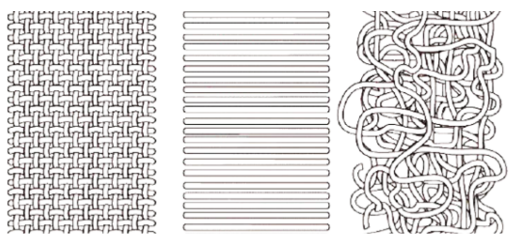


Figure 3: organisation for fibres (Kula, et al. , 2013)

2.3 MATRIX

In bio-composites, the matrix is the continuous phase that binds all other constituents together and enables the material to function as a coherent whole. It surrounds the fillers and fibres, transfers stresses between them, protects them from environmental influences, and largely contributes to the final geometry of the composite. Without a matrix, the fillers and fibres would remain loose particles and could not be shaped into a structural or functional building product (Neuhaus, 2024).

The matrix is nearly always a polymer, called a polymer resin. Some well-established polymers, such as polyesters, epoxies, and vinyl esters, are derived from fossil fuels. They are stronger and more durable than bio-derived resins. Still, they are non-biodegradable thermosets, which means they do not decompose naturally at the end of life. They cannot be easily demoulded or remanufactured into a different product after first use. These petroleum-based polymers can also have a poor adhesion with some of the plant fibres, leading to weaknesses in the bio-composite. Alternatively, bio-based polymers such as PLA, PHA, or furan resin can be used; these biopolymers are thermoplastic and biodegradable (BKTUDelft, 2025). When used as the binding phase in a composite, such materials are referred to as bio-plastic matrices. In bio-composites that incorporate plant-based fillers or fibres, the matrix often becomes the limiting factor for biodegradation and end-of-life behaviour, as it governs how the material can be recycled, degraded, or reused (Neuhaus, 2024).

The particular selection of this resin defines the mechanical performance, durability, processability, and environmental impact of the composite. Properties such as stiffness, heat resistance, moisture resistance, UV stability, and long-term durability are largely governed by the matrix material rather than by the fillers alone (SOURCE...?).

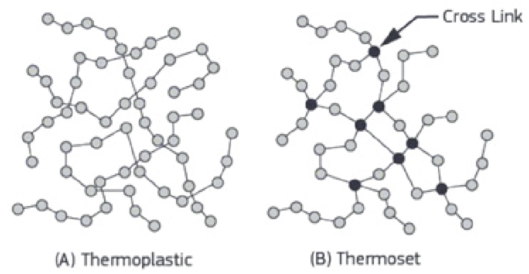


Figure 4: molucular difference between thermoplastics and thermosets (protolabs.com)

2.4 GRANULAR FILLERS

Granular fillers in bio-composites can be divided into two categories: functional- and bulk fillers. Functional fillers are typically added to composites in small quantities to achieve particular material characteristics such as colour, electrical conductivity, ultraviolet resistance, or improve processing efficiency (Neuhaus et al., 2025). In contrast, bulk fillers are the predominant filler type and are primarily used to reduce the end product costs and improve dimensional stability by limiting shrinkage during moulding (Tan et al., 2022). Considering bulk fillers often constitute about 40-65% of the total composite weight, depending on the application and the material characteristics of the filler, their selection can strongly influence both the mechanical performance and the sustainability profile of a bio-composite, especially when low-density, low-cost fillers are used (Neuhaus, 2024).

Previous research on bio-based bulk fillers, such as fruit pits, bone dust, and walnut shell powder, shows that they can increase dimensional stiffness and improve certain absorption and swelling behaviours.

However, the higher the filling content, the greater the reduction in bending strength. Therefore, the amount of filler content should be adjusted to the type of application and other performance requirements. Several parameters are essential when selecting a filler and its volume fraction:

surface texture
porosity grain size
grain shape
chemical structure
filler-matrix ratio

There is no single ideal combination; the success of the composite depends on these filler characteristics in relation to the chosen matrix, the processing method, and the intended function (Senthil Muthu Kumar et al., 2020).

What is often even more important than the intrinsic properties of the filler itself is the compatibility between the filler, matrix and fibre. Good compatibility can be obtained through mechanical interlocking, which is facilitated by rough, porous particle surfaces, or through chemical bonding, for example using coupling or binding agents at the interface (Senthil Muthu Kumar et al., 2020). In many bio-composites, lignocellulosic fillers are combined with relatively hydrophobic polymer resins, leading to high moisture absorption, poor adhesion at the interface, and insufficient dispersion of the filler in the matrix if not addressed properly (Senthil Muthu Kumar et al., 2020).

Additionally, the size, shape and loading of filler particles influence the mobility of polymer chains and thus the mechanical properties of the composite as well. Higher filler content and larger particle size in thermoplastic matrices, can make the material significantly stiffer, but also more brittle. While thermosets, the cross-linked network already limits chain mobility and partially determines the response (Senthil Muthu Kumar et al., 2020). So, larger particles may increase crack formation under load, but also reduce the proportion of resin in the composite and can therefore reduce costs and environmental impact. As a result, the optimal filler volume and particle size distribution must be adjusted to the porosity and surface properties of the filler so that the composite achieves the desired balance between stiffness, strength, toughness and durability for the intended application.

2.5 CHAPTER CONCLUSION

This chapter has outlined bio-composites as multi-constituent materials in which matrix, fibres, and granular fillers each play a distinct role in determining mechanical performance, durability, and environmental impact. The matrix acts as a continuous phase, binding and protecting other constituents as well as managing stiffness, heat and moisture resistance, UV stability, and long term behaviour. Fibres provide extra reinforcement, specifically in bending and tension. Bulk fillers, primarily affect cost and dimensional stability, but can also influence stiffness, because they can compose 40-65% of the composite. The effectiveness of the filler does not only depend on its intrinsic properties, such as particle size, texture, and porosity, but also on compatibility with the matrix and manufacturing method.

3. PISTACHIO SHELLS BIO-COMPOSITE IN CONTEXT

3.1 PISTACHIO CULTIVATION AND SHELL WASTE IN SYRIA AND THE REGION

North-western Syria is known for its extensive pistachio cultivation, particularly in parts of the provinces of Aleppo, Idlib, and Hama, where climatic conditions and soils are suitable. Before and during the conflict, farmers in these regions managed production around family-owned orchards, with yields fluctuating from season to season but still producing thousands of tonnes of nuts annually, making pistachios a strategic cash crop for rural livelihood (iMMAP, 2019).

The pistachio market chain consists of four main phases: production, processing, trading, and consumption, each involving distinct actors and infrastructures. This market chain is illustrated in Figure X. Small and medium-sized farmers, who are the primary producers, harvest pistachios and sell them primarily to wholesalers, followed by processors and occasionally to other farmers with their own processing capacity. This customer pattern hasn't fundamentally changed during the conflict, although the number of buyers has increased by about half. Processing companies and village-scale workshops near orchards are responsible for cleaning and sometimes de-hulling the nuts, drying, and occasionally roasting. Larger traders consolidate volumes, store them in warehouses, and organise transport to regional markets or even border crossings for export (iMMAP, 2019).

Conflict, displacement, and bombing have disrupted this system by damaging warehouses, interrupting trade routes, and reducing the number of active buyers. However, pistachios remain an attractive crop, and more recent reports indicate that farmers are returning to their orchards and re-entering the market now that conditions have slightly improved. Current production in northern and eastern rural Aleppo alone is estimated at tens of thousands of tonnes of pistachios per year, with more than two

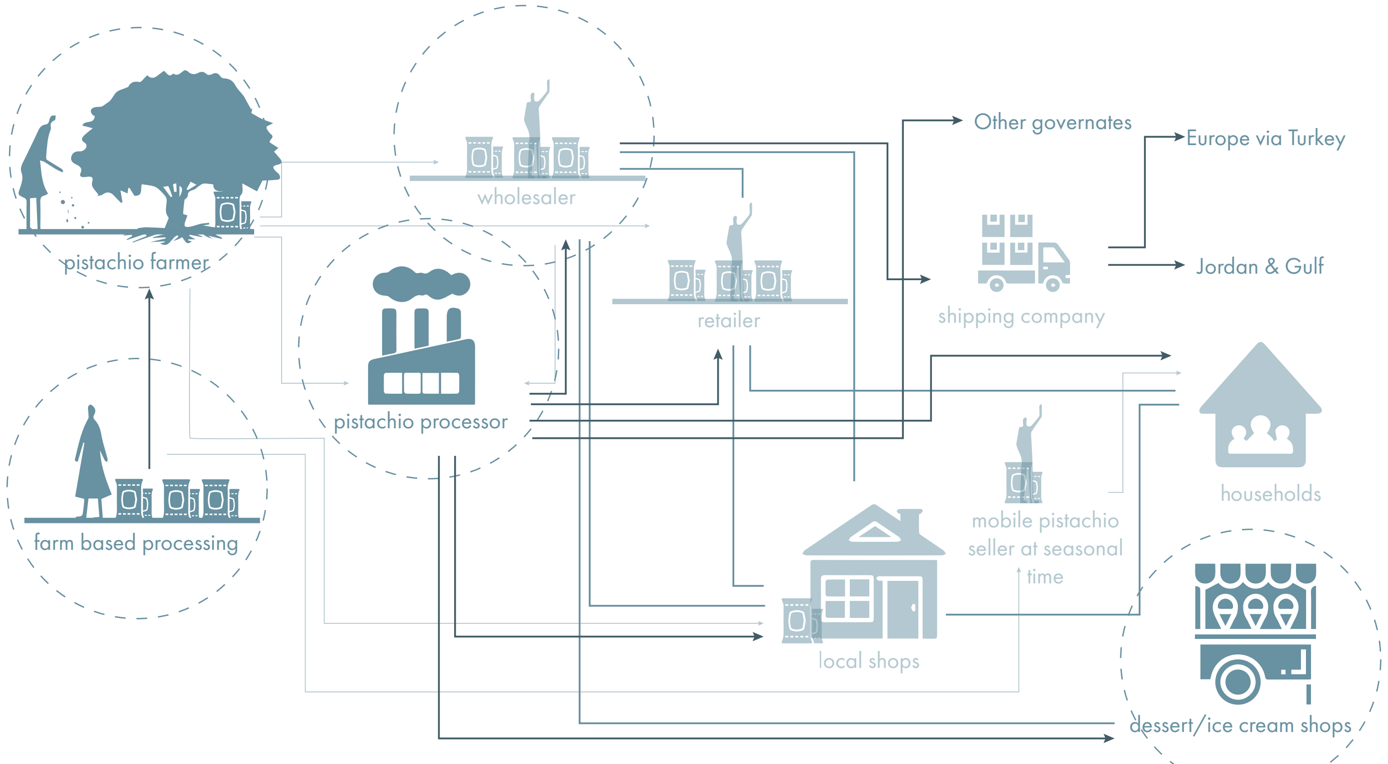


Figure 5: Mapping of pistachio (shells), based on data from (iMMAP, 2019)

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Based on the value chain mapping in northwest Syria, a feasible scenario for the supply chain of Homs and similar cities can be outlined, in which shells are captured as building material input instead of remaining unused by-products. In rural areas, primary collection points for shells would be village-scale processing workshops and larger drying facilities near orchards, where shells are collected. In the urban context, collection points could be wholesale markets, which generate a steady but more dispersed flow of shells that can be aggregated through municipal or cooperative collection programmes (iMMAP, 2019). In such a scenario, shells would be moved via already existing trader networks to a local 'material hub', where they can be ground into bulk filler for bio-composites.

3.3 MATERIAL COMPOSITION AND PROPERTIES OF PISTACHIO SHELLS

Pistachio shells are a lignocellulosic material composed of mainly cellulose (approximately 30 – 55 wt%), hemicellulose (20-30 wt%), and lignin (12-38 wt%), which gives them a hard, dense structure suitable for use as a granular filler (Fereidooni et al., 2024) These ingredients are comparable to other nut shells and fruit stones that have already been successful as bio-fillers in polymer composites. This suggests that pistachio shells can contribute to stiffness and dimensional stability when properly integrated into a matrix.

Mechanically, pistachio shell particles have been shown to increase tensile and flexural strength, however, this conclusion comes from a study where they tested a glass fibre reinforced polymer composite, so not bio-based (Thiagarajan et al., 2021). In epoxy-based systems, for example, the addition of micro-sized pistachio shell particles up to about 10–20 wt% can raise tensile modulus and compressive strength, while higher contents tend to reduce tensile strength because of stress concentrations and weaker matrix continuity (Kumar et al., 2025; Şahin et al., 2024). Pistachio shell-reinforced composites provide a promising eco-friendly alternative to conventional composites reinforced with glass or carbon fibres. Their production holds potential for diverse industrial applications due to their biocompatibility.

Overall, these properties indicate that pistachio shells are technically viable as a bulk filler for bio-composite façade panels, assuming that the choice of matrix, fibre, particle size, and any surface treatment is carefully balanced to achieve a balance between stiffness, strength, moisture resistance, and durability.

3.3 CHAPTER CONCLUSION

The analysis in this chapter shows that pistachio shells meet both contextual and technical criteria for use as a bulk filler in bio-composites. The pistachios are already produced within an existing agricultural value chain that is recovering after conflict. The shells can be collected at various points in the market chain. From a technical perspective, their lignocellulose composition, hardness, and proven performance in polymer composite materials indicate that they can contribute to dimensional stability and stiffness while also lowering end product costs.

Within the bio-composite framework established in Chapter 2, pistachio shells thus fulfil the role of a high-volume bulk filler that can have a strong influence on durability, density and hygro-mechanical properties, while the choice of matrix and fibres is left to proven technologies. This makes pistachio shells the most important material in the design of a bio-composite panel on a facade scale for Homs and forms the basis for the following chapters, which focus on identifying compatible matrices and fibres and outlining feasible production methods.

Inhabited edges, Homs
Extreme graduation - AR4EA010

4. MANUFACTURING

4.1 COMPATIBLE MATRICES AND FIBRES

Furan resin is identified as the most suitable matrix for combination with crushed pistachio shells. This resin has been applied by NPSP and other practitioners, demonstrating strong performance in prior testing. Furan resin is a bio-based thermoset derived from furfuryl alcohol, which in turn is produced from agricultural waste streams such as corncobs, sugar beet, and sugarcane bagasse (Biron, 2013). As a thermoset, the material offers advantageous processing characteristics and meets the thermal and durability requirements associated with façade applications, including enhanced resistance to elevated temperatures and ultraviolet radiation.

Insights from discussions with practitioners experienced in working with this material indicate that fibre reinforcement has not been incorporated in existing applications. However, the introduction of fibre alongside granular filler may result in improved tensile strength compared to composites relying solely on particulate reinforcement (Neuhaus, 2024). The relevance of this mechanical enhancement depends on the specific performance requirements of the application.

4.2 PREPARING & PROCESSING

To function effectively as a bulk filler, pistachio shells first need to be washed to remove dust, soil and residual salts, then thoroughly dried, and finally mechanically crushed and sieved to obtain optimal target size distribution, balancing processability and mechanical performance (information from NPSP).

Depending on the scale of the project, different levels of equipment can be used to carry out these steps. At a community scale, washing can be done in simple tanks or basins, followed by sun-drying on racks or other clean surfaces and, if available, low-temperature oven drying to ensure low moisture content before grinding. This final preparation stage can be handled with a small industrial grinder or a grain mill with similar functionality. The pistachio shells are now ready to be combined with the chosen resin and natural fibres in the composite manufacturing process.

Name	Material class	Comments
Partially bio-based polyester/epoxy	Thermoset	= more stable and predictable
Bio-based PLA or PHA	Thermoplastic	Re-meltable, low footprint, potentially compostable
Bio-based furan	Thermoset	Thermoset: high temperature, UV resistance, good for exterior

Figure 6: Compatible matrices and fibres

4.3 MANUFACTURING METHODS & MOULD

For the processing of polymeric composites, several moulding options are commonly applied.

For this project, the most feasible route is therefore compression moulding. In this process, the 'dough' that was created by mixing all ingredients is placed in the moulds and pressed with a preheated press, yielding relatively uniform façade panels with manageable equipment demands.

Name	Description	Comments
Injection compression moulding	High precision: melted plastic inserted into mould	- Fillers and short fibre bundles can be added to matrix before injection. - Not fit for dry woven fibre reinforcement and long fibres
Thermoforming	Sheet of polymer gets heated in fixed frame vacuum suction	- Extra production step needed to make sheet. Sheet has higher variations in performance
Bulk compression moulding	Pressing of a moulding compound on a preheated mould	- Granulated and short fibre fillers. Design freedom. - Less suited for woven sheet/long fibre reinforcement. Extra step of mixing resin, mixed with fillers

Figure 7: Manufacturing methods

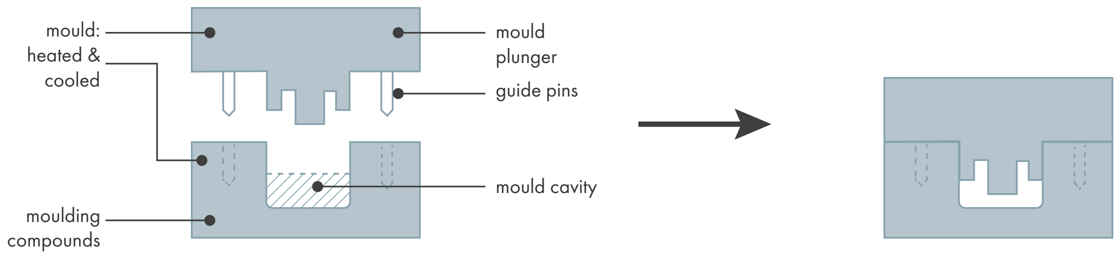
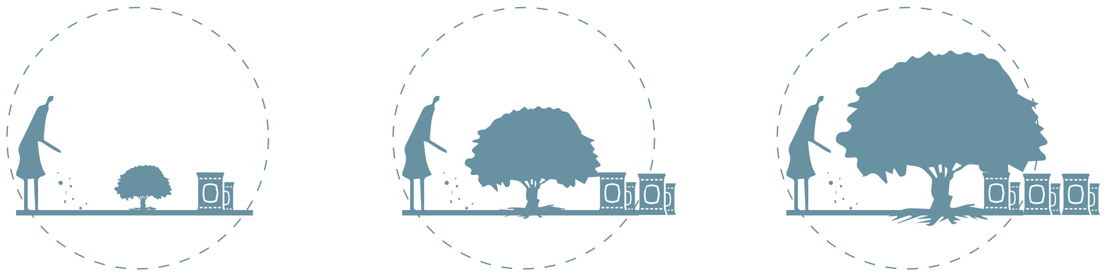


Figure 8: Compression moulding

5. QUANTITIES



	YOUNG TREE	AVERAGE TREE	MATURE TREE
PISTACHIO KG/TREE	1 - 2 KG	6 - 10 KG	> 15 KG
SHELL KG/TREE	0.5 - 1 KG	3.0 - 5.0 KG	> 7.5
FACADE PANEL (M2)	0.10 - 0.20	0.6 - 1	> 1.5

Figure9: quantities of pistachio shells Syria based on data from ....

The average pistachio tree with buds usually comes into bloom in the fourth or fifth year of its life. Production at this young age usually varies from 1-2 kg of dry nuts per tree. Average production requires 7-10 years. At this age, reasonable production ranges from 6 to 10 kg of dry nuts per tree. When the trees reach full maturity at 12-14 years of age, the production of a healthy and well-cared-for pistachio tree can reach or even exceed 15 kg of dry nuts.

Pistachio shells are 50% of the total weight of a pistachio nut. NPSP concludes that around 5 kg is required for a 1m2 façade panel. This leads to the following calculation.

Recent data on the number of pistachio trees surrounding Homs is missing. However, the number of trees in Hama is available, which is 800,000 trees. This leads to around 1.2 million façade panels of 1m2.

6. DISCUSSION & CONCLUSION

4.6.1 DISCUSSION

The findings of this paper indicate that pistachio shells could be a technically and contextually viable bulk filler for bio-composite façade panels in Homs, but several limitations temper the conclusions. This paper uses literature as its main resource rather than experimental testing, which means that important performance aspects , such as long-term moisture and UV ageing, still need to be validated in practice. Furthermore, estimates of quantities are based on old data. Without up-to-date figures on the orchards around Homs, the upscaling potential can only be approximated and not accurately quantified.

Future research should therefore be focused on three directions: the technical viability of the proposed composite with the selected matrix (and fibre), and production setups with local stakeholders in Syria. Together, these steps would ensure that pistachio shell bio-composites evolve from a plausible construction material into a tested component socially embedded in the context of Homs. Further research could also be done on other applications of a pistachio shell bio-composite.

4.6.2 CONCLUSION

This paper explored how pistachio shells, an agricultural waste product, can be converted into a bio-composite material suitable for façade panels in post-conflict Homs, Syria. By understanding bio-composites as a multi-component material, in which matrix, fibres, and granular fillers each play a specific role, the research identified bulk fillers as an important factor for balancing material performance, sustainability, and local availability. Pistachio shells present a promising bulk filler, as they are generated within a reactivating agricultural value chain and can be sourced at identifiable collection points within a market system that is gradually being re-established.

The literature review on fillers based on pistachio shells shows that when used in moderate amounts and with suitable particle size distribution, they can increase the stiffness and dimensional stability. However, a high content carries the risk of a reduction in tensile strength. The paper identified furan resin as a suitable matrix, based on its thermoset behaviour and realistic prospects for regional sourcing. Due to the product's application, no fibre is needed.

On the manufacturing side, the paper outlined feasible routes for producing façade-scale panels using relatively low-tech equipment, focusing on bulk compression moulding. This method is compatible with community- or workshop-scale production, and can accommodate the bio-composite mix, which is created from the selected components. A rough quantity analysis further suggests that, even with assumptions based on old data, the shell output of pistachio orchards could translate into meaningful façade areas, indicating real potential for future integration into reconstruction strategies.

APPENDIX B - SYRIA'S TRADITIONAL COURTYARD HOUSING

ABSTRACT

This analysis examines the Syrian courtyard house as a typology that combines spatial organization, material expression, and lived cultural practice to create belonging. Focusing only on the courtyard house, it studies the façade as component, space, and process, and reads it through Syrian architectural critiques, studies of traditional dwellings, and oral accounts of everyday life before the war. The analysis shows that the courtyard house creates a graded relationship between privacy and collectivity, supports climate-responsive living, and records adaptation through incremental construction and local craft. From these observations, the paper extracts design principles relevant to façade design and domestic space in the Syrian context.

Keywords: Syrian courtyard house, Syrian architecture, Islamic privacy

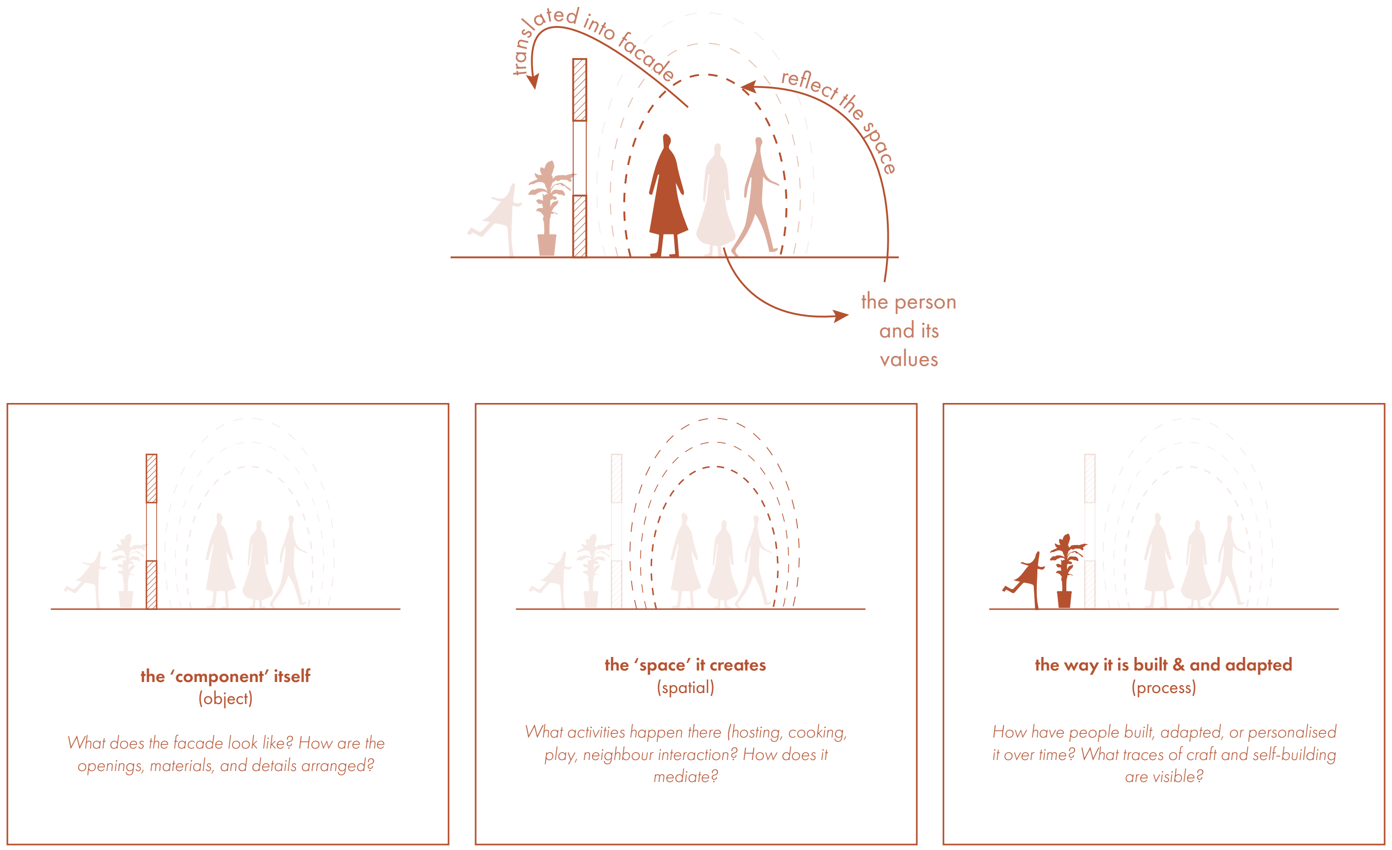


Figure 1: design principles

1. INTRODUCTION

This short analysis examines the Syrian courtyard house as a typology in which façade, space, and everyday life work together to produce a sense of belonging. Rather than treating the courtyard as a static historical form, the analysis reads it as a lived architectural framework that organizes privacy, supervision, climate, social interaction, and gradual adaptation over time. It examines the courtyard typology, as this is the most relevant pre-war domestic setting for understanding how belonging is embedded in Syrian housing.

The analysis answers the question: which architectural characteristics of the courtyard house make it a meaningful model for belonging, and what design principles can be extracted from it? To answer this, the analysis brings together three sources of knowledge: Syrian architectural critiques, studies of traditional dwelling typologies, and oral descriptions of everyday life before the war. These sources are read through three lenses: the façade as a component, the space it creates, and the process through which it is built and changed.

The paper is structured in four parts. First, it introduces the courtyard house as a spatial and cultural type. Second, it examines the courtyard as a lived interior and social room. Third, it discusses the façade as a material and perceptual interface. Fourth, it considers how incremental transformation and local craft shape the house over time. The conclusion draws together a set of design principles that can inform contemporary work on façade and domestic space in the Syrian context

2. CONTEXT

The concept of the courtyard house evolved both as a unit and as part of a settlement structure, pleasing to all humanity (Petruccioli, 2007). In ancient Syrian cities, courtyard houses were built to meet the social, functional, ecological and architectural needs of the people and their way of life. They organically grew as a community-sustaining architecture (Al-Sabouni, 2017).

The courtyard house was not just a typology but a dominant way of organising domestic life. A typical house is entered via a relatively narrow alleyway that opens onto a curved corridor, before turning onto the courtyard (Sahlabji, 2016). This 'dog leg' arrangement immediately separates the public street from the community/family domain. The first real space one encounters is the interior open court rather than the street façade. Around the court, rooms are stacked on one or two storeys, with semi-open iwans and upper galleries framing the space and mediating between enclosed rooms and the sky. The traditional Syrian courtyard house is composed of three parts: a basement floor, a ground floor comprising the main living areas, and a first floor comprising the private areas.

3. THE SPACE

In the Syrian courtyard house, the façade is primarily oriented inwards, thereby establishing the courtyard as the central spatial and social heart of the home. Facades frame a communal, semi-open living space that shapes daily movement. In terms of climate, this space is carefully adapted through orientation and spatial arrangement. In houses with two iwans, one typically faces north and the other south, which allows households to adapt their daily activities to seasonal and daily conditions. The southern iwan provides shade in the summer, while the northern side catches the sun in the winter. This layout transforms the courtyard into a continuously habitable space.

Across variations in size and layout, the courtyard's spatial role remains consistent. Low-level areas, such as the courtyard floor and iwans accommodate three type of social functions:

- Private space: as it is a place for daily life activity (eating, sitting with family, cooking, workspace).

- Collective space: for guests and relatives such as religious ceremonies and wedding celebrations with folk music bands, in addition to open space for entertaining close friends like weekly female parties.

- Safe space: especially for kids to play within parents' close supervision from the gallery.

Figure 2: courtyard house movement based on season and time of day diagram

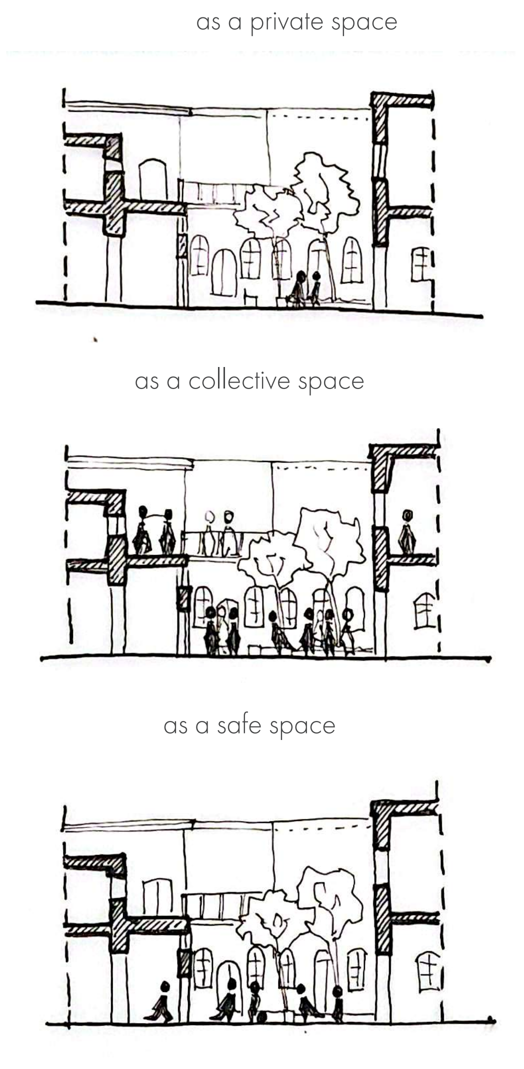
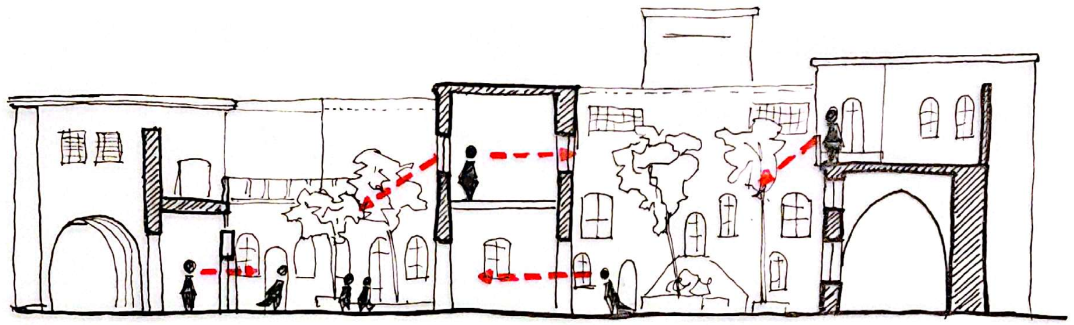


Figure 3: courtyard house social functions diagram

The facades surrounding the courtyard frame the views between the different storeys, allowing family members to see and be seen whilst engaged in various activities. This layered visibility encourages social interaction, whilst at the same time respecting the cultural values of privacy and modesty, particularly for women.

Privacy is further reinforced by the inward orientation of the house. Although the courtyard is an open space, it is visually protected from the street and neighbouring buildings through controlled access and enclosed perimeter walls. As a result, domestic life unfolds in an environment that is both open and sheltered, allowing social routines to be shared without exposure to public view (Zein Alabidin, 2010).



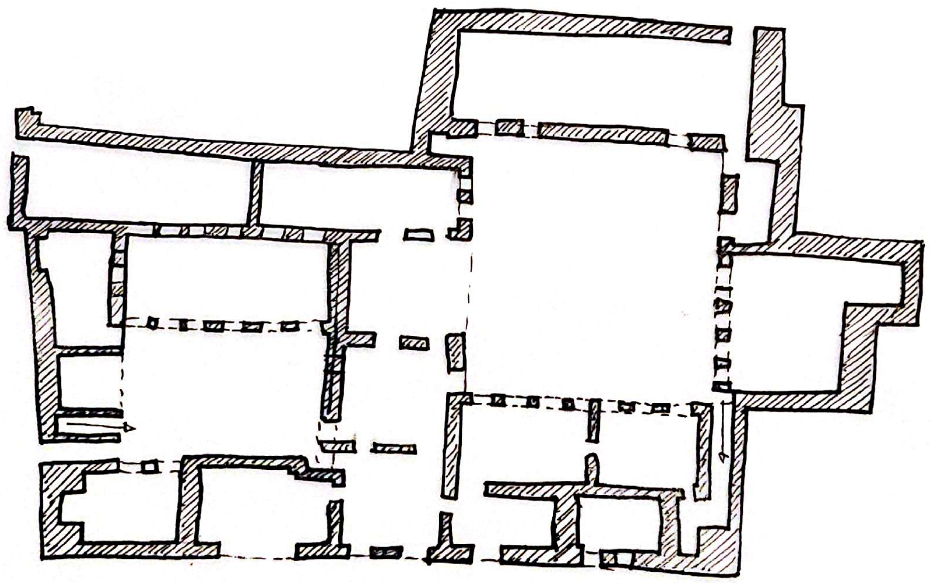


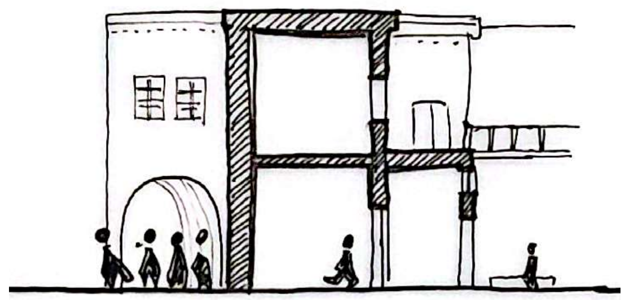
Figure 4: open view across spaces and levels diagram

4. THE COMPONENT

Building on the spatial logic of the courtyard as a shared, inward-facing living space, the courtyard façade translates and or supports social practices and cultural values into a coherent architectural element. The façade not only functions as a self-contained surface, but as a layered interface that supports visibility, movement, and interaction around the communal space that the courtyard provides.

Sahlabji (2016) recognises a consistent architectural language in traditional Syrian courtyard houses. On the ground floor, the facades are characterised by thick masonry walls, deep window frames, low doors, and relatively small openings, which reinforce the sense of privacy and the thermal mass needed in Syria's climate. The upper floors become lighter and more permeable, articulated through continuous or rhythmic galleries supported by columns or beams, with balustrades, arches, and repeated openings (pp. 53–60). This vertical differentiation corresponds directly to the spatial hierarchy described earlier: collective and service-oriented activities below, observation, retreat, and private uses above.

Despite differences in dimensions and craftsmanship, these facades display a high degree of compositional coherence. Through repetition, simple symmetries, and regular rhythms, the layout of the house is clear at a glance. While sometimes subtle variations, such as the height of the doors, the colour of the shutters or the details of the balconies, indicate differences in the status, use or occupation of the rooms. This balance between order and variation allows residents to recognise both the collective structure and the individual presence.



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https://stock.adobe.com/ar/images/oriental-and-islamic-architecture-in-syrian-old-house-in-ancient-city-of-damascus-syrian-arab-republic-in-november-2010/299400671

https://www.researchgate.net/publication/359802718_Uluslararasi_Sosyal_Arastirmalar_DergisiThe_Journal_of_International_Social_Research_Cilt_15_Sayi_85_Subat_2022_Volume_15_Issue

Figure 6: privacy gradient through the facades

In terms of materiality, the courtyard facades are characterised by rich textures and local craftsmanship. Stone plinths, lime-washed plaster, wooden shutters and screens, iron railings, and geometric motifs create a layered surface that invites touch and close perception (Sahlabji, 2016; Kader & Önder, 2021). Coburn et al. (2020) suggest that these kinds of combinations of clear structural order and intricate detailing support feelings of homeliness and fascination. Human-scale articulation helps people situate their bodies and activities within the space.

A key distinction exists between outer and inner façades. The exterior wall facing the street is typically flat and minimally decorated, reflecting a cautious and reserved attitude toward public space. In contrast, the inner façade—facing the courtyard—is more open and expressive. This difference relates to who is allowed to access these spaces: the exterior addresses the general public, while the interior is visible only to those who have already been admitted into the private domain (Sahlabji, 2016; Kader & Önder, 2021; al Sabouni, 2016).

This contrast reflects a culturally embedded gradient of privacy. As one moves from the public street through a sequence of thresholds into the courtyard, the architecture becomes increasingly elaborate. The richer expression of the inner façades signals that one has entered a more private space and is recognised as a trusted guest.

Inhabited edges, Homs

Extreme graduation - AR4EA010

5. THE PROCESS

Courtyard houses in Syria are rarely the result of a single, completed act of construction. Studies show that they are typically built and transformed incrementally, responding to changes in family structure, economic capacity, and changes in traditions and values (mainly around privacy). Sahlabji (2016) documents how many houses began as modest one-storey dwellings around a small courtyard, with additional rooms added on upper levels as families grew, followed by partial roofing or enclosure of galleries and courtyards in response to overcrowding or climatic demands (pp. 83–96).

These changes are often clearly visible on the facades facing the courtyard. Variations in brickwork, differences in the quality of the plasterwork, sometimes different types of balconies or newly installed balustrades are visible traces that record the phases of adaptation. Such adaptations often make use of local building trades, stone masonry, brickwork, woodworking and metalwork, and are carried out by family members or by craftsmen who are part of local social and economic networks (Sahlabji, 2016; Ismail, 2015). As a result, the façade becomes a physical archive of daily labour, skills, and investments rather than a uniform, finished surface.

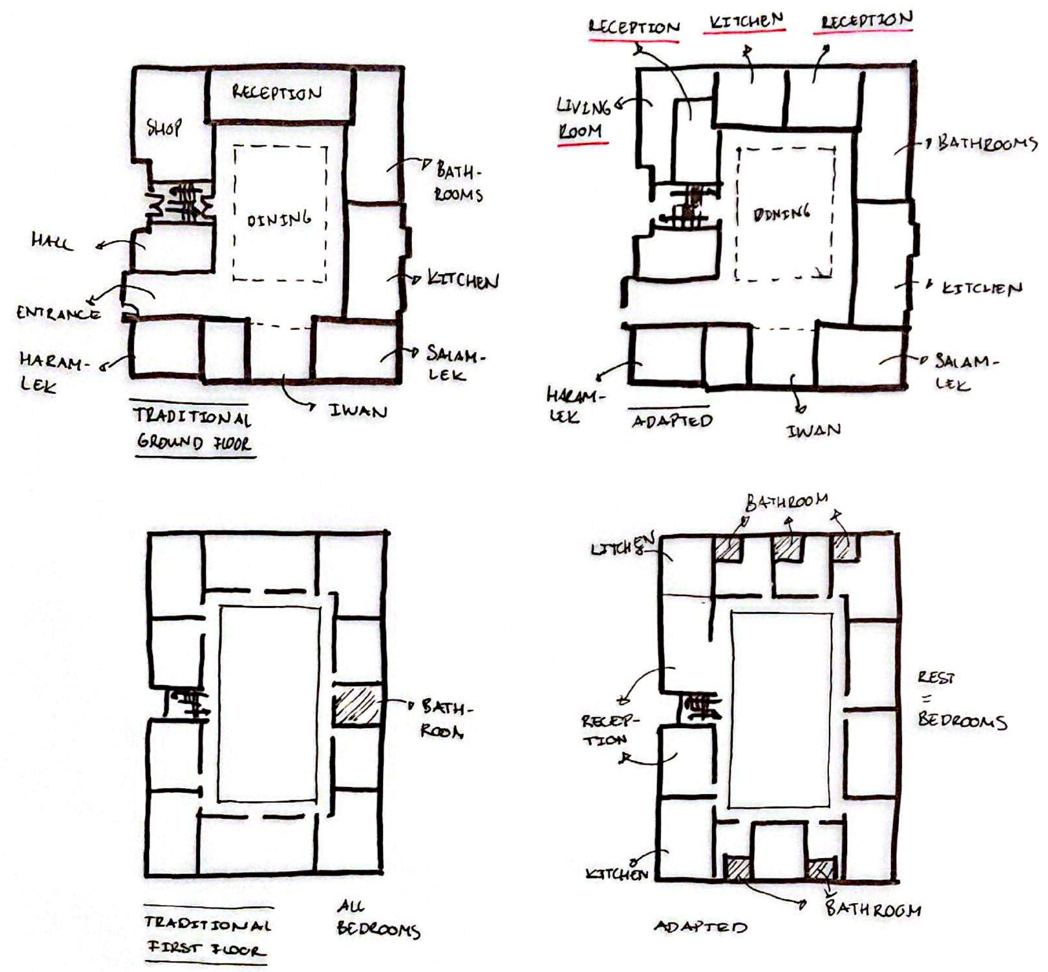


Figure 7: change in households visible in spaces

Ismail (2015) emphasises that these incremental alterations are not solely driven by economic necessity, but also function as culturally expressive acts. Households selectively introduce new materials or technologies, such as aluminium windows or ceramic tiles, while preserving spatial configurations that support valued social practices (pp. 142–150). Through this process, residents negotiate their identities between tradition and contemporary aspiration. Azzouz (2023) similarly describes homes in Homs as "spaces of identity," where savings, effort, and care are concretised in walls and façades (pp. 52–54).

The inner facades continuously evolve: rooms project into the courtyard, galleries are enclosed, and canopies are added for shade. Each intervention subtly redefines the boundary between inside and outside, private and shared. Some changes may compromise environmental performance or 'historic integrity', but they also show this ongoing relationship with people and their living space. This layer of modification operates as marker of collective accomplishment, tracing back to the perspective of belonging. The house is something made and remade through use (Ismail, 2015; Azzouz, 2023).

6. CONCLUSION

These courtyard houses show how façades, space, and everyday routines work together to make a dense, shared environment feel both communal and private. From this analysis, several conclusions and corresponding design principles emerge.

1 These courtyard houses show how façades, space, and everyday routines work together to make a dense, shared environment feel both communal and private. From this analysis, several conclusions and corresponding design principles emerge.

2 At the heart of the house is the courtyard, an open-air room that brings family life together. It is where daily activities unfold, where children can play safely, and where vulnerable family members can be outdoors without exposure to the street.

3 The façades that surround the courtyard are inward-looking and carefully framed, allowing family members to see and supervise one another across floors and galleries while remaining within a modest, protected visual world.

4 As the day and the seasons change, life moves through the house, from the courtyard to shaded galleries, interior rooms, and the roof, guided naturally by thresholds, shadows, and façade elements.

5 Privacy is built into the architecture itself: open and decorated surfaces face shared family spaces, while quieter, more solid walls protect intimate rooms, making the social structure of the house visible at a glance.

6 Although households change over time, this courtyard-and-façade framework remains stable, flexible enough to absorb new uses and relationships while preserving a strong sense of collective life.

APPENDIX C: DESIGN PROCESS AND EXPLORATIONS

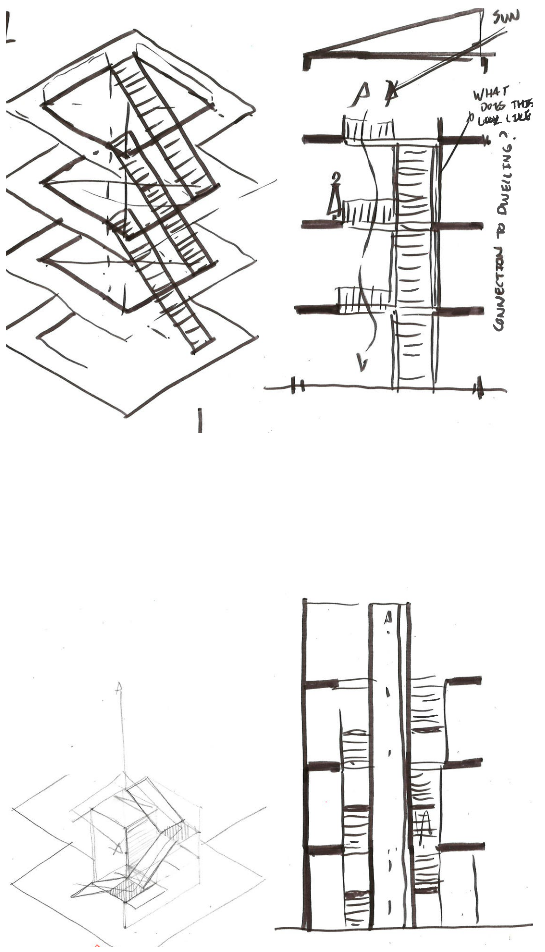
CONCEPTUAL FLOORPLANS

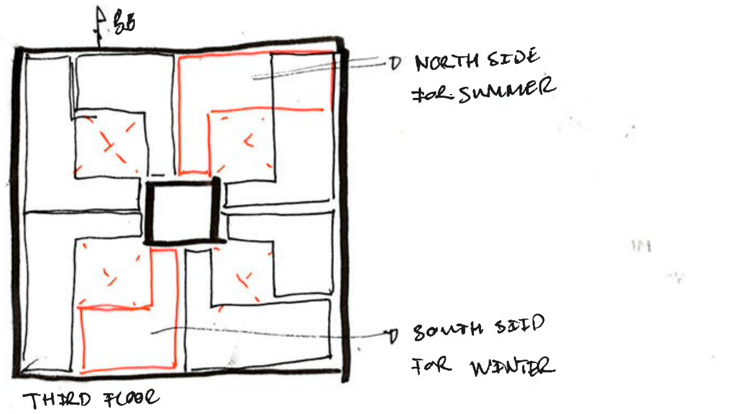
BUILDING TYPOLOGY DEVELOPMENT

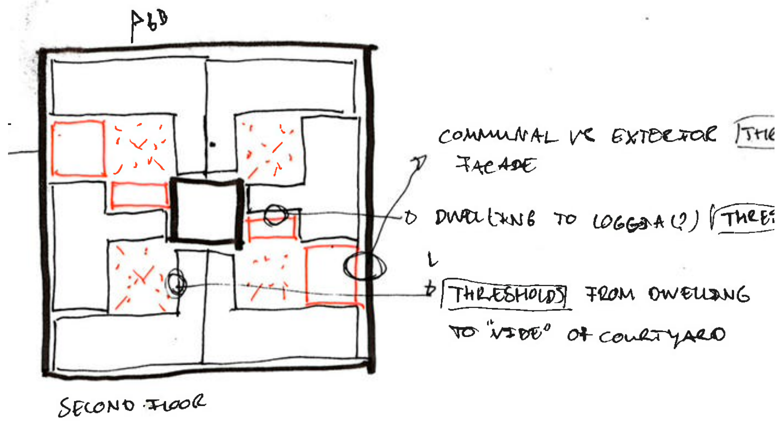
First experimentation with how dwellings, public and private patio's can be organised in the building block.

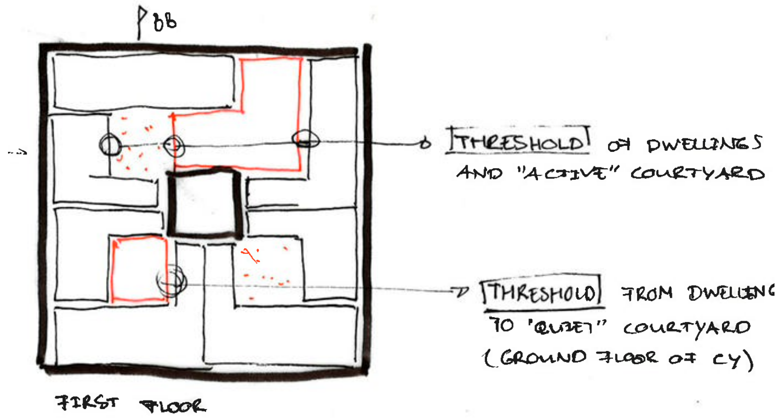
Housing is 'folding' around the courtyards.

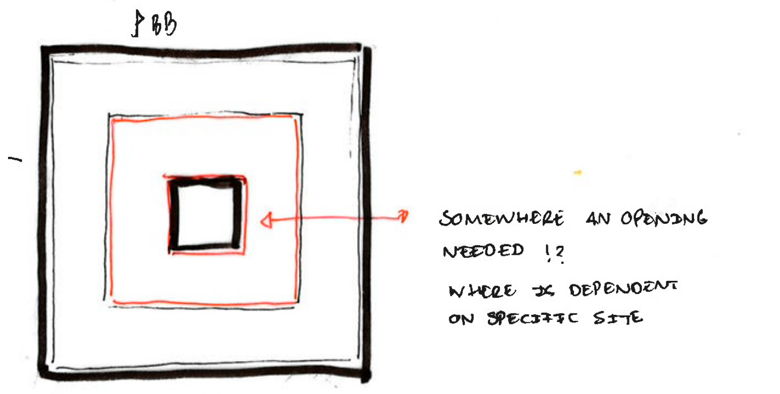
THE INFLUENCE OF THE STAIRCASE





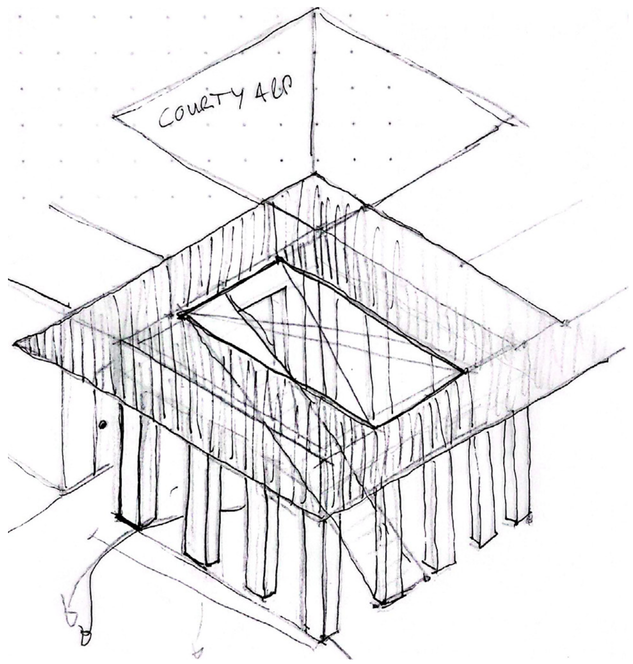


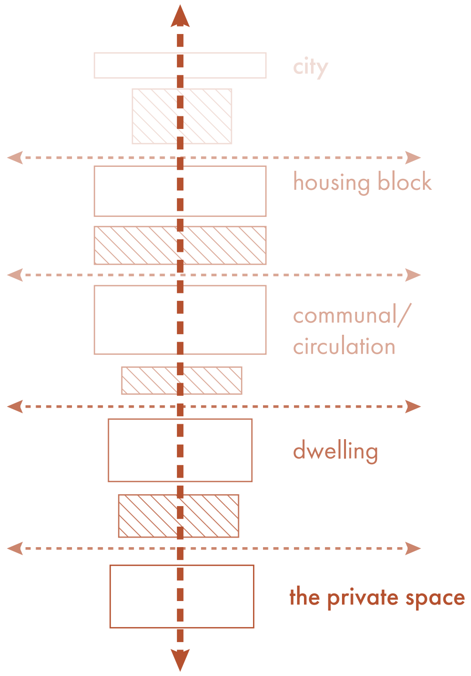




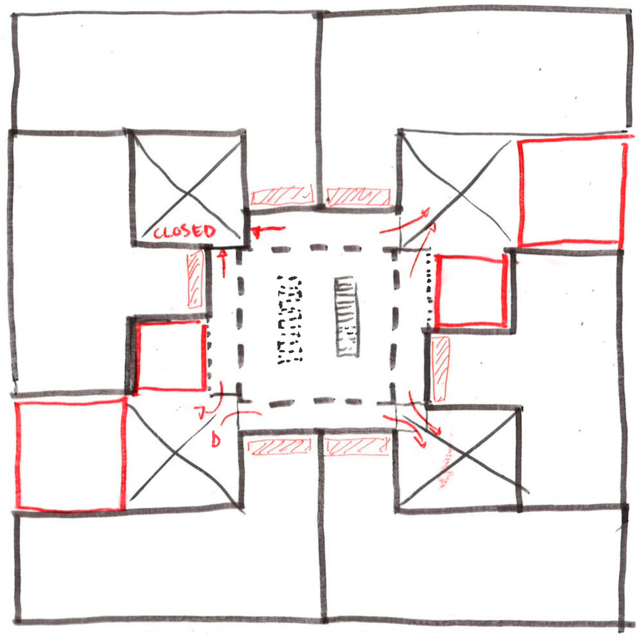
INTEGRATING CONCEPT OF THRESHOLDS

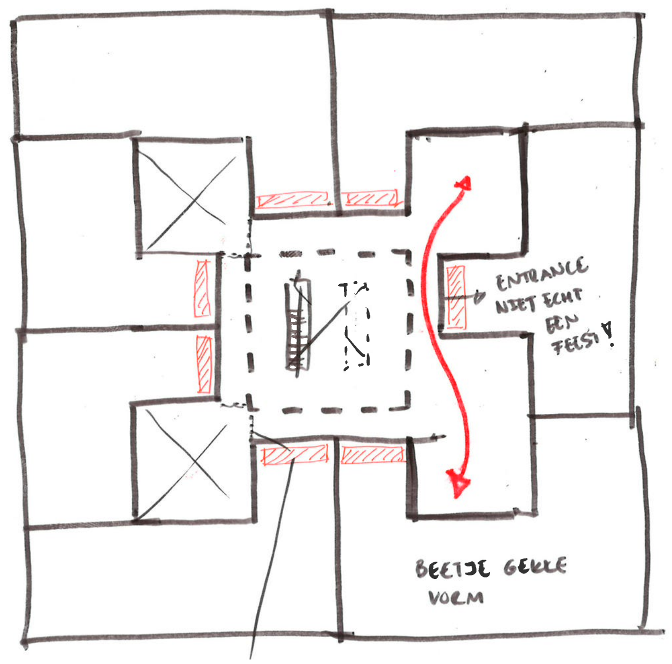
The core acts as both the entrance hall of the building and an intermediate layer within the circulation system. By introducing a spatial separation between the main circulation routes and the dwelling entrances, it creates an additional threshold. The arrangement of columns and galleries selectively opens and closes sightlines, reinforcing the transition from shared circulation space to the more private domain of the front doors.





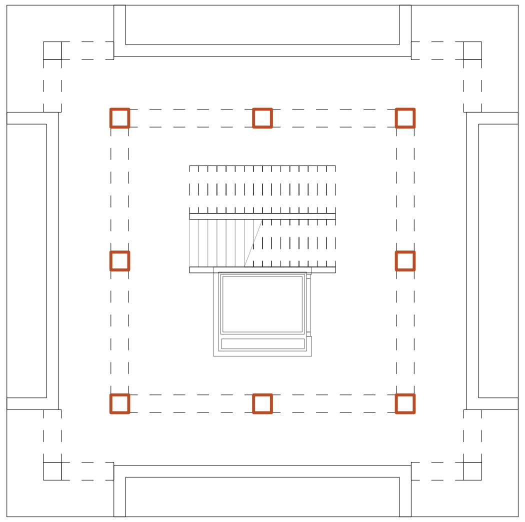
VERTICAL ORGANISATION VARIANTS

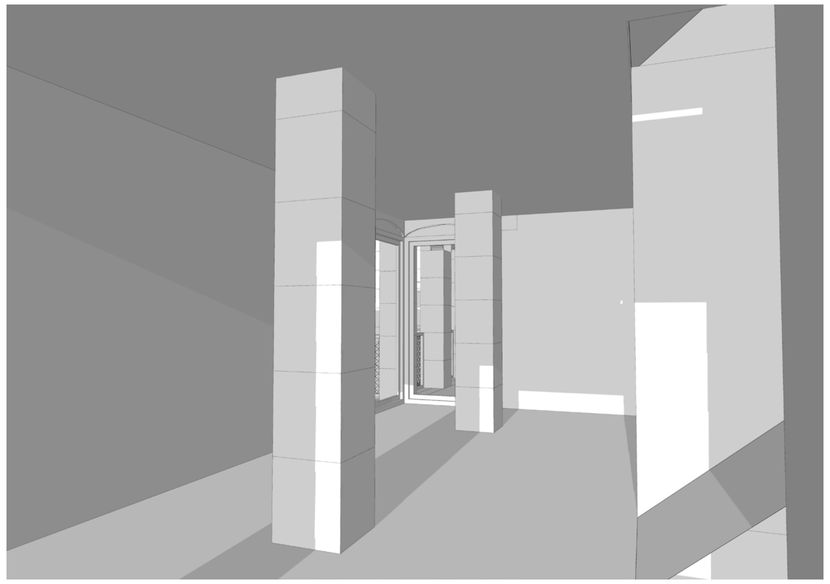


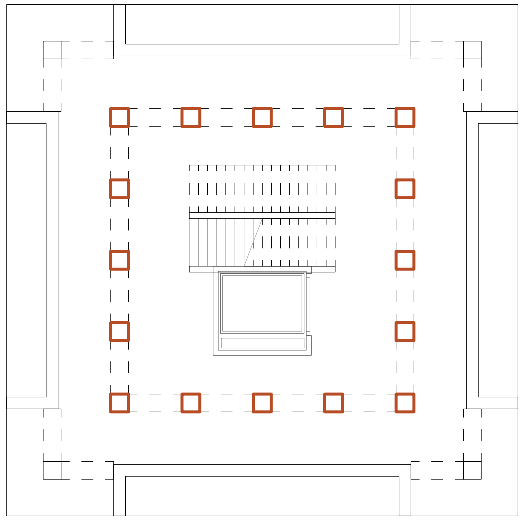


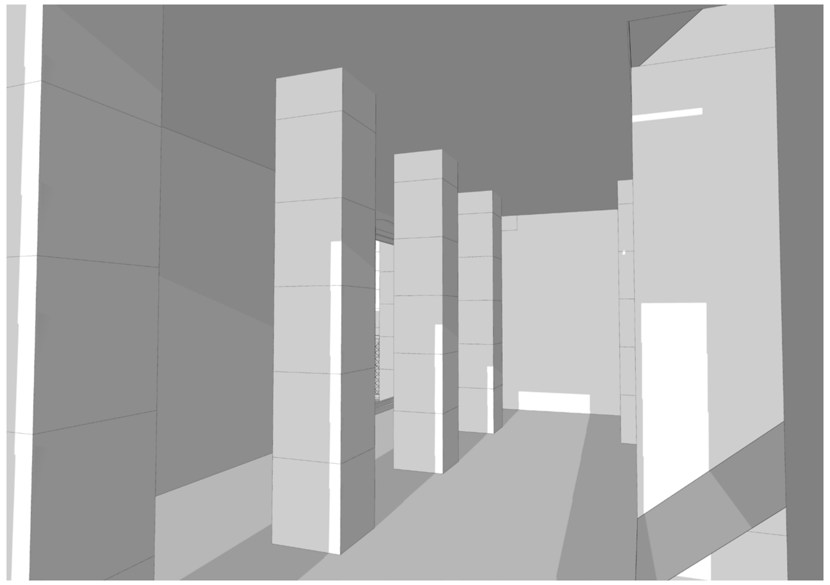
CORE STUDY

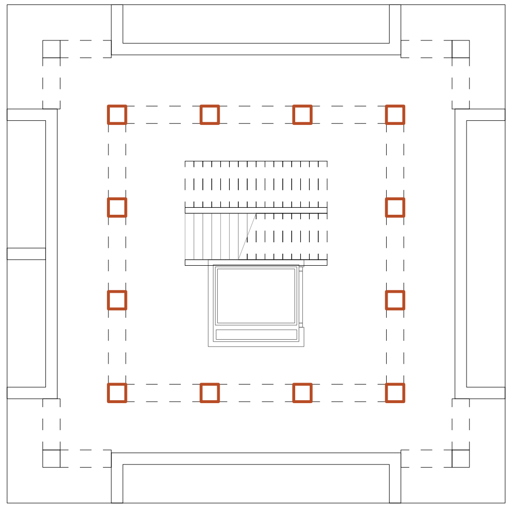
COLUMN SPACING

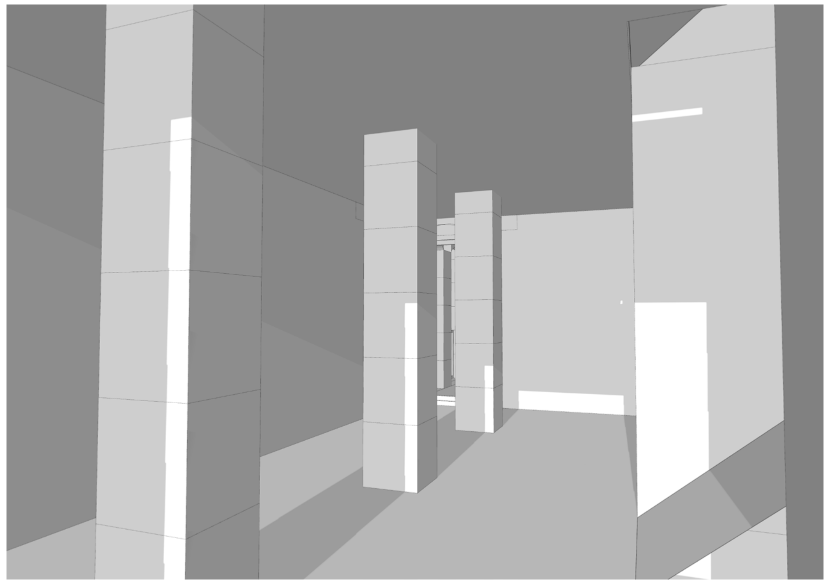


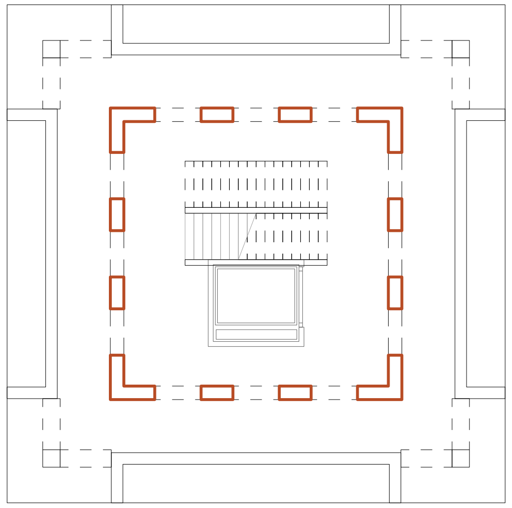


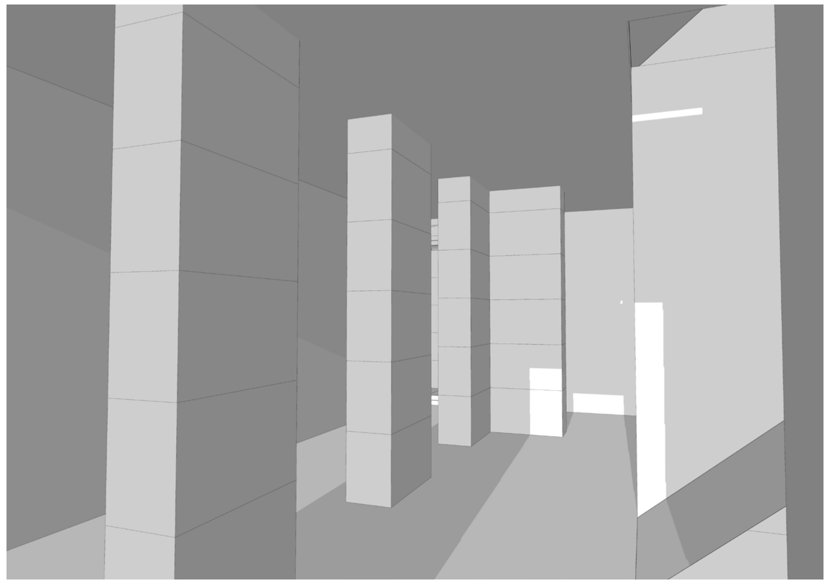








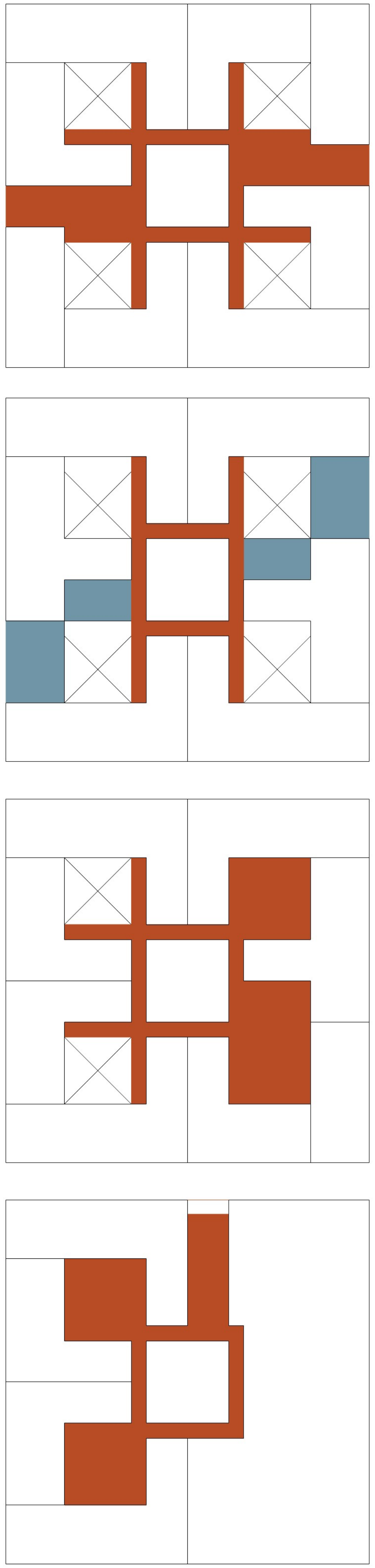




GALLERY DEVELOPMENT

CONFIGURATIONS

Earlier plans connected entrances directly to the corridor. By extending galleries from the core, entrances can be placed "around the corner," creating an additional threshold and avoiding direct access through the kitchen. Different configurations tested whether galleries should run continuously across all floors and courtyards or only be applied selectively. The diagram on the right shows one approach where galleries are introduced only where recessed, indirect entrances are needed.



third

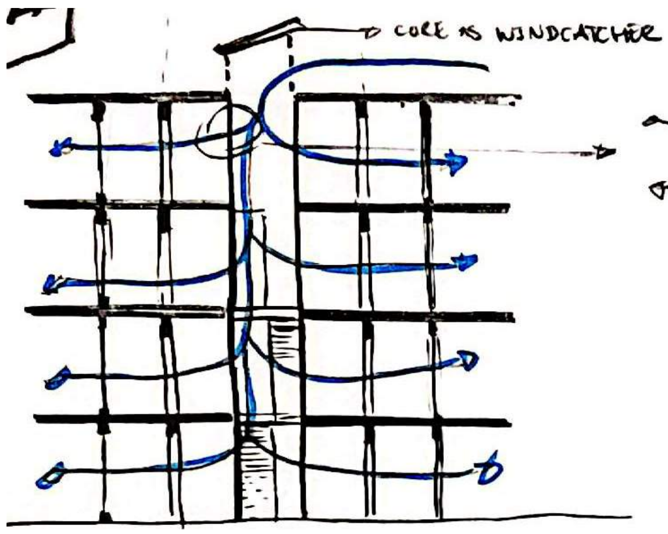
second

first

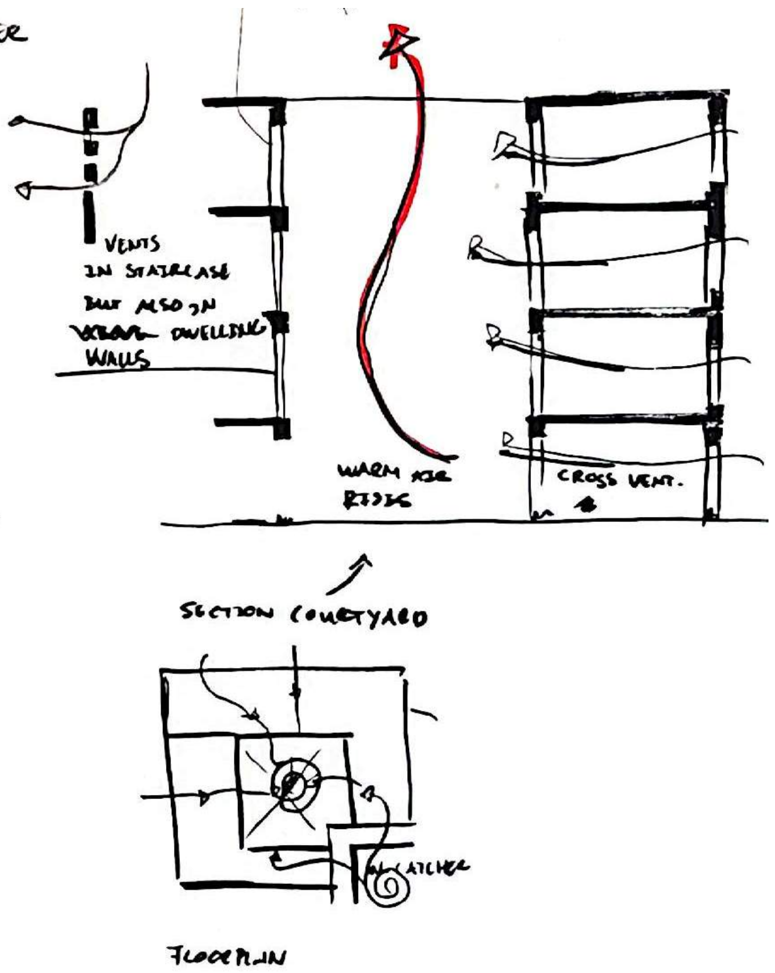
ground

CLIMATE IDEAS/PRINCIPLES

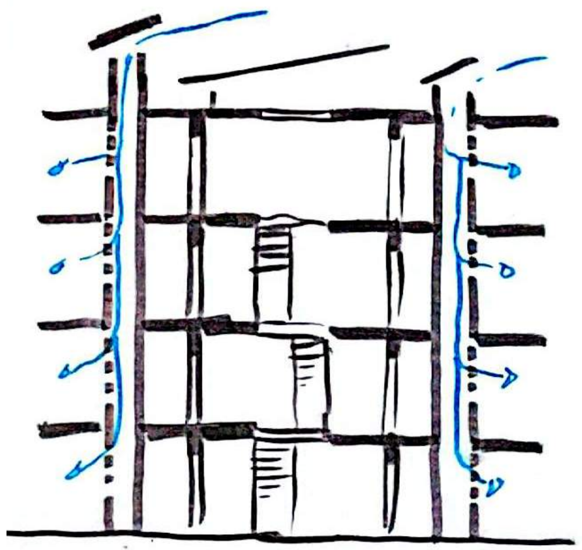
VENTILATION OPTION A



First idea of staircase as a windcatcher

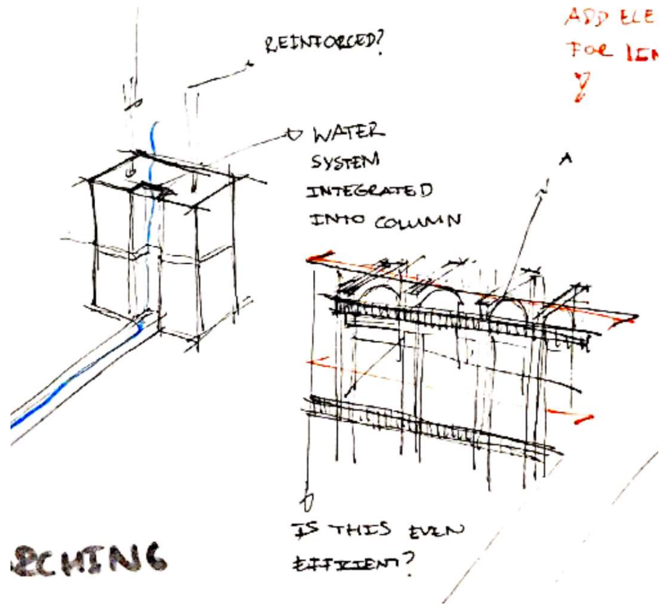


VENTILATION OPTION B



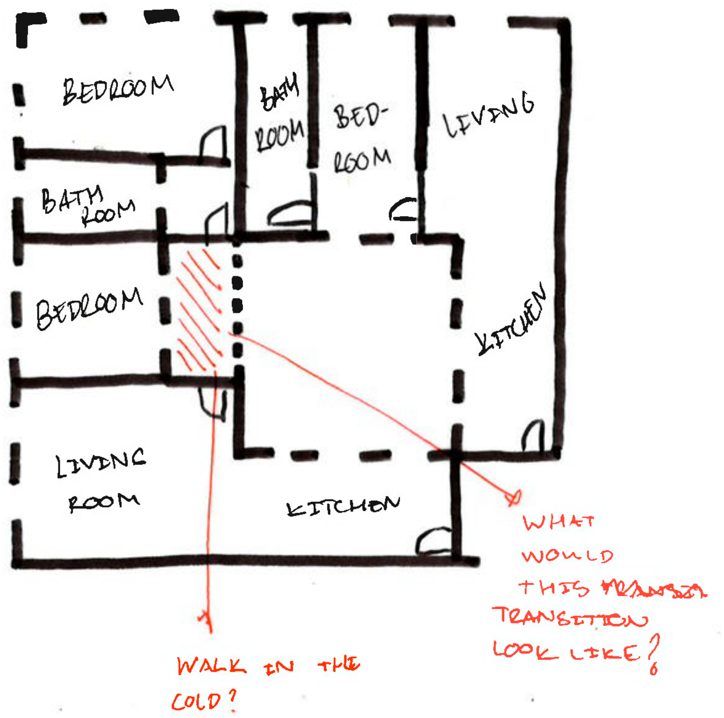
Move the windcatcher to the dwellings, minimizing the distance of airflow. This was not needed in the end.

WATER SYSTEM

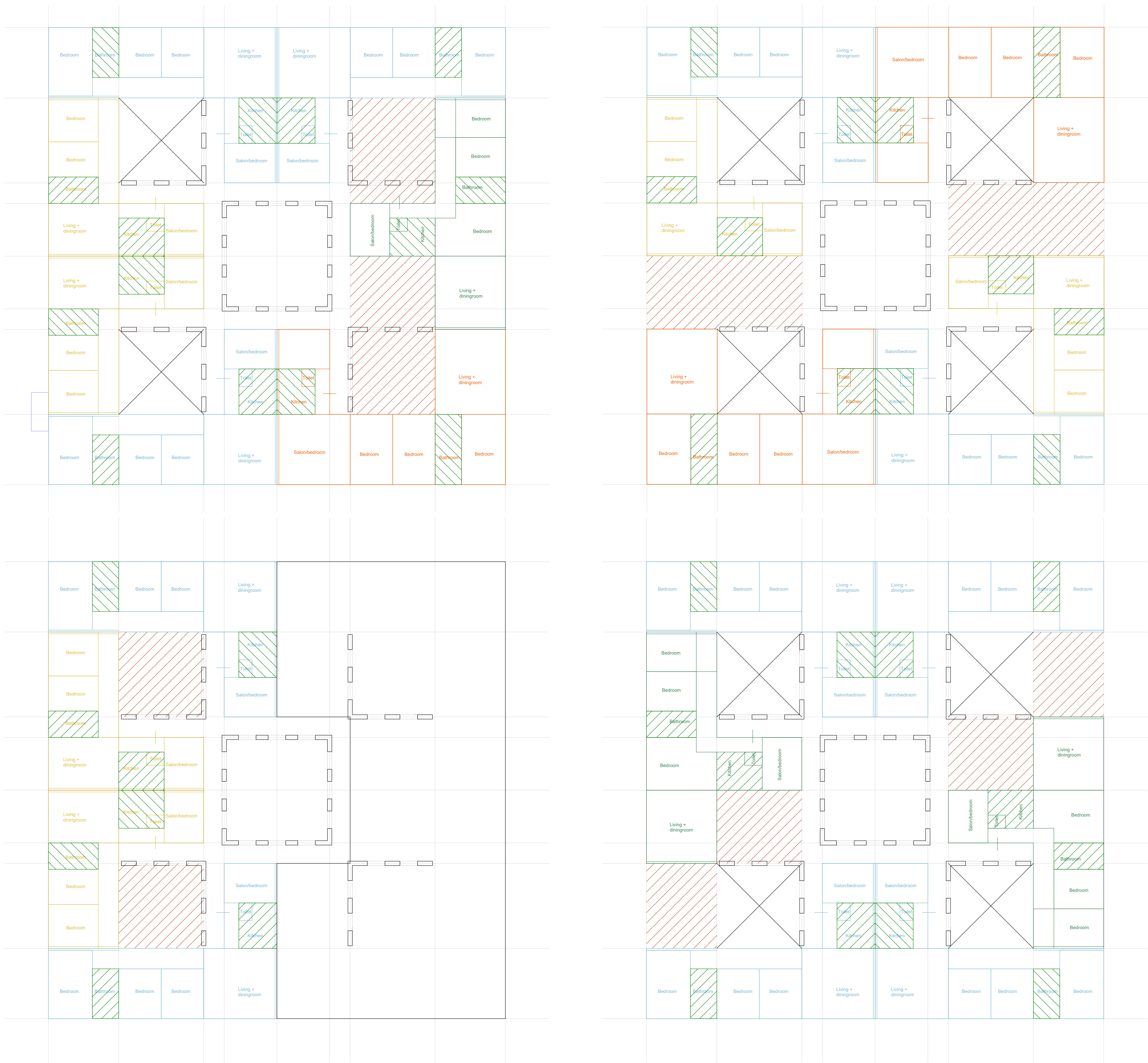


CONCEPT OF DWELLING TYPE

FIRST CONCEPT

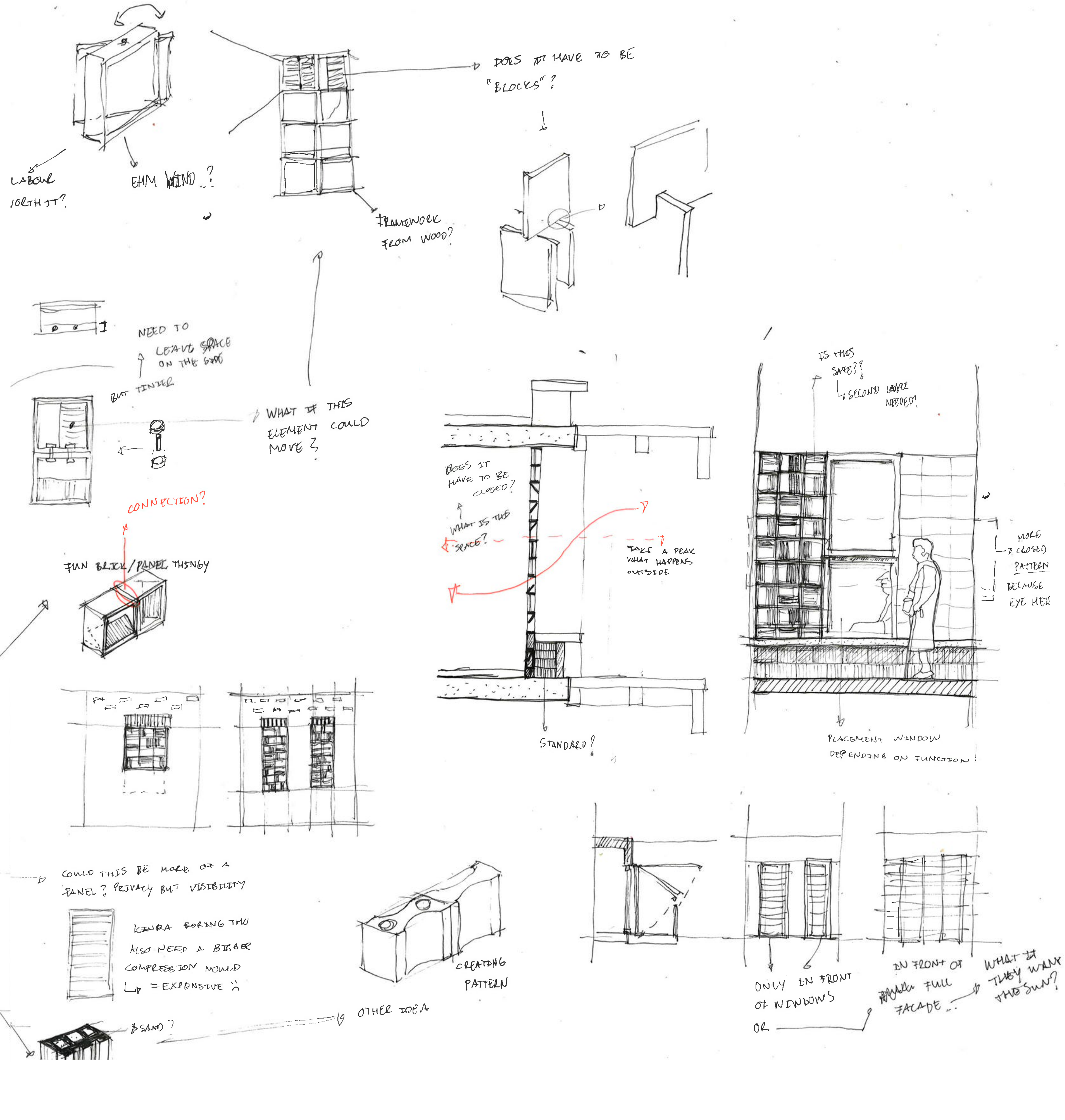


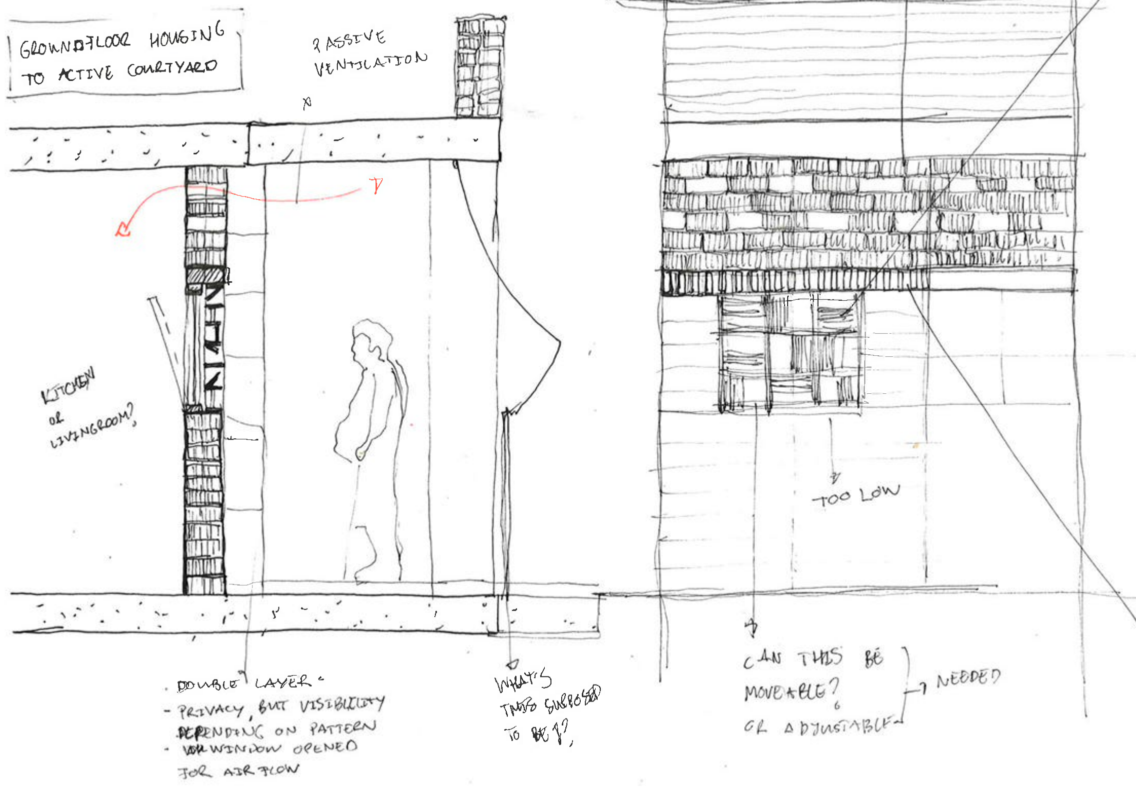
BROUGHT TO SYRIAN CONTEXT



THRESHOLDS IN FACADES

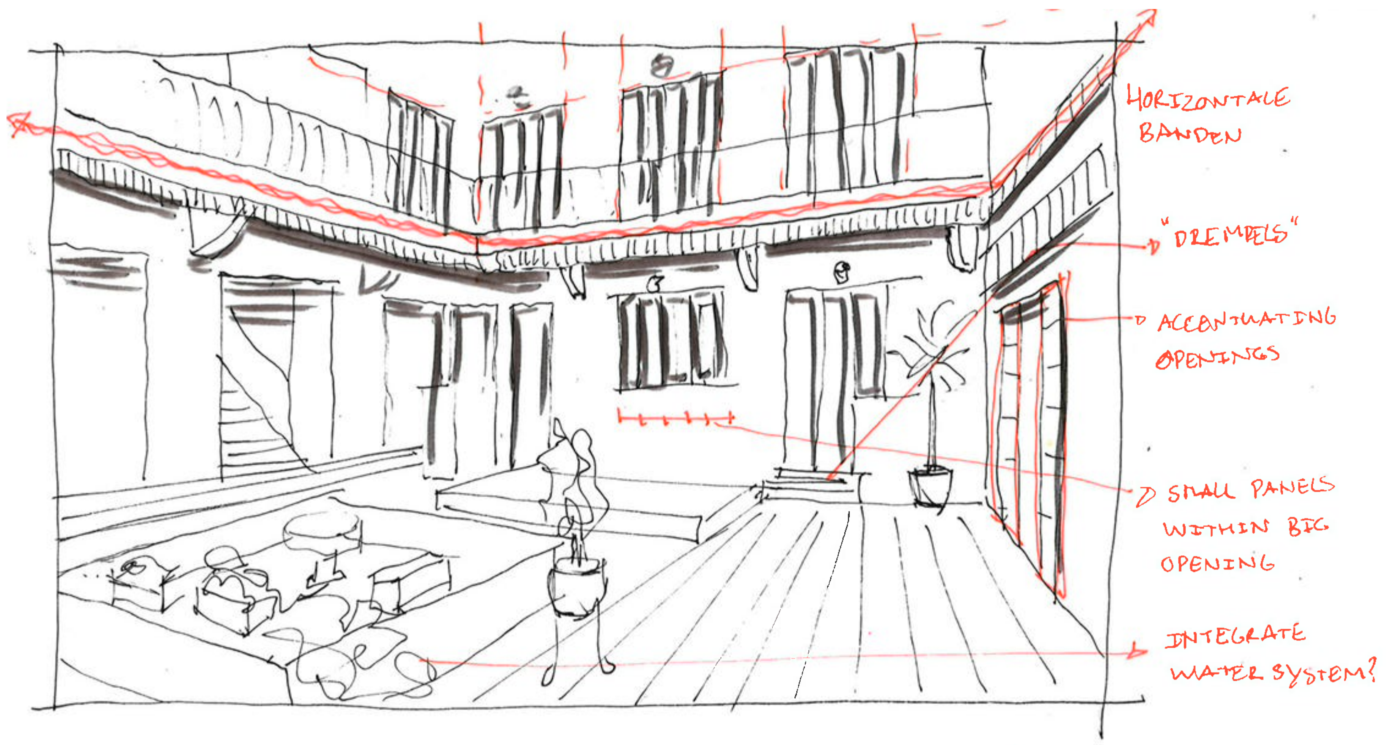
First sketches of facade elements

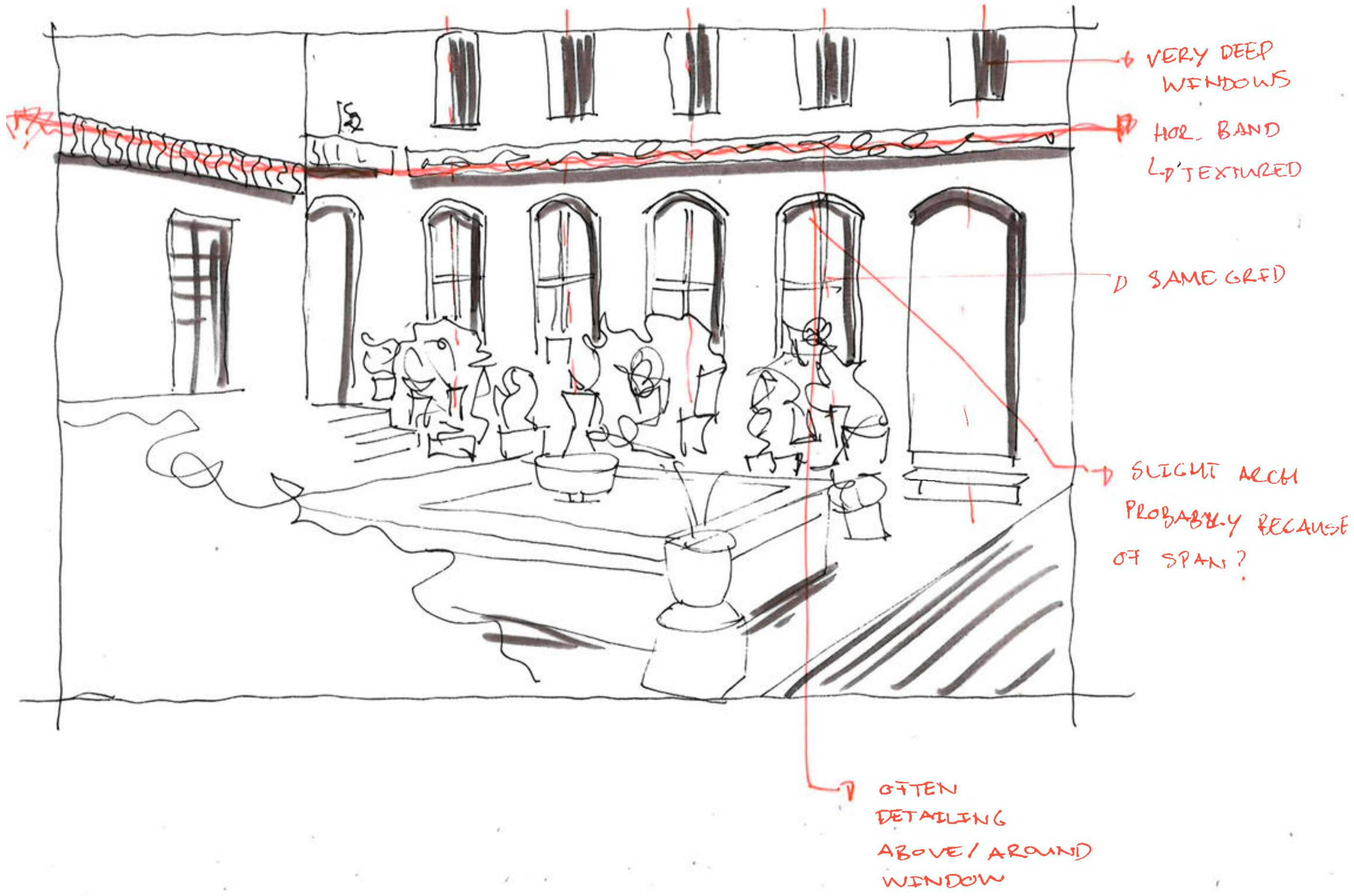


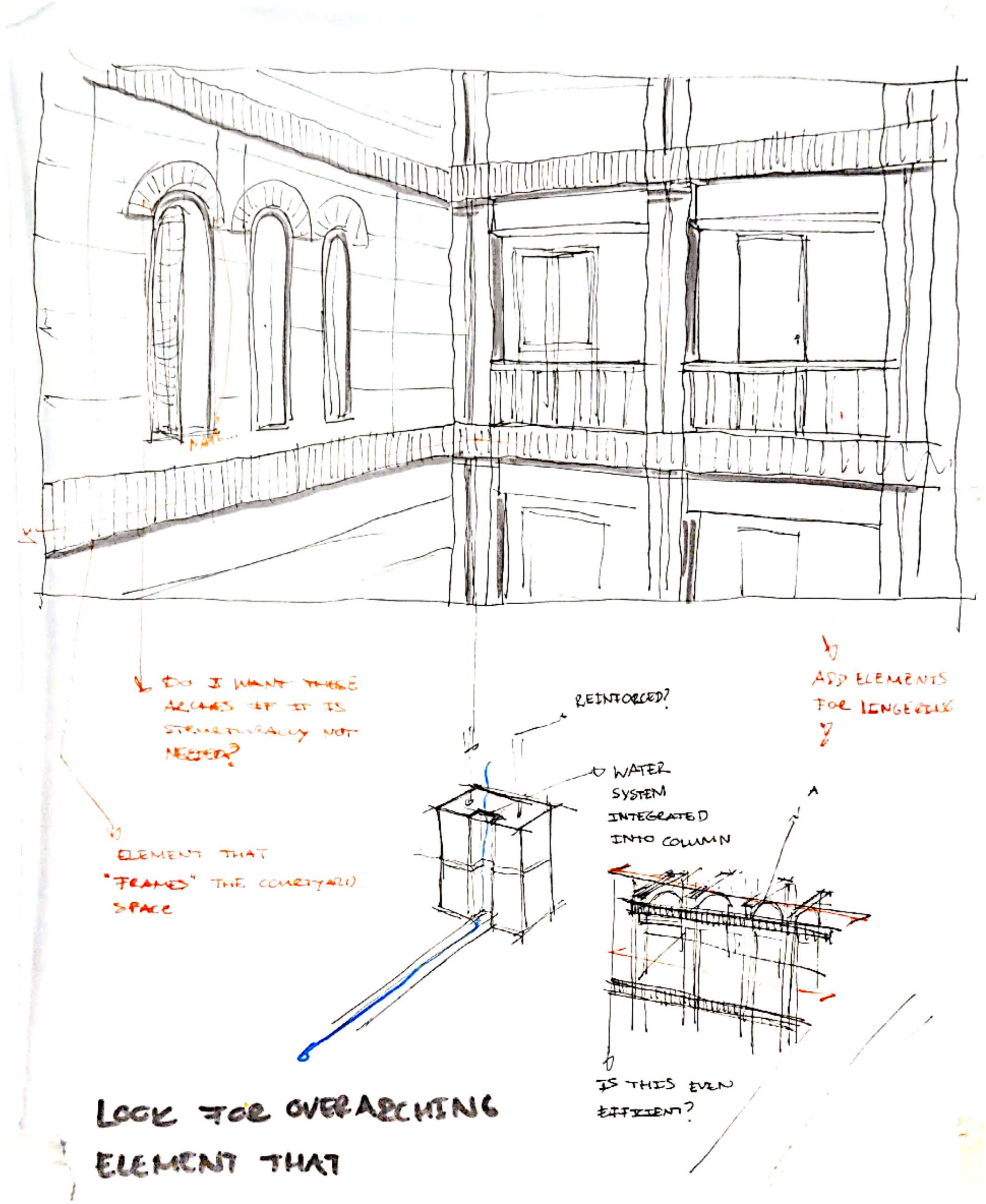


COURTYARD FACADE ANALYSIS

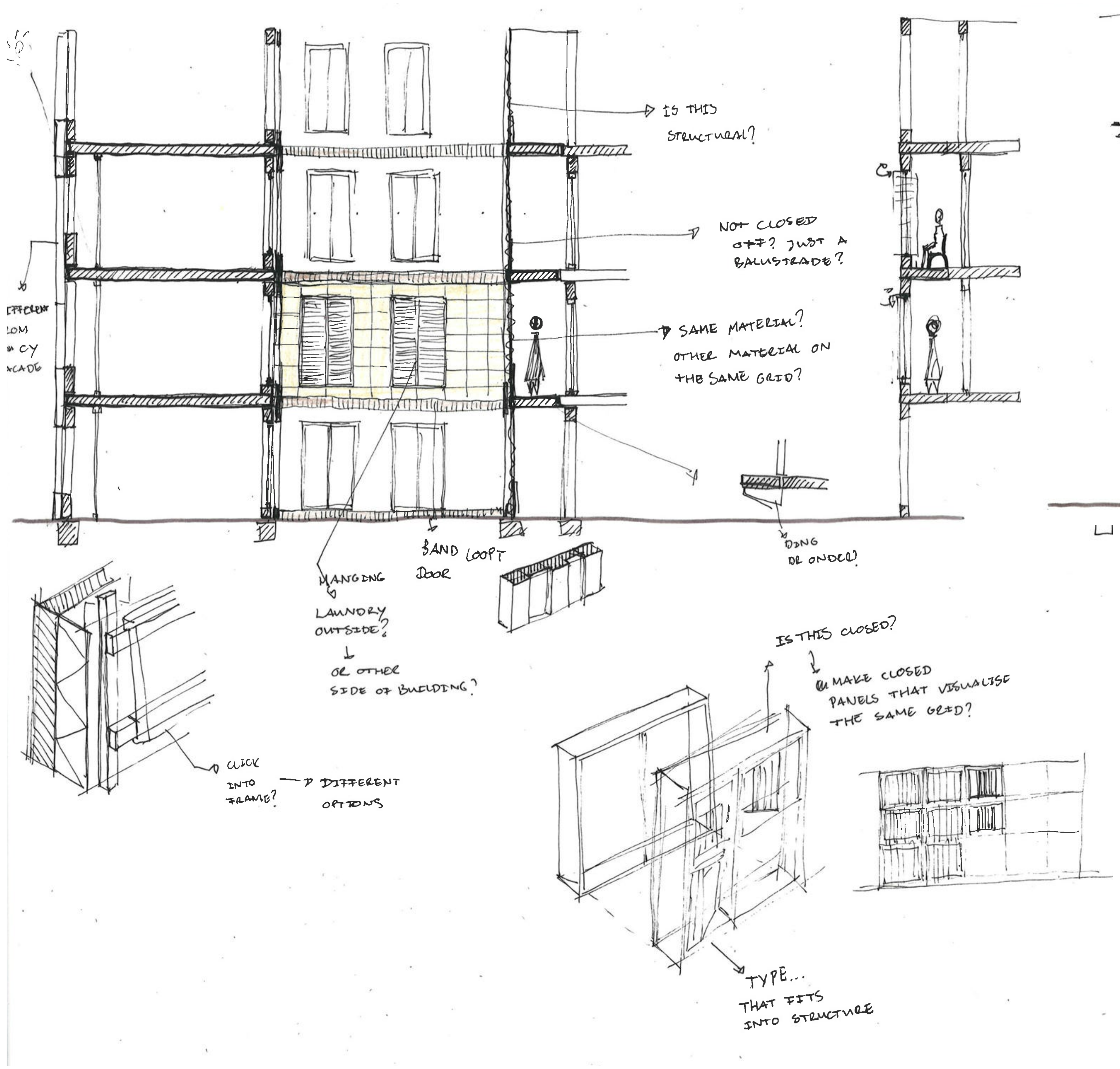
EXTRACTING ELEMENTS

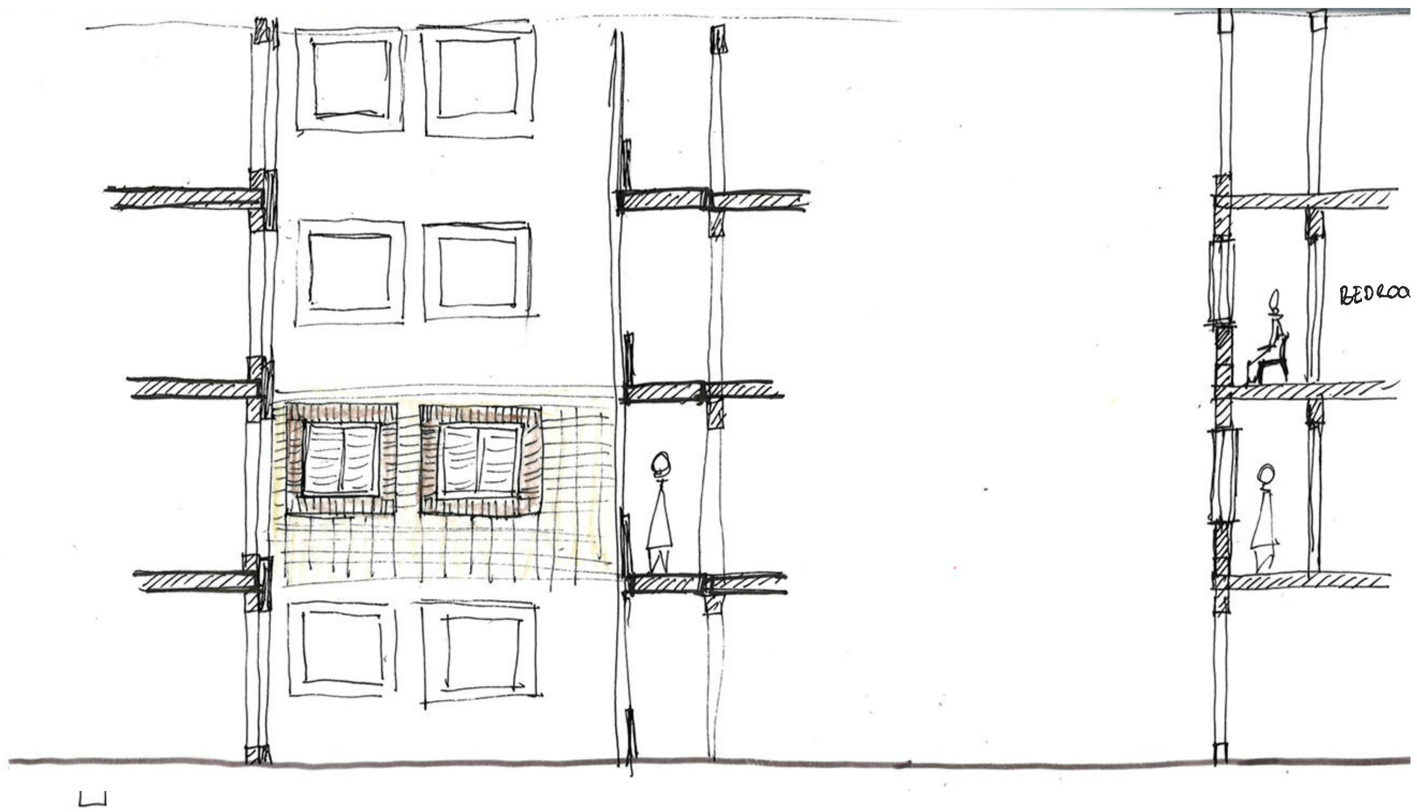






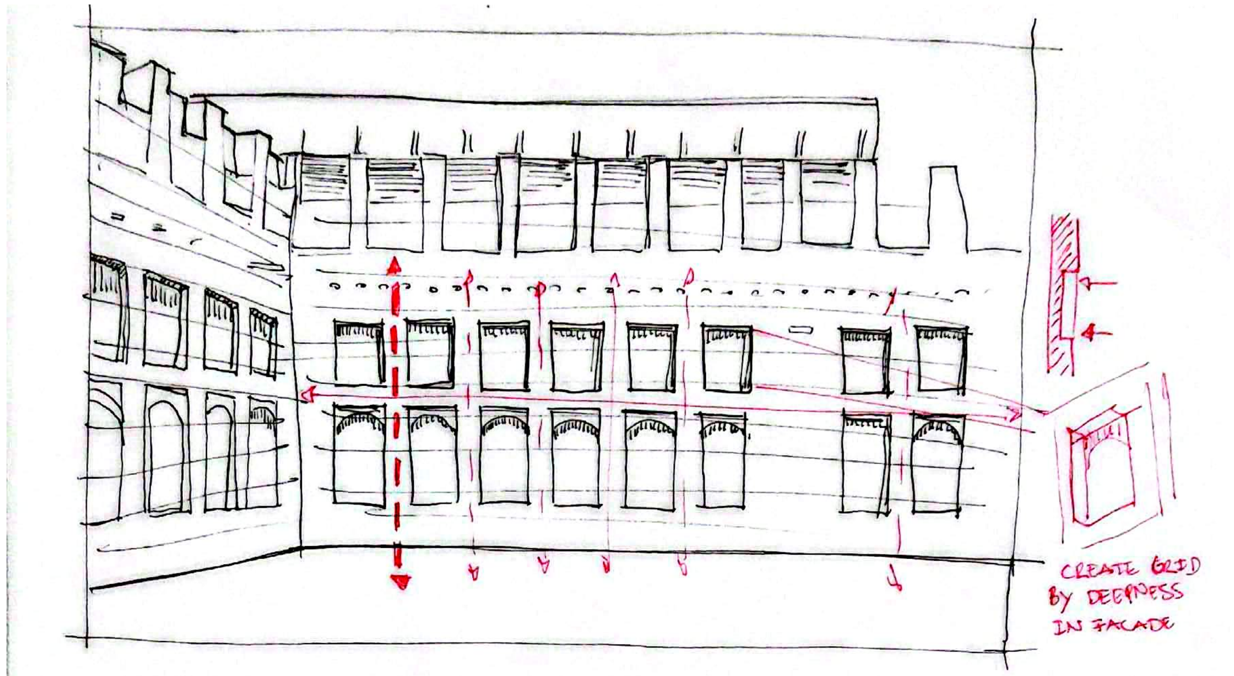
COURTYARD FACADE STUDY

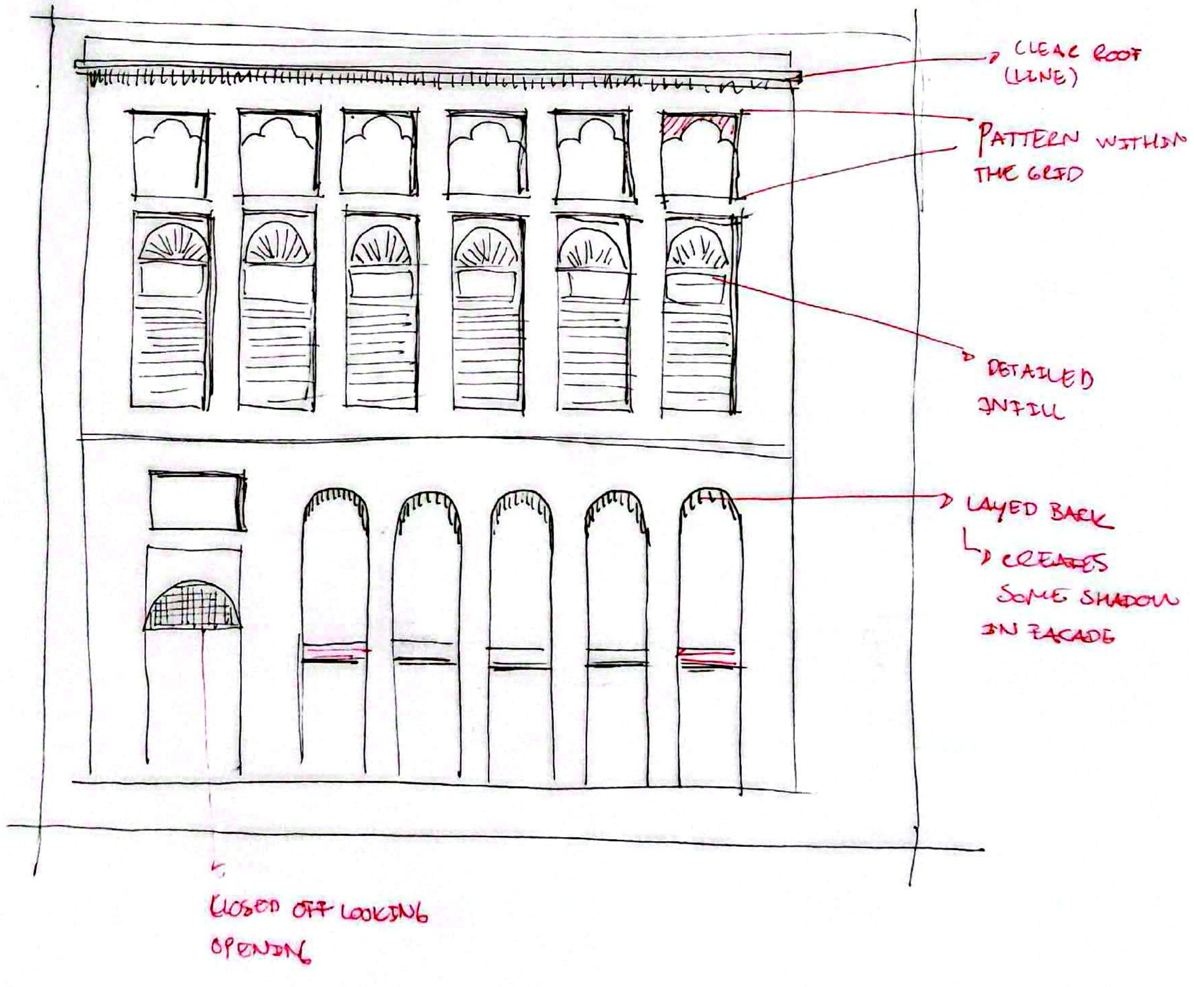




EXTERIOR FACADE ANALYSIS

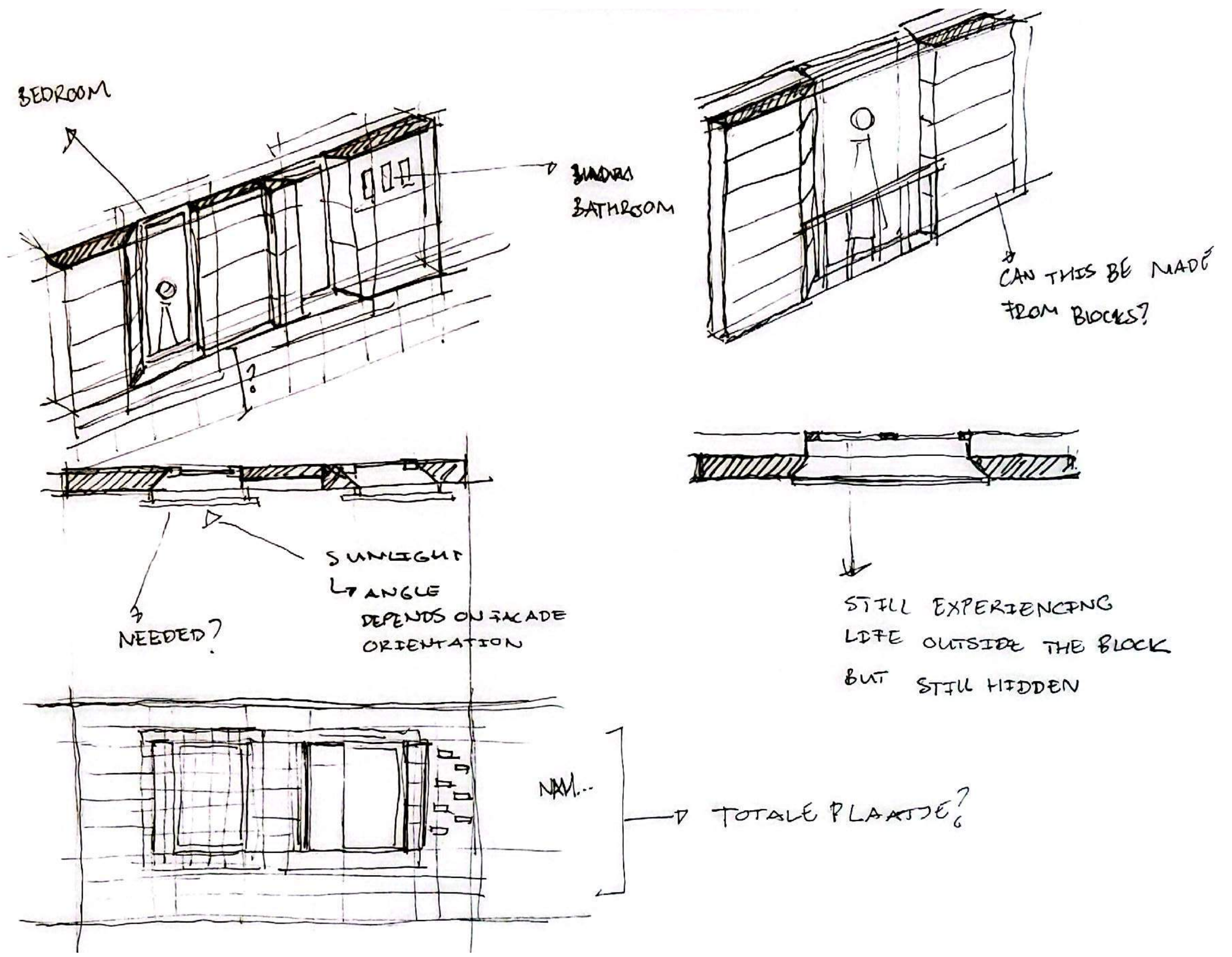
EXTRACTING ELEMENTS



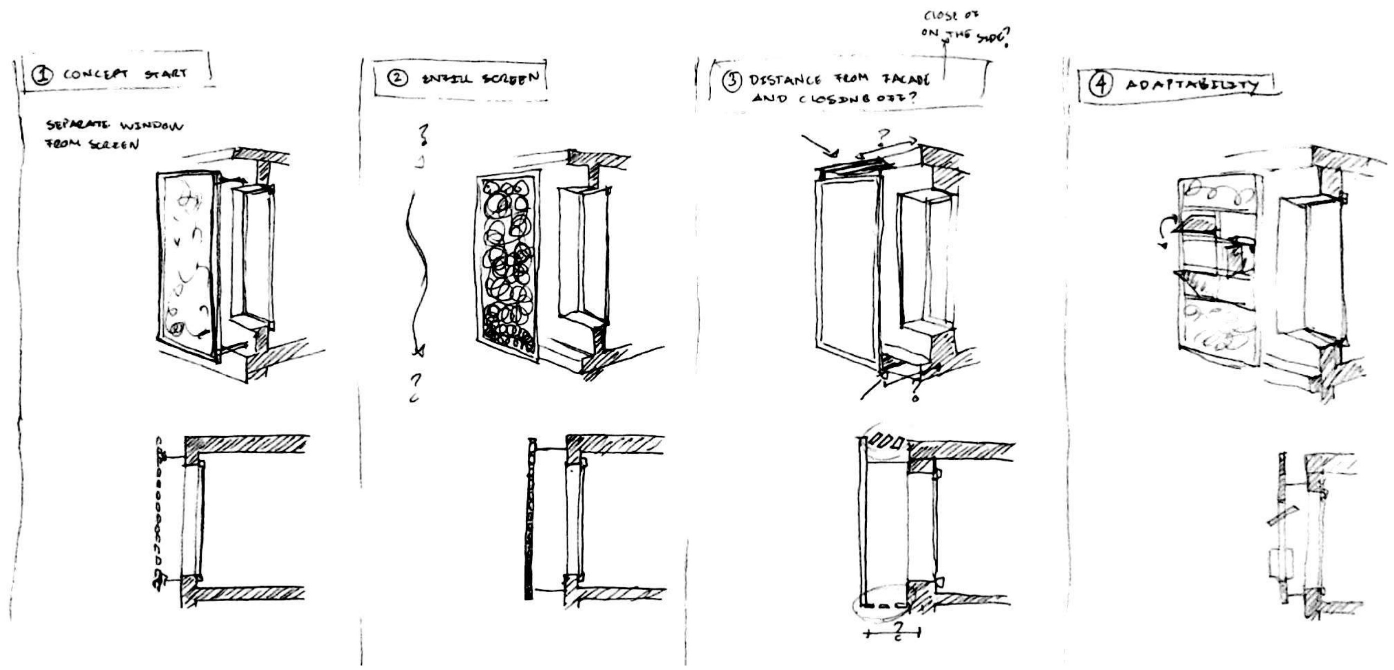


EXTERIOR FACADE STUDY

ANGLED WALLS



DESIGNING A CONTEMPORARY MASHRABIYA

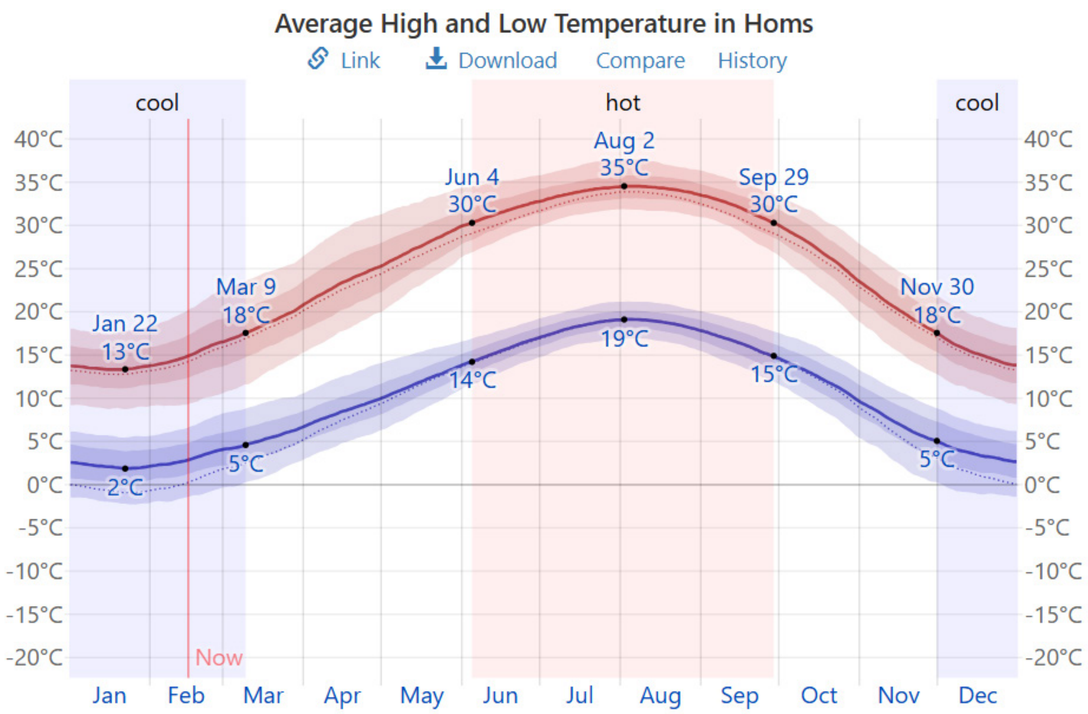


APPENDIX D: CLIMATE OF HOMS, SYRIA

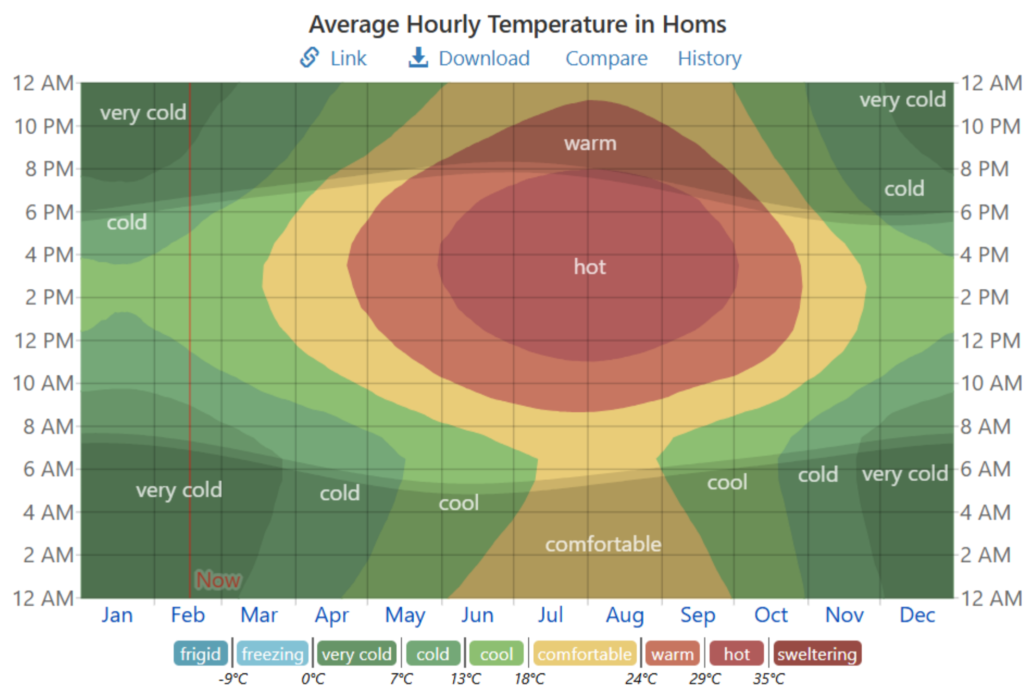
TEMPERATURE

Hot season
around 4 months, from June to December
average high temp: above 30 (10-34 in Aug)

Cool season:
around 3 months, from November to March
average high temp: below 18 (2-13 in Jan)



The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

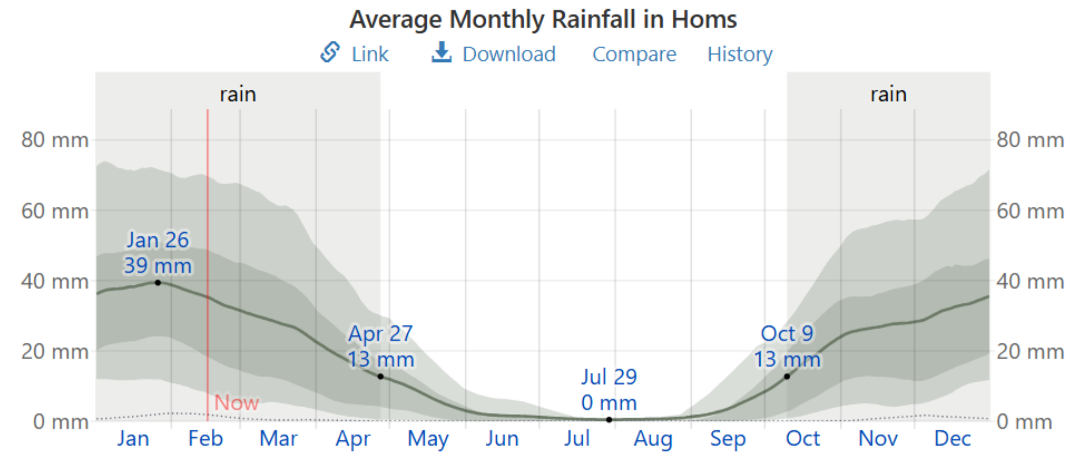


The average hourly temperature, color coded into bands. The shaded overlays indicate night and civil twilight.

RAINFALL HOMS

Rainy period
around 7 months, from October to April
average 13mm
highest 38 mm

Rainless period
around 5.5 months, from April to October
average 1 mm



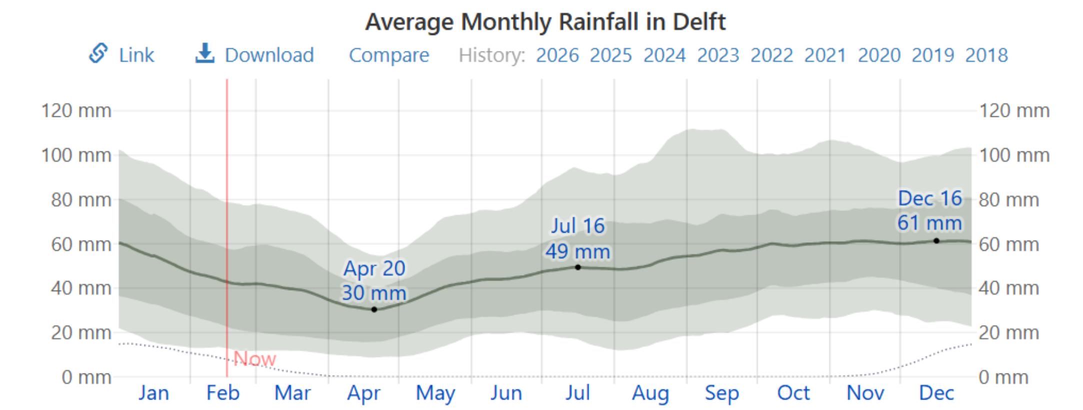
The average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands. The thin dotted line is the corresponding average snowfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	38.2mm	35.6mm	28.0mm	16.7mm	7.2mm	1.6mm	0.6mm	0.6mm	3.4mm	16.4mm	26.7mm	32.2mm

COMPARISON WITH DELFT

Rainy period
average 61 mm

Rainless period
average of 31 mm



The average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands. The thin dotted line is the corresponding average snowfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	54.6mm	43.5mm	39.6mm	31.0mm	38.8mm	44.2mm	49.4mm	50.5mm	57.1mm	59.1mm	61.2mm	61.3mm

APPENDIX E: MANAGMENT CHECKLIST

Instruction

This checklist is relevant for all graduation projects of the Master AUBS. The form is intended to highlight common aspects of graduation projects that require particular attention with regard to planning the research and data management. Relevant information and supplementary sources regarding each question are provided below each question.

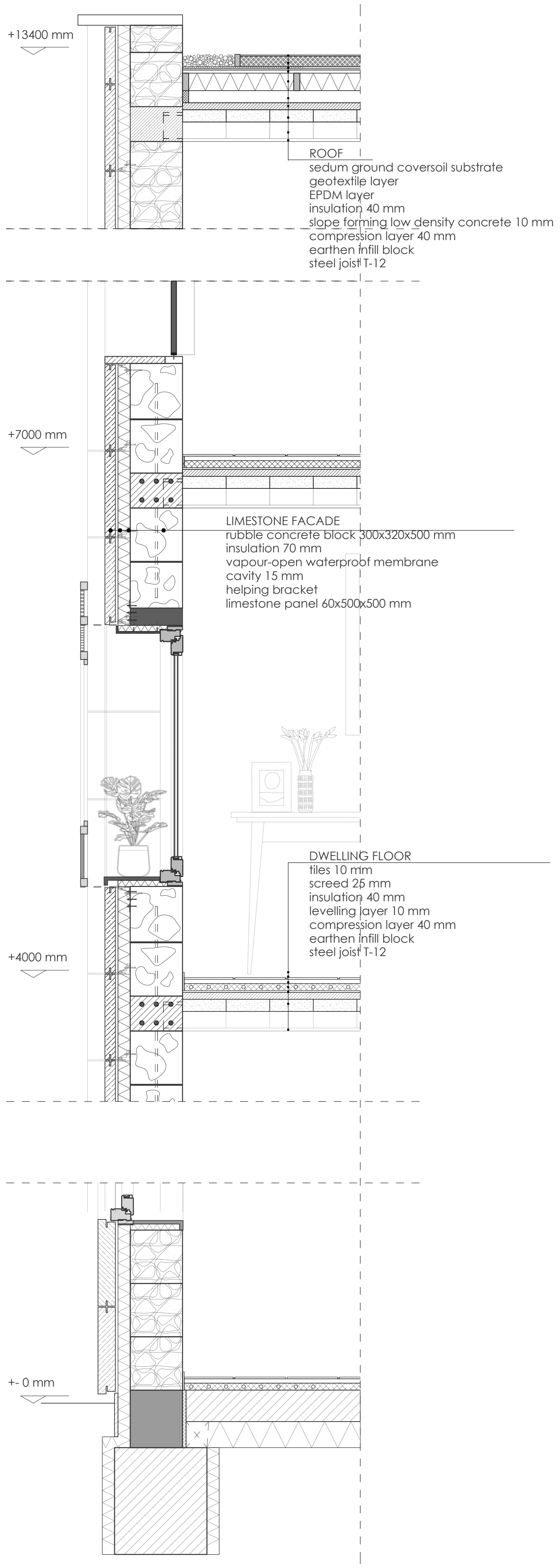
With this checklist, the faculty wants to avoid that students unexpectedly find themselves in complex and stressful situations, in which ethical or privacy matters and/or other laws and regulations become an issue. In projects involving humans, certain types of data processing increase the risks to the human participants: planning such projects requires additional evaluations and advice from university staff before ethical approval can be received and the project can begin. In the case of a graduation project, obtaining additional advice or permits may delay the project with an extra education period or semester. To avoid this, it is recommended that students set up a graduation project with a low level of risk. Therefore, all students have to check their risk, by completing this checklist before their A1.

The first section of the checklist (A) should be completed by all students, together with their supervisor, during the planning of the graduation project, before the A1. It does not need to be submitted to anyone for review or approval. Please consider questions 1 to 3 carefully in relation to the intended graduation project, and answer with 'yes' or 'no'.

The second section of the checklist (B) should only be completed if the graduation project involves working with data from human participants. In that case, the student and their supervisor must apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before the project can begin (see the paragraph 'Explanation and follow-up' after the questions). The student can submit the application to the HREC, but the supervisor is responsible for making sure that the project is compliant with relevant privacy regulations and ethical policies.

Section A. General considerations	yes	no
1. Is the graduation project conducted as part of an internship (at a company), or as part of a research project at TU Delft? If a student's graduation project is conducted at a company or as part of a research project at the university, questions of data ownership and intellectual property rights need to be addressed in a written graduation or internship agreement before the project begins. Students and their supervisor should consult the Intellectual Property Rights of Students webpage. Additional information can also be found in the Extended Personal Research Data Workflow.		✓
2. Does the project involve conducting (part of) the research outside the Netherlands? Students who intend to travel abroad (even to other EU countries) for study, exchange, research, internship, or graduation project purposes need to follow the Travel Safety Protocol. This includes attending a mandatory Travel Safety Training Session: see the Disclaimer.		✓
3. Will the research involve processing data from humans, such as running a survey, conducting interviews or workshops, collecting data through social media or internet forums, or re-using existing datasets about humans provided by a third party? (If 'yes', see follow-up questions 4 to 13 in Checklist B.) Students who work with data from human participants must complete the next section and apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before conducting the research.		✓

APPENDIX F: 1:50 GROUND FLOOR - ROOF OVERVIEW



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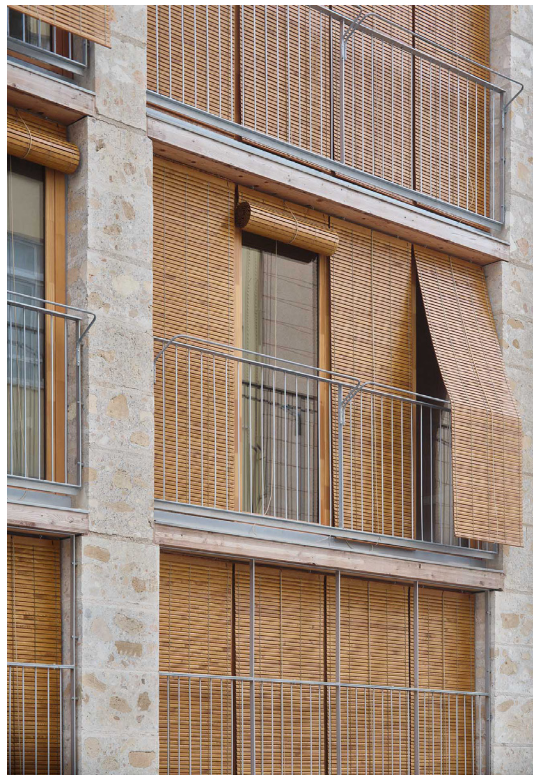
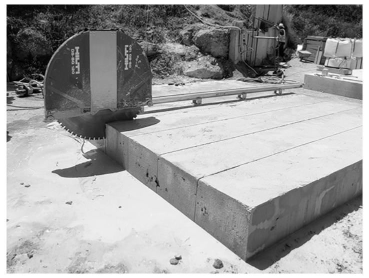
REFERENCE PROJECT

MATERIAL USE





The project is based on reusing materials from a demolished three-story school to construct new social housing, applying an urban mining strategy. Almost all demolition waste was repurposed on site. Ceramic and concrete debris were reused as infill for foundations and basement walls, while sandstone (marès) was transformed into cyclopean concrete blocks. These prefabricated blocks, composed of up to 40% recycled stone and lime or cement binders, were cut to expose the stone on their faces. Varying in size by floor load, the blocks form load-bearing walls supporting cross-laminated timber floors, reducing construction time and material waste.

https://www.harquitectes.com/en/proyectos/ibavi-2104/

Inhabited edges, Homs
Extreme graduation - AR4EA010

Acknowledgments

The completion of this project would not have been possible without the support of many people. I would like to express my gratitude to everyone who supported me.

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