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Inhabiting the Architectural Envelope

A Design-based Research on Redefining the Climatic and Atmospheric Performances of Architectural Envelope

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To my family

CONTENTS

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Abstract

A variety of contemporary approaches in architectural practice emphasize the separation of architecture from its local context by prioritizing technological, formal representations or economic affairs, and there is a dominant trend promoting this separation with increasingly generic architecture. The focus of this trend is predominately on energy efficiency, optimization, and modulated interior climates that result in highly insulated building façades. As a consequence, the role of the building's façade is reduced to that of a representational or spatial support zone for the building's technical requirements – a stark contrast to traditional façade that provided climatic comfort and comprised the building's inherent design criterion because of the close relationship between the built form and the exterior environment. This dissertation utilizes the term *envelope* rather than other common terms such as *façade* or *building skin* in order to position the spatial realization of the envelope.

This dissertation argues that architecture must be able to deal with latent changes through its spatial configurations and allow for a dynamic interface between the building, the climate, and the inhabitant. Latent changes refer to the possibilities for change of use, program, or adaptive spatial construct that allows different activities to emerge and occur upon inhabitation and in the building's interactions with its surrounding environments. The domain

of surrounding context primarily concerns climatic elements and the adjacent exterior of the building. During the course of this research, the initial interest in the building's dynamic interactions with its context led to further investigations into rethinking the position of architectural envelopes. This dissertation thus revisits the integration of climatic and experiential aspects of the architectural envelope by redefining it as an in-between space that can be experienced and inhabited. Aldo van Eyck presents the notion of the in-between as a place that brings together conflicting polarities to reunite them and thus form a dynamic whole (Eyck, 2008a, pp. 204–205). According to Bernard Tschumi, in-between spaces are passages and relays between architectural components that facilitate the perceptual and cognitive understanding of the integrity of architecture (Tschumi, 1977. See section 2.3. of this dissertation). Following Tschumi, the experience of architecture is therefore the ensemble of both real and virtual (memory and imagination) implicitly ingrained in the architectural experience. The in-between spaces of the envelope accommodate spatial realities that are situated between the two physical realms of inside and outside, providing atmospheres and in-between climatic conditions. These conditions provide a spatial experience for which interior and exterior spaces are integral parts. They foster semi-controlled interior spaces and enable the flexible use of space based on seasonal requirements; this characteristic seems to be a valuable area of focus in envelope design in terms of adaptive use of space in times of climate change.

The aforementioned is explored via research through design by proposing a way of working with contextual information early in the design process with the aim to develop the conceptual aspects of building envelopes. Research through design is an approach in which design practice forms the core of the investigation. The studies developed for the investigations include a taxonomy of envelopes, as well as the mapping of relevant envelope concepts and design approaches through literature studies. These studies have been the core operative components for small-scale design investigations as part of the inquiry. Insights gained through conducting workshops in Master-level architecture studios have facilitated the development of the dissertation's design methods. Additionally, the research through design efforts include an independent design experiment that examines a custom-designed approach. The digital tools used in current architectural practices were utilized in the experiment to inform and evaluate the design project's climatic, conceptual, and atmospheric aims.

This is an article-based dissertation consisting of an exegesis and three articles. The exegesis presents the theoretical perspective and conceptual

approach, as well as the research methods and methodologies, and includes an overarching reflection on the outcomes and findings.

Glossary

The following glossary contains key terminology pertaining to core concepts explored in this dissertation.

Atmosphere

In the context of this dissertation, the *atmosphere* of the envelope refers to the ambiance in the space and the sensation it evokes in its inhabitant(s). Atmospheres shift attention from "what" something represents to "how" something is present, therefore, they rehabilitate the sensory perception rather than a judgmental one through the aesthetics of space (Böhme, 2018, p. 26). Here, aesthetic refers to "the study of the relations between ambient qualities and states of mind"(2018, p. 26). Atmosphere has a deep-seated spatial definition that can be consciously constructed through structural/architectural elements, geometrical specifications, etc. (and the internal and external relations between them), or unintentionally emerge from the composition of various natural and accidental phenomena within the space. These spatial ambiances are nested conditions in the human's environment, which also implicitly notes how humans can impact and modify them. Thus, they arise from the disposition of the interior, exterior (climatic elements, built and natural surroundings), and the inhabitant.

Boundary

Boundary indicates or fixes a limit or extent (Merriam-Webster Dictionary, retrieved on 07.11.2019); it is a dividing line (New Oxford American Dictionary, retrieved on 07.11.2019). Its synonyms include: extent, border, or outer limits (Oxford American Writers Thesaurus, retrieved on 07.11.2019). In this dissertation, the term boundary is used as the delineator of the interior from the exterior space. As such, the boundary of a building has a strong border character whose function is to separate and render one distinct environment from the other. In the architectural discipline, this term is commonly used to refer to the physical extent of a building; nevertheless, in the realm of energy and heat transfer, it refers to the "zone within which energy exchanges take place" (Addington, 2009, p. 13).

Building Envelope

Unlike the building skin or façade, which define boundary conditions, the *building envelope* is elaborated in the context of this research as a space through which the interior and exterior environments are connected and become interdependent. The envelope is thus an extended and inhabitable threshold, the architectural experience of which is closely integrated with the interrelations and context-related conditions of the interior and exterior environments. The building envelope includes elements like walls, floors, roofs, fenestrations, doors, and openings that create fully- or semi-closed spaces. Contemporary architectural practices use the notion of the *performative envelope* in various ways and with different meanings. The prevailing definition of the term is "polyvalent wall, intelligent façade, high-[energy] performance envelope, smart skin, or double-skin wall, that mainly refers to a thickened envelope housing many mechanical and electrical functions, of which the most elaborated constructions are highly engineered" (Addington, 2009, p. 14). In this dissertation, the notion of performative envelope includes an approach to envelope design that seeks to create a strong interrelation and interaction between interior and exterior. This comprises envelopes that create a comfortable and aesthetically pleasant space through their eminent spatial design provisions – closely informed by occupying a location, climate factors, tectonics and material organization, and the inherent force/counterforce relations between the built form's inside- and outside environments.

Building Skin

The complexity of demands and expectations concerning interior environments (including comfort, energy and cost efficiency, environmental

awareness, etc.) has led to extensive use of control mechanisms and technologies in building enclosure design. The growing application of this design approach has led to the emergence of terms such as *intelligent building* and *intelligent building envelope* or *building skin*, characterizing built forms that can meet the demands indicated (Wyckmans, 2005, p. iii). This "intelligence" is usually associated with "sensible goals such as energy efficiency, compliance with human needs, and the use of renewable energy sources" (2005, p. 16), and an intelligent skin is characterized by "the interaction between the façade, the building's services and the environment" (Compagno, 1999, cover). The conventional paradigm of intelligent buildings "relates to the use of more or less complex building management systems [that equip] a building with active systems and controls [to allow for] motorized action of what might be called subordinate functions and appliances" (Wigginton & Harris, 2002a, p. 3). Seen thus, the intelligent skin is part of the intelligent building that encloses an inhabitable interior, the design and construction of which forms the single greatest controller of the interior environment as regards light, heat, sound, ventilation, and air quality (2002a, p. 3). This active control mechanism facilitates "interchanges between the external and internal environments through its adaptive and dynamic systems to provide optimum [interior] comfort (2002a, p. 27). The intelligence of building skins can thus be defined and measured through behaviors of various applied systems (2005, pp. 21–25) that concurrently and continuously perform the three functions of perceiving, reasoning, and acting (Hayes-Roth, 1995, p. 329).

In this dissertation, the term building skin indicates a three-dimensional reading (representation) of a building façade, usually associated with certain functions (through technical systems) whose role is to create and maintain a controlled interior environment. The three-dimensional character of these boundaries is derived from their intelligent skin typologies, which go beyond a 2D surface by engaging roof structures while breaking down the façade surface into individual entities that respond to factors in their surrounding environments. This is the most common approach in current architectural designs, at least with the environmental demands of large-scale buildings in which the primary task of the building's covering is "the modification and mediation of the environment in its widest sense, from climate to human behavior" (Leatherbarrow, 2005, p. 53). Leatherbarrow calls this the *device paradigm,* characterized by the operation of movable elements in which the range of "positions of each element … script the device's performance" (2005, p. 54).

Climate-related Definitions

Weather is what we see and feel at a specific time and place in the exterior environment, while climate is "an idea aggregated over many years and across a region" (Hill, 2012, p. 2). "*Climate*, as opposed to weather, refers to the state of the Earth's atmosphere as established by statistics, over a period of time, which may be as long as several decades" (Hausladen & Liedl, 2012, p. 12). In articles published on the earlier investigations conducted for this PhD project, the term *climatic factor* was used carelessly in place of *climatic element*; the differences between the two terms as applied in the exegesis will thus be distinguished and clarified here. Climatic factors "are processes and situations that produce, maintain or alter a climate … includ[ing] a location's latitude, the distribution of land and sea, the local and trans-regional wind systems and altitude" (2012, p. 12). Climatic elements are identified by features of climate that determine the conditions of a climate – the most significant of which are air temperature and humidity, solar radiation, precipitation, wind, etc.

"A *microclimate* may exist for only a very short space of time and is a climate in the smallest unit of space [which is] influenced by terrain, distance from the ground surface, and the ground surface's composition and flora" (2012, p. 12) and impacts of the built (human) environment. The microclimates within the construct of envelopes are determined and regulated through the envelope's construction materials, the spatial dimensions, vegetation, air streams, outdoor climatic conditions, mechanical systems (HVAC) of the building, and other influencing factors. In the author's view, the difference between the microclimate and microenvironment of envelopes lies in their psychological construct beyond physical comfort. Microclimate emphasizes the experience of the physical (and psychological) climatic conditions within the space of the envelope, whereas microenvironment includes the ensemble of architectural, climatic, and other physical realities within the space that affect the architectural experience. Microclimate can be regarded as a preparatory or semi-sheltered space between two or more different climatic and thermal conditions, whilst microenvironment accommodates the experience of the shelter itself. Microclimates are thus included in the incorporated elements of microenvironments.

Environment

This dissertation's definition of environment includes the surroundings of an organism that influences, conditions, shapes, or determines the development, life, or behaviour of that being. The environment is thus relative to the being to which or whom it belongs, and by which that being

is affected. In so being, environment and organism as dependant entities are continually under construction and complementary to each other; as "the world is constituted in relation to a being as its environment" – thus, they become two inseparable entities that mutually shape each another (2000, p. 40).

Extended Threshold

In this dissertation, *threshold* has an indeterminate and temporary conceptual and functional position. Conceptually, it is a space that encapsulates a change – climatic or spatial – and affects the perception and experience of other spaces to which it relates. Functionally, it represents a space with a temporal character and usually accommodates a transition. Here, the notion of *extended thresholds* (Hensel, 2011, 2013; Hensel & Sunguroğlu Hensel, 2010a) represents a prolonged experience of the threshold by obscuring the explicit boundaries of inside and outside. The dissertation's typology of extended threshold envelopes identifies envelopes that, through their semi-open spatial structures and material composition, provide binary spaces between inside- and outside environments of the building. Depending on their degree of enclosure, these spaces can accommodate an extension of the interior or exterior environments; this aspect is what distinguishes the notion of extended thresholds from *in-between spaces* in the context of this dissertation.

Façade

For the sake of clarity, the terms *façade*, *building skin* and *building envelope* (as explained in the next paragraphs) are here distinguished with focus on the differences in their spatial definition. The term *façade* is frequently used to refer to a false, or deceptive, appearance that is "completely in keeping with the original Latin word facies (meaning 'face') from which façade is derived" (Matzig, 2004, p. 25). However, facies also means "external appearance," which is used in architecture as a fixed term (2004, p. 25). "Façades are not limited to the actual space they occupy as part of the entire structure, but also influence the space in and around the building" (Knaack et al., 2007, p. 9); they form "the face of a city" (Schittich, 2006, p. 9). The façade is the leading character of a building (Pälmke, 2013, introduction), "the image we want the world to perceive" (Wenders, 2013), and the primary instrument of representation (Leatherbarrow & Mostafavi, 2002a, p. 9). While the façade's primary function is to separate the interior from the exterior, it can also possess other functional features; historical examples include the traditional ice fridges in Iran, in which a well-oriented wall structure was the key element in the ice-making process, or encompassing façades that form *piazze*

in historical Italian cities. In this dissertation, the term façade is positioned as a two-dimensional representation of a building; whilst defining its expressive character, it also establishes a disconnect between the interior and exterior environments through a material boundary. In this context, the role of the façade as a separating boundary is augmented.

In-between Space

In-between spaces represent spatial entities that unite or connect other spaces of the building and provide them with complementary aspects and functions, and in doing so create an integrity for both the inner spatial relations and envelope design. In-between spaces thus emphasize functional aspects in relation to other built spaces, whereas extended thresholds can be discussed in relation to the spheres of interior and exterior of the building.

Interiority – Exteriority

The term *interiority* refers to the enclosed space of the building with a controlled climate and defined boundary condition that separates it from the non-climatized exterior environment. The term *exteriority* is used to refer to exterior space outside an enclosure in its generic sense. *Exterior environment* represents the (immediate) surroundings or the vicinity of the built form.

1

Introduction

Positioning the Research

In contemporary built environments, the building envelope appears to be positioned primarily as a tool for the manifestation of technological advancements or formal expressions of architecture. Currently, a considerable number of building envelope designs lead to built forms that are unrelated to their surrounding contexts – represented through autonomous objects with highly insulated outer boundaries. This tendency in envelope design is becoming increasingly common in contemporary architectural practices, although it seems evident that the densification and development of contemporary cities demands stronger integration of the envelope in its local context; the design of the envelope should not only meet the needs of the building, but also promote and incorporate new spaces for the urban life around it. One of the main tasks of architectural envelopes is thus to establish a close relationship between the built form and its surrounding context and link the interior and exterior environments. To fulfil this aim, the building envelope should meet the needs of enclosed interior spaces whilst also contributing to the urban realm in which it is situated. By unfolding the characteristics of the most common approaches in today's envelope design, the following paragraphs intend to clarify the framework of this research.

There are two main discourses on the performative aspects of architecture. One concerns qualitative aspects of architectural performance, and the other quantitative. The former includes approaches that emphasize the aesthetic performance of architectural design; the latter is predominantly focused on engineering solutions and aspects related to energy consumption. The qualitative approach to envelope design concentrates primarily on the objective manifestation of architecture and the representative role of envelopes. In today's urban context, the broad scope that this spans includes different domains of the monumental and iconic expressions of the building (to convey a cultural, political or aesthetic position); "green" approaches that rely heavily on mechanical systems to achieve sustainability goals; and kinetic and intelligent systems that respond to and interact with their exterior environments to modulate interior conditions. These approaches frequently limit the role of envelopes to that of an outer layer that represents the "face" of the building, and its body is the space that contains the mechanical means for a highly insulated building interior environment. Jeffery Kipnis' reflections draw attention to the criticality of this current condition:

> Three features of the building dominate the adulations: (1) the detached wrap structured as a poured-concrete diagrid that allows the interior spaces to be almost column free. Of more interest to me than its ability to liberate the interior from columns, however, is its ability to liberate the exterior from the tedious, heavy-metal machismo that has become the default riff of steel diagrids and exoskeletons; (2) the "chimney effect" caused by the one-meter gap between the wrap and the glazed core that contributes to passive HVAC support; and (3) the pattern of holes in the skin, which, according to prevailing wisdom, does double meritorious duty as both a shading device and a gesture toward the tradition in Middle Eastern architecture of intricately patterned screens. None of these is inaccurate and each has its obvious virtues, yet they also ring as if the goal of contemporary architecture is to wind up as a feature in Popular Mechanics or on the Discovery Channel (Kipnis, 2012, p. 137).

The strong emphasis on the object-orientation of architecture often leads to discrete forms that are separated from their surrounding contexts and predominantly depend on mechanical means for controlled interior comfort and to compensate for the absence of suitable (climatic) design solutions. Some notable characteristics of discrete envelopes are their object-orientation, high energy use and technological and mechanical dependencies, vulnerability to technological failure, high long-term maintenance costs, intelligent materials and technologies with an undetermined life span, and restricted use and conditions of interior space, which limits the flexibility to programmatic changes.

Apart from the mainstream approaches, there are design strategies that attempt to create a comfortable interior environment via the envelope's spatial and material design and organization and its integration into the local and climatic context. These approaches strive to deliver interior living comfort – if not completely, at least to a great extent – through architectural design provisions. They aim to utilize technological and mechanical systems predominantly as a supportive structure for the architectural climatic design. This non-discrete approach (see Hensel, 2013, pp. 31–44) results in buildings that interact with and respond to the changing conditions around them by way of a range of design considerations and strategies. Their aim is thus to accommodate comfortable indoor spaces not only through architectural design provisions for changing climatic conditions, but also other factors including discussions on human adaptation, clothing and activity, flexibility of spaces for different patterns of use, and latent changes

in the exterior vicinity of the building (vegetation and outdoor use). Notable characteristics of non-discrete envelopes include close integration into the local context (context-dependent), environmental awareness (sustainable approach), human adaptation capacities (free-running buildings – see Chapter 2, pp. 27–29), flexibility to latent changes (program and use of space in addition to provisions of growth for natural vegetation in the building's vicinity), less dependency on mechanical systems for indoor thermal comfort, and time-/weather-dependant peripheral inhabitation of intermediary spaces based on the inhabitant's preferences.

The notion of a permeable and inhabitable building envelope and the desire to achieve energy efficiency in a given climate might seem inherently contradictory, giving rise to questions such as: Is the role of the building envelope to shield off the interior space from the exterior climatic conditions regardless of the location's specific climatic conditions? Are control systems and automated mechanical setups the optimal solution for ensuring inhabitants interior thermal comfort and for energy efficiency in different climatic regions? To address such questions methodically and to demonstrate that these aims are not necessarily contradictory, this dissertation includes an analysis of selected cases in which architectural solutions have been successfully implemented to achieve such aims in specific climatic regions. These include design approaches that take spatial considerations as well as architectural elements into account (see Article 2 of this dissertation). While the case studies selected comprise a number of small-scale projects, there are other noteworthy large-scale projects whose design is based on local climate considerations that should be mentioned, for example the Malaysian architect Ken Yeang's "bioclimatic skyscraper," developed for a hot, humid Asian climate. The bioclimatic skyscraper's porous and inhabitable envelope is designed to both harness energy from the environment and to facilitate the dissipation of unwanted heat and humidity. For a cool-temperate European climate, Norman Foster designed a number of double-skin façades that – while still relatively airtight – provide inhabitable, transitional spaces. Nevertheless, approaches such as that of Foster utilize various types of mechanical and electrical devices to regulate the condition of the interior; Yeang's high-rises are often richly vegetated and require a great deal of maintenance and economic turnover for construction costs and technologies.

This PhD project redefines the architectural envelope as the space that allows for the close integration of the built form and its local context. Furthermore, it rethinks this space as one that accommodates inhabitation and flexible use of space as an intermediary zone between inside and outside

environments and strives to develop and further unfold the notion of non-discrete envelopes through analytical and reflective design thinking. In so doing, it aims to provide further knowledge and contribute to discussions on the underlying position of building envelopes within the theme of location-specific designs, in the context of current environmental challenges.

Discussions on aspects of local context focus on climatic design strategies and spatial experience of the envelope and serve as the foundation for the dissertation's discussions on performative features of envelopes and the basis on which literature and case studies were selected. The reflective and analytical studies of the selected literature and case examples facilitated the production of concepts and design principles as operative tools for the design studies in workshops conducted in Master-level studios, as well as the author's own design experiment for this dissertation (Fig. 2). The design investigations incorporate a selection of existing theoretical concepts and design approaches from literature studies – in short referred to as concept mappings throughout this thesis (Fig. 5) with design principles extracted from case studies and within the typologies defined in the taxonomy of envelopes (Fig. 4). Some key references from influential literature studies, especially in relation to concept mappings, were particularly significant for the development of the notion of envelopes investigated here (Fig. 3) and its performative, productive, experiential, and intermediary position. These include Michael Hensel's discussions on location-specific and performance-oriented designs (Hensel, 2011, 2013; Hensel & Sunguroğlu Hensel, 2010a, 2010b; Hensel & Turko, 2015); various notions defined by David Leatherbarrow as ways by which architecture can "both adhere to and distinguish itself from 'context' and 'program' [by] performing in ways that acknowledge existing conditions while enriching them" (Leatherbarrow, 2009, p. 8); Kengo Kuma's anti-object stance and his aim to "erase architecture" (Kuma, 2008, p. 2); Louis Kahn's design studies on light and utilization of the wall's thickness as living spaces (Cacciatore, 2016; L. Kahn, 1972; L. I. Kahn, 1991c, 1991a); Aldo van Eyck's and Bernard Tschumi's discussions on the essentiality of intermediary and in-between spaces to the internal organization of buildings (Eyck, 1999, 2008c; Eyck et al., 2008) and the integrity of architectural spaces (Tschumi, 1977); and Gehl's percipient arguments on the essentiality of public life for improving the future qualities of urban life and health of cities (Gehl, 2011 [1971]).

Positioning the Notion of Envelope

Of architecture's various functions, the most significant is perhaps the provision of inhabitable spaces that deliver thermal comfort and aesthetic

qualities. The inhabitable space is formed by an enclosure that defines the relationship between the enclosed space and its exterior environment. In other words, as the building's covering, the wall defines the inhabitable sheltered space and affects its spatial ambiance. It shapes a zone between interior and exterior environments and defines the relationship between mass and void. The exterior wall of a building is among the oldest and most primitive architectural elements, dating back to tent-like structures, according to Gottfried Semper, who subdivides the function of the enclosure into structural – as primary and more permanent – and covering, as secondary and more temporal (Semper, 1989). In the first human settlements, as Semper writes, carpets and textiles were used as decorative elements on massive masonry wall structures (1989). The structural role of the wall and its covering has transformed throughout history and been utilized as e.g. hierarchical manifestations of power, representations of economic growth, and to showcase skill, knowledge, and craft. But the wall was also designed to provide comfort or privacy through its material organization and climatic conditioning. The spatial organization of the wall can also contribute to its urban realm by accommodating spaces for social interactions.

As the enclosing element of architecture, the wall has various functions, depending on its material articulation and formal representation. This outer presence of architecture is the threshold between interior and exterior environments and is commonly referred to as a façade, building skin, or envelope. (See Glossary for a brief overview of these terms).

The work at hand defines the building envelope as a space that connects a building to its surrounding environment. It is an extended space that creates graded conditions between the interior and exterior and provides peripheral spaces that can be inhabited and experienced; this experience is closely related to the envelope's features in relation to climatic and contextual conditions. The liminality of the envelope as the space that connects the enclosed (interior) and the exposed (exterior) environments underlines its critical position in the architectural experience of non-discrete buildings. Through its spatial configuration, the envelope allows the experience of in-between spaces that relate and connect these two environments. In this dissertation, the experience of these intermediate spaces is discussed through the position of the human body in relation to the envelope. The discussion positions the experience of the envelope in relation to adjacent environments, thermal comfort conditions, and atmospheres.

Historically, architectural design fulfilled the requirements of interior space through considerations of spatial and material organizations in relation to climatic and contextual conditions. Design provisions and strategies were used to achieve the necessary indoor comfort and could also carry certain aesthetic and architectural expressions. This dissertation argues that the traditional and historical approaches to climatic design of buildings should be reconsidered and re-evaluated in relation to current envelope design processes. However, the direct application of strategies seems insufficient for accommodating the complexities of a medium- or large-size building today, and current technological advancements can be valuable complements to architectural strategies and solutions. This dissertation is based on the position that the design provisions of building envelopes must provide adequate comfort conditions for the interior (on average climatic conditions) year-round, and technological means would usually compensate in the times of sudden change or extreme weather conditions. Throughout this dissertation, "design provisions" refers to considerations and strategies incorporated in the spatial articulations of the building with the aim to achieve certain functions, (climatic) conditions, and spatial ambiances.

In terms of climatic function, there are countless traditionally-designed building typologies around the globe that continue to work as successfully as they did when they were built – albeit with variations in efficiency due to environmental changes. Generations of knowledge transfer and experience resulted in the design of location-specific forms and typologies that used local materials and were suitable for the demands of their climatic context. In contrast, the materials and forms in today's built environments are becoming increasingly generic and dependent on technology. In addition to the gradual disappearance of indigenousness from architectural traditions and styles in broader urban arenas, there is the significant issue of financial and environmental cost of the fabrication of high-tech materials and technologies in relation to their life span and the amount of maintenance they require. However, more complex or larger building typologies are dependent on new technologies that, to a certain extent, enable their functions and programs; for example, air conditioning allows for much deeper buildings, whilst elevators make tall buildings possible.

In the context of this dissertation, a range of design approaches and strategies are needed in order for architectural design to meet the needs of the building's interior and exterior and to provide a comfortable living environment. The building envelope's performance thus relies on a number of integrated and interdependent design aspects, as discussed within the context of non-discrete built forms. Additionally, this dissertation includes

arguments on the dependency of creating specific atmospheres through climatic elements; i.e., the atmospheres of daylight in a space resulting from the material and spatial organizations of envelopes. The envelope is seen as an interface that can promote greater social interaction within the urban realm, which broadens the scope of the investigation's discussions of the envelope's performance. These discussions incorporate the envelope's role as an intermediary space for offering shared public spaces to promote social interaction (see Chapter 2). Here, the various stages of inquiry were coordinated to facilitate close examination and clarification of different notions and to address specific areas of the investigations, the ensemble of which forms the basis of the dissertation's overall argument on the question of architectural envelopes.

Objectives and Research Questions

This research questions the common contemporary position on architectural envelopes in which the emphasis is on the object-orientation of buildings. It attempts instead to rethink and redefine this position through a systematic analysis of buildings, methods and approaches to design processes and aims to encourage a different approach to envelope design. The pivotal discussion of this dissertation focuses on the notion of the envelope and the specific question: How can the envelope as a concept or notion be used constructively and contribute to the broader field of research in location-specific buildings? To address this, the investigations draw on a variety of literature- and case studies to define characteristics of an inhabitable, locally integrated envelope, responding to the questions: How does local-integration as a design criterion impact the living boundary of the envelopes? and: How do climatic factors and exterior environment relate to the atmospheric experiences of envelopes? Aiming to propose a way of working, this dissertation seeks to identify a set of criteria that must be addressed and incorporated in the envelope design process. Finally: How can the qualitative and quantitative (climatic and atmospheric) aims of envelopes be implemented and evaluated in the architectural design process?

Research Framework

This dissertation aims to redefine the climatic and experiential aspects of architectural envelopes by positioning the notion of envelopes as inhabitable in-between spaces that provide climatic modulation and architectural atmospheres. It revisits the notion of architectural envelopes in contemporary discourse on performance in architecture. In this dissertation, the performative aspects of envelopes include their impact on the creation

of specific climatic conditions and atmospheres that can be experienced upon inhabitation. Atmospheres refer to spatial ambiances initiated by the interactions of envelopes with surrounding exterior and climatic factors; the experiential aspects within the spaces of the envelope are thus directly driven by the interactions between the built form and its surroundings. The research-by-design mode of the investigations attempts to explore and reflect on the aforementioned by proposing a way of working. The design process incorporates contextual information for the development of concepts and ways of linking various types of design criteria (qualitative and quantitative), and thus begins to establish a definition for architectural envelopes that unpacks their functional, atmospheric, and societal performative position.

For the purpose of this dissertation, the features of location-specific envelopes are focused on design strategies that incorporate the spatial- and material organization of envelope to fulfil desired atmospheres through daylight; and thermal considerations through aspects of adaptive comfort. The investigations emphasize inhabitants' adaptive capacities and the importance of transitional spaces in architecture, underlining the envelope's potential when it comes to providing the construct for semi-sheltered spaces. These spatial constructs offer more flexible use of space with changing weather and seasons. Here, the investigations foreground the role of the local exterior context, especially within the building's premises, and its close relations to the interior. The discussion also addresses the role of building envelopes in relation to the urban context. While more extensive discussion of sociopolitical, cultural, tectonics, and technological themes as related to envelopes would certainly be warranted, this was beyond the scope of this dissertation; the discussions thus remain potentials for further investigations. Although the dissertation emphasizes local-specificity, the investigations do not focus exclusively on any single location or region; this reflects the aim of maintaining a holistic view that questions the notion of envelope more generally and more comprehensively.

Methods

The investigations maintained a pragmatic approach in applying concurrent mixed methods at different stages of the investigations. These methods include both experimental approaches – developing tools for the purpose of design studies – and the application of existing methods and techniques. The systematically developed tools for design studies include qualitative and quantitative critical analysis of existing literature and built case projects (Article 2 of this dissertation). The resulting tools incorporated a taxonomy

for building envelopes (Fig. 4 in the Appendices), established through a subjective critical analysis of a group of selected built projects, and concept mappings from literature studies (Fig. 5 in the Appendices) in correspondence to the proposed typologies. As mentioned earlier, together with the design experiment of the dissertation, these formed the main framework of the design studies in the author's workshops in Master-level studios. Conducting the investigations in this way allowed the methods and the argument of this dissertation to progress simultaneously.

Thesis Outline

This dissertation is article-based and includes three peer-reviewed articles and an exegesis. The exegesis is structured as follows:

Chapter 1

Chapter 1 introduces the state-of-the-art of building envelopes in current architectural practices and argues for the relevance of the PhD project's topic. It positions the dissertation with a brief account of the conducted studies, methods, and the questions and objectives and provides the present outline of the dissertation, a brief summary of the published articles, and the dissertation's contributions.

Chapter 2

Chapter 2 consists of an overview of the topic of the PhD project and areas of interest in the literature review. By unfolding the interest areas and mapping the relevant discussions, the chapter attempts to lay the foundation for the development of the investigation's design methods and tools. It begins by calling attention to the lack of clear definitions for the architectural envelope and highlighting shortcomings in current architectural practice as regards a systematic approach to envelope design. The chapter contains a redefinition of architectural envelopes that emphasizes the importance of their spatial role in the creation of an intense relationship with their surroundings. The discussions are framed by the intermediary role of the envelope that creates specific climatic conditions and atmospheres. The chapter takes a holistic view of the notion of envelope, and discussions range from the envelope's potential for providing semi-public spaces for the surrounding urban context on the ground level, as well as potentially on upper levels, to extended living spaces for the building. Chapter lays the foundation for further examinations of the design experiment, including the design of semi-open spaces with specific atmospheres resulting from daylight conditions, as presented in Article 3 of this dissertation.

Chapter 3

Chapter 3 summarizes the various methods, design techniques, and tools that were used, established, and developed for conducting the literature- and case studies and the design explorations. It positions the role of subjectivity in the developed methods, techniques, and tools to highlight both their values and potential observatory misinterpretations. In addition, it calls attention to the intentions behind the investigations' use of computational analysis, simulation, and modeling tools. Finally, the chapter elaborates on the strengths and limitations of the investigation methods and briefly positions the role of public presentations and publications in the progressive development of the dissertation's argument.

Chapter 4

Chapter 4 discusses the dissertation's findings and the difficulties encountered in both theoretical and methodological realms while the investigations were been conducted. It provides a thorough description of the challenges accompanying the way of conduct and reflects on complementary methods for improving the current shortcomings of the dissertation, as well as potential paths for further development.

Chapter 5

Chapter 5 summarizes the main conclusions of the dissertation, highlights its contributions and the value of the developed methods and tools, and suggests further improvements and progress of the conducted investigations.

Publications Summary

ARTICLE 1: Rethinking the Performance of Envelopes in Architecture

Article 1 of the dissertation was published in the *International Journal of Design Sciences and Technology* (IJDST) 23:1, 2017. The article aims to provide a redefinition of the notion of "envelope" in architecture that goes beyond the common definitions of "building skin" or "façade," grounding the notion of envelope in the contemporary discourse on performance in architecture as an extended threshold that affects humans' experience of architectural space. The three thematic categories presented in the article shape the initial framework of the investigations. They include: Environmental conditioning and climatic design consideration to position interiority and exteriority; Conscious and unconscious architectural

experience; Co-authoring performance through design provisions and flexibility. The themes emerged from literature readings on the existing notions of envelope within the architectural discipline and the contemporary discourse on performance in architecture. The first two themes were narrowed down and developed further through concept mappings, more focused literature readings (a summary of which is presented in Chapter 2 of this dissertation), and case- and design studies. However, the lattermost theme was only important at the initial stages of the dissertation; and because it required extensive discussions of Object-oriented Ontology and human-centric designs – which were outside the focused scope of the PhD project – it was not included in later work.

ARTICLE 2: Envelopes and Exteriority: Local Specificity and Extended Exterior as Design Criteria for Architectural Envelopes

Article 2 was published in *FormAkademisk* – forskningstidsskrift for design og designdidaktikk, 12:2, 2019. The article discusses the surrounding exterior of the building as a key criterion for envelope design. The investigations discussed in this article seek to reposition the relationship of architecture and its surrounding exterior by systematically defining the exterior space as design input through detailed examinations of selected case studies, as well as in the design studies in the author's workshops mentioned earlier.

ARTICLE 3: Advancing Architectural Envelope Design with Focus on Transitional Spaces:Towards a systematic approach to coupling measurable and immeasurable design criteria

Article three has been accepted by the Journal of Architecture (Taylor & Francis) in November 2019 and is currently under revision. The article examines a tailored design approach that utilizes digital tools used by contemporary architectural practices to inform and evaluate climatic, conceptual, and atmospheric performances of envelopes in a design experiment. The design exploration uses a systematic iterative process to develop the correlation between qualitative and quantitative methods in envelope design.

The design focuses on a basic, simplified, semi-enclosed form in which climatic conditions and perceived atmospheres are modulated by local climate and site-specific features in order to examine the dissertation's focus on extended thresholds as the pivotal feature of the notion of non-discrete envelopes. The experiment aims to create transitional spaces through the concepts of thickened walls, hollowed walls, and breathing walls to create

specified intermediary climatic conditions. In addition, there is emphasis placed on how daylight interacts with the forms of these conditioned walls. The design process includes integrating design sketching and computational parametric modelling and computational tools, such as evolutionary optimization and automatized iterative analyses, for architectural concept evaluation and development at different stages and iterations of the design. Additionally, the analysis and evaluation include a qualitatively-oriented assessment by way of selected rendered illustrations that seek to convey the perception of atmospheres.

Contributions

The dissertation focuses on repositioning the spatial organization of architectural envelopes in relation to their local context, emphasizing the need to revisit object-oriented approaches to architecture. This redefinition can open a discourse as a way of addressing current demands on environmentally-sound buildings and as regards diminishing shared spaces and outdoor urban life. It is only possible to discuss the notion of architectural envelopes in this context if both quantitative and qualitative aspects are incorporated simultaneously. The developed taxonomy and concept mappings are attempts to address these vital criteria.

The main contribution of the dissertation regards expanding the spatial notion of architectural envelope to construct a refined, holistic view that incorporates the climatic, atmospheric, and urban performances of envelopes. This is done by defining and linking a taxonomy of envelopes (developed through analytical case studies) to selected concept mappings from the literature studies, which formed the assessment tools for the dissertation's design studies. These tools have been important for the development of arguments on spatial recognition and the performative aspects of the envelope, as well as for questions of local specificity. The analytical literature- and case studies provide an overview of relevant existing theories and concepts in the architectural discipline in relation to architectural practice, whilst also offering the means for design investigations. As such, they illustrate a way of working with existing knowledge for further development (by the assessment of concepts) and the construction of new discourses and knowledge.

2

Envelopes and Local Context

Why Architectural Envelopes?

The Enclosure

Walls partition spaces, separate interior and exterior environments, and define the relationship between mass and void. The building's covering is the oldest architectural element, delineating the enclosure and considerably affecting the building's formal expression, spatial and climatic aspects. According to Gottfried Semper, who systematically analyzed the elements of the enclosure, the wall's function can be structural – primary and more permanent – and one of covering – secondary and more temporal (Semper, 1989). Elaborating on both representational and functional roles of the wall, his analytical studies illustrate how the temporal aspects of the wall position it as an expressive device that has been used in various ways throughout architectural history to represent specific styles or symbolize specific intentions (e.g. to demonstrate power).

As the critical interface between interior life and the external world, the envelope's design is at the center of the architectural design process (Allies, 2013). Envelope design strategies and responses to the aforementioned issues must thus be addressed at an early stage of the design process. There appears to be a prevailing tendency in contemporary architectural practice to concentrate design decisions regarding envelope performance predominately in relation to energy consumption or expressive features. In such cases, concepts that incorporate architectural solutions for creating atmospheres in relation to specific climatic conditions are less frequently realized. The same is true for integrating semi-closed spaces in envelopes as a way of providing flexible use of space and semi-public spaces for the urban environment; in many historical buildings, architectural elements like niches or arcades (e.g. of a Roman piazza) were meant to provide semi-sheltered spaces for the urban public life. Today, it is generally assumed that such functional aspects will be fulfilled by landscape design features, rather than via building designs. This research focuses on the importance of perceptive discussions that engage with design challenges of interior comfort and aesthetics in architectural formal expression not only through technological solutions of the envelope, but also through considerations concentrating on its spatial and material organizations.

This dissertation seeks to rediscover and reemphasize the role of the building envelope as a threshold that is strongly integrated into the surrounding context through architectural design considerations and provisions. The framework of this relationship focuses on spatial and

climatic features of the envelope that respond to local and site-specific factors. This approach to envelope design leads to built forms that Hensel has referred to as *non-discrete architectures* (2013).

The structural role of building envelopes has been shifting since early modernism: the loadbearing, heavy structures common in many historical buildings have become thin and often transparent layers, rendering the relation between the building envelope and its structure more distant. The contemporary preference for a flat skin has also led to the disappearance of the architectural threshold (Meisenheimer, 2011, p. 627); as a result, many built forms demonstrate a singular focus on the expressive role of the building envelope that leads to an object-orientation of built forms (Kuma, 2008) and a strong emphasis on their surficial representation. In the context of this dissertation, object-oriented built forms represent buildings whose main focus is on facilitating a controlled, optimal interior environment through technological and mechanical means. Object-oriented buildings typically fail to sustain a strong local integration in their surrounding built environment and local climate, and their envelope design tends to encourage the disconnect between the interior and exterior environments. This type of built work is referred to as *discrete* architecture (2008). The outcomes of these configurations typically result in "representations that oscillate between the visual reflection of systems of production and pictorial recollections of earlier styles and … outdated modes of construction" (Leatherbarrow & Mostafavi, 2002b, p. 1). These built forms tend to become rigid, self-governing architectural entities whose envelopes are a supportive structure for advanced (intelligent) technologies and mechanical systems.

The object-oriented approach to the envelope results in discrete typologies that feature climatized interior space and differing formal and technological orientations. They are organized into three distinct types: *intelligent device*, *representative device*, and *blob* (Fig. 4). These three discrete approaches to envelope design are often manifested through a strong focus on the outer skin articulation of the surficial representation of the building's envelope. The term intelligent device is inspired by Leatherbarrow's *device paradigm* (Leatherbarrow, 2009) and represents building skins that respond to features of their surrounding environment by conducting specific operations using contemporary technology and control systems. Based on Alejandro Zaera-Polo's discussions on the instrumentalized role of the building envelopes as a sociopolitical device, the term representative device is utilized to emphasize the external appearance and representational features of the envelopes (further elaborations follow on pp. 20–22). The term *blob*

architecture was coined by Greg Lynn in 1995. Blobs are "sticky, viscous, mobile composite entit[ies] capable of incorporating disparate external elements into [themselves]" (Lynn, 1998, p. 170). Blobs suggest alternative strategies of structural organization and construction that provide intricate and complex new ways of relating the homogeneous or general to the heterogeneous or particular" (1998, p. 169). They are distinguished as geometries that are "simultaneously alien and detached from any place yet capable of melding with their context" (1998, p. 170). "[A] sphere is exposed as a blob when it demonstrates the capacity of fluid and continuous differentiation based on interactions with neighboring forces with which it can be either inflected or fused to form higher degrees of singularity and multiplicity simultaneously" (1998, p. 166). The envelope design of these three typologies thus promote the disconnect between interior and exterior environments. Essential factors that need to be addressed in discrete approaches to envelopes are the effective lifespan of the selected technologies and intelligent systems, as well as issues such as possible technological failures. Approaches to discrete envelopes with high energy-efficiency and optimized design solutions often result in building strategies such as e.g. zero-energy or "green" buildings. Nevertheless, there are other approaches that emphasize a more spatial take on architecture and a close relationship to the local context.

Approaches that lead to non-discrete built forms attempt to de-emphasize the building as an object and highlight the performative role of the envelope as a threshold that creates a strong relationship between interior and exterior environments. The climatic and atmospheric design features of such structures are directly affected by the way the design implements and utilizes aspects of its local environment. Local and site-specific conditions are, thus an integrated criterion when designing the experiential features of envelopes, informed by spatial and material articulation. Experiential features result in atmospheres and spaces that are responsive to seasonal changes. In the context of this research, non-discrete envelopes are organized into four types: *extended thresholds* (Hensel, 2011, 2013; Hensel & Sunguroğlu Hensel, 2010a); *dissolved thresholds* (Kuma, 2008, pp. 58–68); *multiple envelopes* (Hensel & Turko, 2015, pp. 38–50); and *landform envelopes* (Allen & McQuade, 2011). Apart from the landform typology, which focuses on ways of merging to the ground level as the primary strategy for local integration, all other types mainly accommodate transitional spaces as their pivotal spatial strategy to create a strong relationship with their surrounding context. The focal discussions of this PhD project with regard to non-discrete envelopes are within climatic design, intermediary inhabitable spaces, and their architectural atmospheres.

Discrete and non-discrete approaches to envelopes cannot always be clearly distinguished, although they could be regarded as two main design approaches that result in object-oriented or context-dependent built forms. These two typologies appear instead to allow for overlaps where a (highly) controlled built form performs and corresponds to its surrounding and/or adjacent environment, as in the case of *Fondation Cartier* by Jean Nouvel, Paris, 1994; or local climate, as in the responsive façade of *Al Bahr Towers* by Aedas Architects, Dubai, 2011. These examples are not alone in manifesting this overlap; in this dissertation, the overlap is referred to as dual reality due to its shared identity with both main types.

Taxonomy of Envelopes

The dissertation's taxonomy of envelopes distinguishes various types of envelopes as: *discrete*, *non-discrete*, and *envelopes with dual reality*. The taxonomy is a systematized representation of the case studies conducted for the investigations, and it is intended to function as an operative tool for the design studies. Similar typologies developed in architectural theory (Alexander et al., 1977) and practice (Moussavi & Zaera-Polo, 2004) underline "the importance of language in architecture" (2004, p. 36) or "the physical structure of the world" (1977) for developing a "systematic set of tools for sustainable solutions" (Leitner, 2015, pp. 19 & 7). By representing their work as a phylogenetic tree, Foreign Office Architects (FOA) attempted to trace the history of ideas, forms, and knowledge in their design so they could be utilized as operative tools in their other designs. They refer to the typologies presented in this phylogram as a "genetic pool" that provides raw material, and "open organizational structures" that can be modified and proliferated. Using these models as inspiration, the taxonomy of envelopes developed in this PhD research seekss to systematically clarify and create a coherent analysis between the case studies of the dissertation.

The organization of non-discrete envelopes includes the four types: *extended thresholds*, *dissolved thresholds*, *multiple envelopes* and *landform envelopes*. In dissolved thresholds, a clear materialized envelope that divides the interior from the exterior dissolves and transforms the inhabitant's experience of the envelope into the perception of space. The enclosed space of these envelopes is minimized and varies according to the degree to which space is exposed, which blurs the definition of shelter defined in relation to being in- or outside an enclosed space. The ranges of effects in these envelopes are dependent on various contextual and climatic conditions besides the spatial organization and adjacent spaces.

The extended threshold is a conceptual representation of built forms providing various climatic and atmospheric conditions through their envelopes' spatial organization and degrees of enclosure. The approach treats the threshold of the building envelope as a habitable space – semi-closed or exposed, yet sheltered. It closely relates to the notion of free-running buildings as an integrated design approach, addressing issues of thermal comfort and inhabitants' climatic tolerance through the spatial and material organization. Extended threshold envelopes challenge the explicit boundaries between inside and outside through their surficial composition, structural modulation and spatial relations. Design considerations for extended thresholds articulate functional, aesthetic, and experiential aspects corresponding to contextual and environmental circumstances. These include different climatic and inhabitation conditions driven by environmental elements that result in seasonal patterns of use and different atmospheres of the envelope.

Multiple envelopes generate heterogeneous spaces by arranging various distanced layers of materials in a composition of interconnected relations. Their spatial setup creates ranges of conditions in accordance with the material organization and relations between the layers of space, offering different degrees of enclosure, environmental modulation, and diverse spatial qualities and functions. The proximity of the layers, materialization, form, and structure all affect the behavior of the envelope system and spatial definitions. Multiple envelopes can be considered a subcategory of the extended thresholds typology.

In landform envelopes, the topography is conceived as a porous mass capable of not only supporting the built work, but also of generating a new sense of envelope. The topographical features of the ground benefit the design by generating a new envelope surface that puts architecture in accord with the local context and the surrounding environment. The relationship between the envelope and the environment is thus created through extending the landscape to form the envelope. In some cases, this can lead to the disappearance of architecture in its topographical context by formally representing a unified whole.

In the context of this dissertation, the taxonomy of envelopes initiated a taxonomic approach to understanding and systematizing the design of architectural envelopes to render it useful for the design studies of the research. The taxonomy was utilized as a guideline to types in the workshops conducted during the PhD project and the design experiment of

the dissertation. Nevertheless, further extensive research and development are necessary for this to be operative for a broader range of use in architectural practice.

The Architectural Envelope

This dissertation views the building's envelope as an active threshold, "a zone in which change occurs" (Addington & Schodek, 2004). The envelope has various roles in relation to both the enclosure and the urban realm; these include defining a system of spaces, as well as structural, programmatic, and representational functions. Apart from these specific features, the envelope has the potential to address latent climatic changes by accounting for the flexible use of space. "[S]pace is a new landscape, which is to last as long as the material lasts … [although they] are made to change… [t]his is truly the nature of architecture" (Wurman, 1986; as cited in Brawne, 2003, p. 28). This position of space must be considered early in the design process by accommodating sufficient and appropriate capacity for future adaptation. The key aspect is the role of the envelope as a mediator to interrelate, integrate, separate, or connect (visually or spatially) various spaces of the building, and by doing so, to create a system of interrelated spaces. In recent years, there has been greater focus on the representational (Zaera-Polo, 2008, 2009), (Moussavi, 2005) and programmatic (Meisenheimer, 2011) features of the envelope as a temporary space in relation to its surroundings (Leatherbarrow, 2009). The selection criteria for references has been their extensive discussion of the envelope's performative role in relation to the local context.

Zaera-Polo's discussions of the envelope have focused mainly on its representational features and political stance (Zaera-Polo, 2008, 2009), based on his notion of the envelope as the materialized division between the inside and outside, which is by essence politically charged. Zaera-Polo's argument uses as a basis late capitalist dynamics and the works of Gilles Deleuze and Peter Sloterdijk to bring forth the key question of whether architecture is capable of altering the distribution of power in the way that political, economic, and social factors can shape architecture. His arguments confirm the aforementioned power by capturing the operative aspects of the envelope as a device that can be used instrumentally to convey meaning or to represent a sociopolitical position (Zaera-Polo, 2008, p. 77).

Zaera-Polo incorporated discussions with various foci to position the political and representational role of architecture; these range from architectural traditions and styles to environmental concerns and interior

comfort, while proposing new (political) organizational structures and analyzing the effects of envelopes on surrounding urban life. His arguments include insights on security aspects in relation to functional features of the envelope and questions regarding the relationship between public and private space. However, these discussions are framed around large public buildings in a sizeable urban context and thus do not address the role of other ranges of building scales. While Zaera-Polo also addressed environmental and atmospheric aspects of the envelope, the discussion centered on sociopolitical views and thus does not offer the insights or depth of a more comprehensive study.

This dissertation seeks to activate the building envelope as a threshold in order to provide shared semi-public or public spaces for the urban realm, and aims to contribute to the sociopolitical discussions of Zaera-Polo's views on envelopes. Non-discrete envelopes engage with power ecology discussions through their possibilities of creating communal spaces whose spatial flexibility allows social functions and organizations. The semi-closed spaces of an envelope are designed with varying degrees of privacy and thus do not only provide for functions in relation to the interior spaces (the private spectrum of the building), but also to the exterior conditions in the vicinity of the building (the social spectrum of the building). The meaningful urban stance of the building is manifested in the architectural threshold by the way the building meets, interacts, and accounts for its social and physical surrounding context.

Farshid Moussavi has discussed the ornament's capacity as an operative device for reorganizing the envelope as a systematic filter between external constraints and internal functions. Although Moussavi's argument differs significantly from Zaera-Polo's, she also focused on the representational role of the envelope and criticized the position of the envelope as an operative boundary of insulation and spatial support for structural, mechanical, and electrical systems – an approach she calls *blank envelopes* (Moussavi, 2005). In Moussavi's view, the ornamental role of the envelopes is an operative tool that conveys a specific meaning or function, but it is tightly framed around the representational features of ornament. Although her discussion focuses primarily on the ornament within the surficial realm of the envelope and remains vague when it comes to defining the relations between interior and exterior environments, it highlights some key aspects that need to be addressed in envelope design. Among these is an inclusive view that engages the structural notion of the envelope via Moussavi's notion of effective ornaments; this incorporates discussions on materiality and structural treatments of the surface (e.g. opaque vs transparent) and

ways in which the envelope connects to the inner functions of the building or emphasizes the surface for the urban realm (e.g. deep vs superficial), etc. Moussavi's arguments are interesting for this dissertation as they relate to finding ways to advance these themes beyond their operative surficial focus and towards the spatial realm of the envelope as it relates to both interior and exterior environments. The aim is thus to identify capacities of these themes for elaborating ways in which architecture engages with its context – not as a representational device that creates a radical disparity between the interior and exterior, but as a space that connects the two. Within this realm, the discrete and non-discrete types, as defined earlier in this chapter, are discussed with focus on these themes to clarify the underlying concepts and the mapping of their differences. The themes include characteristics of the massing and form in discrete – non-discrete envelopes listed respectively in each of their separate features as: surficial – spatial, restricted – relational, immediate – progressive, superficial – real, thin – thick, transparent – opaque, and unreliable – lasting (Fig. 6 in the Appendices). The first themes incorporate a spatial as opposed to a surficial focus on the envelopes, whereas the last themes focus on its tectonics and materiality.

This dissertation argues that considerations for correlating the physical and representational features of the envelope ought to be designed together with its atmospheric effects driven by direct interactions of the building with its local climate and physical surroundings. The character of the envelope is discussed through the combined effect of its tectonics, materials, and massing organization, as well as the ways in which they affect comfort and the atmospheric conditions of the envelope as an inhabitable space. The envelope is the architectural element that shields and encloses the interior whilst at the same time helping it integrate with or even yield to its exterior environment. It closely incorporates environmental/context-related aspects and spatial dimensions. The climatic and atmospheric qualities of the space are directly affected by the envelope's construction and material organization: its permeability to daylight, ventilation properties, insulation features, solar gain or shading capacities. When discussing the role of the architectural envelope in incorporating the surrounding context, it is important to highlight architecture's position in providing comfort and aesthetic conditions: Architecture and its design configurations supply what the given location itself is unable to provide – Leatherbarrow refers to this as *productive* architecture (Leatherbarrow, 2009, p. 33). Consequentially, the organizational- and material specifications of the envelope are the direct attributes that define the locality and productivity of architecture; within the scope of this PhD project, this includes discussions such as the climatic comfort that buildings need to provide independently of their mechanical

add-ons. In addition, this includes discussions that address how architecture is located; that is, the relation of the built form to its topography, the urban setting, the situation in its context, orientation on the site, or the role of proximity and distances of the human body to architecture that affect architectural perception (for further elaborations see Article 2, pp. 5–6). The performative aspects of the envelope are thus not limited to discussions of comfort and the topographical (site-related) integration of a building into its surrounding context, but also by the atmospheres created through the interaction of the envelope with its contextual conditions.

Envelopes in Relation to Context

The following pages summarize the themes of this PhD project, focusing on ways to strengthen the relationship between the built form and its surrounding context through semi-open spaces, including climatic considerations that allow for adaptive comfort and the adaptive use of space. In addition, it highlights the envelope's potential for addressing urban densification and issues of congestion around shared public spaces by providing a mediating space between private and public.

Architecture in its Surrounding Context and the Role of Climatic Control

There appears to be a prevailing tendency in contemporary architectural discourse and design to place emphasis on the interior when discussing spatial qualities; for instance, Le Corbusier's analogy of the building as a soap bubble – perfect and harmonious if the air is properly distributed from the inside – and the emphasis on the design process as a plan that proceeds from the inside out (Corbusier, 2007, p. 216) and Rem Koolhaas' provocation "fuck context" and his essay on *bigness* – an affirmation of what might be considered an excessive object-orientation of architecture (Koolhaas & Mau, 1995, pp. 494–517). More recently, Pier Vittorio Aureli has advocated an "absolute architecture," defined as the individuality of architectural form in the environment in which it is conceived and constructed, and proposed the idea of a city that is "made of closures and strategic forms of containment" (2011, p. x). Aureli highlights urban management through separation rather than connection, and encourages an urban planning approach in which all built forms are independent and only united through a common ground that he calls the archipelago (2011, p. xi). These approaches contrast starkly with other approaches that attempt to create a balance between interior and exterior environments, at least on the building's premises – for example, typologies and traditions in architectural design (e.g. traditional Japanese dwellings and courtyard house typologies)

and approaches in modern architecture emphasizing the integration of interior and exterior, e.g. Frank Lloyd Wright's "breaking the box" (Wright, 2010) through which Wright created individual "features instead of walls" (Pfeiffer, 2007, p. 24), or design approaches by Adolf Loos (Risselada, 2008) and Mies van der Rohe (Frampton, 2001) that pursued spatial continuity (see Articles 2 and 3 for further elaborations and the definition of spatial continuity in the context of this PhD project). In these approaches, the ways in which architecture permits or resists certain contextual aspects or climatic elements not only defines the performance of architecture, but also its atmospheres.

The most common use of the term performance is currently focused on a building's technical or climatic criteria (Kolarevic & Malkawi, 2005). At the same time, other long-lasting analytical procedures are implemented today to design tools to facilitate instantaneous feedback for better informed design decision-making, or to drive a design process, e.g. "formal coherence (such as surface continuity), structural capacity (such as optimization for material efficiency) or the flow of gases and fluids (computational fluid dynamics)"(Runberger, 2012, p. 33). In addition, architectural performance could also refer to discussions on formal and perceptual characteristics (Del Campo, 2009; Lavin, 2012) through which the building achieves "certain qualities that perform at aesthetic as well as structural and other levels" (2012, p. 33). In the context of this dissertation, the notion of architectural performance is advanced by incorporating an approach discussed by Leatherbarrow (2005) that engages with the relationship between planned and unplanned events to which architecture must respond. Such relationships are driven by interrelations between the built form and its local context, and they closely integrate aspects of topography, culture, and program.

Architecture is inclusively responsive to the world in which it is situated – this includes its topography and site, climatic elements and natural, social, political, and urban environments. Of these aspects, interactions between climate and architecture are the most intense and natural. Architecture must work both *with* and *against* the climatic elements and ambient conditions. Throughout history, humans have striven to build shelter as "the main instrument for fulfilling the requirements of comfort"(Olgyay, 2015, p. 15) and provide better living conditions, as well as sought to construct spaces with favorable atmospheres. Viewed from a historical perspective however, the building of shelters was primarily a response to the desire for "protection from an inimical outside world and the rigors of the weather" (Herzog, 2004, p. 19). Semper argued that the wall defines the spatial

enclosure, and thus, that the enclosed space is the result of a surface exercise (Semper, 1989). This view positions the wall as beyond a decorative or structural surface, and as a performative element that affects the atmospheric and functional characteristics of the space through its material and spatial organization. Various other demands, such as e.g. light, ventilation, privacy, etc., were later functions of this boundary, which can be classified into two groups depending on the viewpoint: site-specific external conditions, and demands on internal conditions (Herzog, 2004, p. 19).

The development of environmental technologies in the late 19th and early 20th centuries – particularly heating, ventilation, and air-conditioning (HVAC) – led to a strong disconnect of architecture from its surrounding context and a dependency on mechanical needs for providing comfort. Over time, the envelope became a technical-material boundary required to compensate for environmental shortcomings caused by the choice of materials and the atmospheric solutions that became necessary as a result of eliminating the spatiality and inhabitation of other (traditional) approaches to the envelope. As a result, the envelope has become the determinant of the surrounding conditions instead of being the mediator of these conditions (Addington, 2009, p. 13).

There are however theorists and critics of architecture who strongly advocate approaches to location-specific buildings, albeit with variations in terms of details and perspectives (Canizaro, 2007; Grobman & Neuman, 2011; Hensel, 2013). One notable example is "regionalism," defined as an architectural approach that is firmly based on regional practices and derived from considerations of local climate, geography, materials, cultures, and traditions (Colquhoun, 2008, pp. 280–291). Regionalism differs from the vernacular in that vernacular built forms emerge from the experience transferred over generations and through years of experience, and the vernacular does not necessarily engage with aesthetic aspects and foci that regionalism takes into account. Vernacular architecture refers to "the buildings of and by the people" (Oliver, 2006, p. xxii), where the built forms are attuned to their surrounding environments and provide various patterns of adaptation and inhabitation. According to Victor Olgyay, whose sustainable climatic designs remain a source of inspiration for many architects, architecture must react to nature as organisms do – by surviving environmental impacts through the equilibrium of internal and external forces. This, he believes, leads to a truly regional architecture that works with its natural surroundings (Victor Olgyay, 1968, personal notes, as cited in Olgyay, 2015, p. xix) and places human comfort – rather than energy efficiency and optimization – at the center of its design strategies.

In defining critical regionalism, Kenneth Frampton advocates a geographical and climatic-responsive approach that truly lays the ground for an indigenous architectural identity through design provisions that integrate the built form into its local context (Frampton, 2003, 2007). Architecture must therefore "recognize very deeply structured personal response to particular places" (Ujam & Stevensen, 1996). The strong focus on the particularities of place, use of local materials, appropriate spatial and formal response to climatic and microclimatic conditions, adaptive use of space, and the incorporation of cultural impacts are examples of traditional design strategies and aspects of regionalism. These aspects include architectural typologies such as e.g. courtyard houses in Iran (see Article 2, pp. 9–10) or regionalist approaches of architects such as Hassan Fathy and Laurie Baker with cost-effective, energy-efficient, environmentally-attuned architecture with regional expressions, or the low-cost, environmental designs of Glenn Murcutt and Balkrishna V. Doshi, all of whom are known for incorporating concepts of sustainability in innovative ways with contemporary expressions.

In contemporary architecture practices, interest is growing in incorporating climatic and local design strategies; this is largely due to the current environmental crisis and increasing public awareness of the impacts of short-term construction strategies and technologies. Another contributing factor is the available knowledge regarding various shortcomings and disadvantages of commonly applied technologies, especially in terms of lifespan, that can be gathered via application and feedback. Current approaches that attempt to integrate architecture into its local climate range from zero-energy buildings (Hestnes & Eik-Nes, 2017) and passive and green building strategies (Malkawi et al., 2018, pp. 44–87) to approaches that focus on the climatic role of the façade (Hausladen, 2008) and intelligent façade structures (Wigginton & Harris, 2002b) such as high-performance skins, smart skins, double skin façades, or other technological innovations and emerging definitions of performance (Grobman & Neuman, 2011). The latter category includes typological solutions that have partially emerged from technological advancements and the possibilities they provide. However, these approaches tend to focus almost exclusively on energy efficiency, optimization, and high-end technological means, and engage to a lesser degree in the incorporation of design solutions that emphasize other post-inhabitation features of space (e.g. flexibility of use and program of space). Nevertheless, in many large-scale buildings, passive design strategies appear insufficient and require complementary mechanical means to ensure thermal comfort. Reducing nonrenewable energy-use is imperative for

environmental sustainability, and a mixed mode intermediary stage might be a feasible solution; emphasis could remain on climatic design provisions (adaptive comfort), and mechanical systems could be available to compensate in extreme circumstances in which architectural means on their own do not suffice.

Adaptive Comfort and Free-running Buildings

It has become increasingly evident that many of the contemporary debates on "green" designs or other multiple-environment design strategies in architecture are barriers to finding solutions to combat e.g. global warming (Guy & Farmer, 2001, p. 140). The emphasis on programs that focus on measurable values for understanding the environmental conditions tend to ignore social questions that are critical for the sustainable practice of architecture (Woodgate & Redclift, 1998). Rational science presents the environment through metrics and assessments that identify environmental features, leading to standardizations and sets of values which tend to ignore "particular local culture" and "competing forms of local knowledge" (Macnaghten & Urry, 1999, p. 1). Climatic design engages acutely with design provisions that take into account aspects such as orientation, the choice and organization of materials, degrees of openings and shading strategies, etc., as well as considerations that closely incorporate aspects such as daylight and natural ventilation. Humans' adaptive capacity when it comes to seasonal changes demonstrates that architectural design can encourage an attitude of acceptance and tolerance toward undesired thermal conditions. Comfort values cited in building regulations and standards are generally defined by calculating averages and exclude many significant influential factors that emerge when a building is inhabited; many indoor climatic conditions that are based on these values are thus prone to failure when it comes to fulfilling individual needs in terms of the use of space.

Certain areas of focus must be considered when designing for greater flexibility of interior thermal comfort, including: "enhancing adaptability in humans, managing human expectation towards the indoor environment, and enhancing adaptability of buildings" (Hellwig, 2018). Although Hellwig proposed the aforementioned areas in relation to heatwaves and overheating, it is the author's view that they are also applicable for other thermal conditions that can be generally regarded as undesirable, but tolerable.

Some current approaches to architectural design center around patterns of adaptation and flexibility, both of the built form and of human beings, in

order to achieve their design objectives; these include approaches that focus on addressing comfort and ranges of thermal conditions provided by spatial design and material considerations, e.g. free-running building and adaptive thermal comfort, both of which are discussed below. In addition, there are approaches that attempt to ascribe varying experiences through the interaction of the human body with specific features of space provided by sensor-based or intelligent systems. An example is Philippe Rahm's design approach to creating specific microclimates and the ways in which these microclimates affect the (thermal) experience of the person who experiences them. Rahm aims to closely (re)incorporate climatic factors into living spaces and architectural experiences. He stated that "form (and function) follow[s] climate" (Rahm, 2007, 2014, p. 85; Rahm & Clement, 2007). Rahm's approach encompasses meteorological explorations of the physical environment in built spaces and landscapes through high-tech systems and installations, resulting in specific tectonics and atmospheres for his architecture – an approach that would seem overly dependent on what is exhibited in the room rather than the spatial construct of the room itself.

Adaptive thermal comfort (de Dear & Brager, 1998a) suggests ways of connecting humans to the exterior environment rather than isolating them from it, and encourages adaptation to – and at times even preference for – a wider range of thermal conditions. Thermal comfort is affected by air temperature, radiant temperature, relative humidity, and air velocity, and also incorporates personal factors such as clothing, metabolic rate, and physical activity. Adaptive thermal comfort is among the design concepts recognized for sustainable standards of indoor climate considerations (Nicol & Humphreys, 2002).

The term free-running buildings (de Dear & Brager, 1998b), or FRB, designates an integrated design approach that deals with thermal comfort and climatic tolerance through spatial- and material organization. By focusing on inhabitants' adaptive capacity, FRB offer a variety of indoor climates that are closely associated with non-discrete envelope types; as an example, people can adapt more easily to gradual changes in temperature. In FRB, adaptation refers to provisions that allow inhabitants to take control of their thermal environments. FRB are directly connected to their outdoor environments and respond to the weather and seasonal conditions. Unlike in centrally air-conditioned buildings, where intelligent systems provide specific conditions based on a predetermined setup, inhabitants must thus make daily adjustments to e.g. clothing, body posture, activity, and use of space to maintain thermal comfort inside the building. Surveys indicate that inhabitants living in air-conditioned buildings have different expectations

regarding their level of comfort in relation to air-conditioning services than inhabitants of naturally ventilated buildings (Nicol & Humphreys, 2002; Nicol & Pagliano, 2007); in the surveys, inhabitants of naturally ventilated buildings were more forgiving when it came to unpleasant thermal conditions, whilst those living in air-conditioned buildings expected indoor conditions to meet their demands at all times. As a general observation, the author has also witnessed this on hot summer stays in arid areas of Iran spent in both naturally ventilated traditional houses and modern houses equipped with HVAC systems. When entering a traditional house on a hot summer day, one is prepared to experience non-optimized thermal conditions. Variations in temperatures, corresponding to the different microclimates of these houses, are not necessarily undesirable, but they might not be consistently optimal throughout the whole day. Centrally controlled buildings on the other hand are associated with certain expectations of constant thermal comfort.

Envelopes in Relation to Their Urban Context

Architect and urban planner Jan Gehl calls cities with the potential and space for stimulating more interaction between people "living cities;" according to Gehl, such cities are rich in experiences (2011, p. 21). The change from living to lifeless cities and multifunctional to monotonous neighborhoods that followed industrialization, the segregation of various city functions, and reliance on the automobile (Gehl, 2011, p. 21) underline today's need for stimulation (Gehl, 1971). Creating conditions that promote and facilitate social interaction and thus a more active urban life is one way of tackling this issue; such conditions could be spatial interventions at the scale of individual buildings and in relation to their shared street scope. Gehl explores the notion of the living city further as "one in which spaces inside buildings are supplemented with usable outdoor areas, and where spaces have a much better chance of working well" (2011, p. 31). He cites the example of how people prefer a semi-private front yard to a backyard because of the possibility it offers for interaction with the public (2011, p. 25). Many contemporary residential buildings are lacking when it comes to activities and interactions due to the absence – or rather disappearance – of suitable spaces for short outdoor stays or social interaction. For instance, a bench on which to sit at the entrance of an urban house can constitute a semi-protected space in bad climatic conditions. A small design consideration of this kind facilitates social interactions at street level, offering a place from which to watch the urban life of the neighborhood-scape, or simply a seat on which to take a brief rest. European medieval urban spaces were particularly suitable places in which to be out-of-doors

"by virtue of their spatial qualities and ample dimensioning … unlike urban spaces from later points … [that] generally tend to be too large, too wide, and too straight" (2011, p. 38).

A great deal of research has been conducted about the effects of the constructed urban environment on both the city's biological and social spheres. They include extensive observatory research focusing on various built spaces and furniture that promote planned and unplanned opportunities for social interactions in the urban fabric (Gehl, 2011). This is of interest for the scope of this dissertation because of the envelope's potential as a semi-private/semi-public realm and a physical location to provide urban spaces that facilitate social interactions. Relation to the street, degrees of enclosure, and public access are among the aspects that greatly impact these interactions. This potential could lead to interesting strategies for shared spaces in the urban fabric whilst also contributing to the sociocultural aspects, especially in relation to contemporary urban densification issues and the decrease of public spaces. The mediating role of the street demands provision of a shared space between buildings while engaging the fabric of the city in all its depth (Vesely, 2015, p. 160). Seemingly, in this mediation "what is communicated takes place on the level of urban fabric, but must be seen only as a mode of embodiment of the city life" (2015, p. 161).

The envelope's tectonics and aesthetic presence, including its spatial elements, can provide places for standing, sitting, offer shelter, and potentially enhance the social engagement and urban life of the inhabitants. Such places are referred to as "pause places" in this dissertation, and they are primarily discussed in relation to the envelope design at a building's ground level, which is in direct contact with the streetscape. This does not imply that other, elevated spaces within the envelopes cannot contribute to shared public spaces; on the contrary, the elevated spaces of envelopes can be discussed as potential semi-private spaces (see pp. 28-33 of Article 2). Pause places offer space for temporal inhabitation or house certain urban functions for both the interior and exterior life of the building – for example, arcades can be used as temporary exhibition spaces, or recessed ground floors can accommodate extended semi-sheltered spaces for a café or restaurant. These functions can be exemplified by arcades that can be used as temporary exhibition spaces or by recesses that accommodate extended semi-sheltered spaces for a café or restaurant. The spatial organization of the building's envelope can be exemplified and further discussed through Christopher Alexander's various concepts (1977) concerning the relationship between the inner life of the building to its

surrounding urban environment beyond its provision of social spaces for the urban life. The former includes e.g. south-facing outdoor areas, private terraces on the street, and outdoor rooms (1977, pp. 513–516, 664–667, 764-768 respectively), and the latter concepts like a sidewalk café, arcades, activity pockets, and seating, a front-door bench, sitting wall, canvas roofs, raised flower beds (1977, pp. 436–439, 580–584, 599–602, and 1118-1134 respectively). Pause spaces thus provide functional and aesthetic features for both the inhabitants and the citizens – the building and the city. Another significant feature of such semi-sheltered spaces is their transitional space-character that provide a preparatory space for connecting the interior and exterior environments.

The Dual Interior – Exterior Spatial Potential of the Envelope

As stated earlier in this exegesis, this dissertation seeks to define a performance-oriented approach for architectural envelopes in which the envelope's material and spatial constituents are conditioned by both the interior and exterior environments, resulting in desired atmospheres, microclimates, and microenvironments between the inside and outside. The exterior factors of the built form (including site, topography, climate, and other influential factors within the built form) would constitute design criteria for both comfort and atmospheric conditions in this in-between space and the interior. The envelope thus has a dual task of interacting with and responding to both interior and exterior inquiries, including the thermal and programmatic requirements of the interior in relation to the effects resulting from the envelope's interaction with climatic elements and the building's adjacent exterior (e.g. vegetation). It takes into account e.g. the geometry and orientation of the envelopes, which determine heterogeneous thermal conditions (various daylight, solar gain, and wind conditions). These microclimates directly affect the vegetation and use of outdoor spaces, as well as comfort and atmospheric conditions in adjacent interior spaces.

The Intermediary Spaces of Envelopes

In many diverse architectural traditions, intermediary spaces of building envelopes in various spatial forms and definitions have played significant functional and spatial roles in the experience of architecture. Often, they have accommodated transitional spaces that featured either as a vestibule between main functions, or as secondary inhabitable spaces facilitating specific use or temporary living spaces in the buildings. Moreover, they have simultaneously incorporated functions of transition and inhabitation.

Transitional Spaces in Architecture

Speed is commonly associated with intelligence (Sen, 2000, p. 607), and it is increasingly encouraged by contemporary society's demands for higher efficiency (Koepnick, 2014) and productivity. Today's culture attempts to "alleviate the pressure of compressed time" (2014, p. 1) and advocates the accelerated temporality and mobility of today's lifestyle (Honoré, 2004, pp. 1–36). Many rely on maps and smartphone prompts to reduce transitions between locations to a minimum. Similarly, the presence and value of transitional spaces in architectural and urban spaces have diminished as greater emphasis has been placed on the spaces that accommodate main functions in cities and buildings, or the spaces have instead been treated as service areas.

Transitional spaces allow for the experience of a threshold (Sensual City Studio, 2018, p. 15) in which a transformation or change takes place. They can take on different roles and fulfil various functions ranging from creating atmospheric effects or offering complementary living spaces to a building's main functions, to simply facilitating circulation and access. These spaces are commonly formed by a semi-closed or semi-open space between inside and outside environments, or between a building's main functions. They offer inhabitable spaces or a place through which to cross "where entry and invitation are offered and interior and exterior are felt, revealing the continuity and discontinuity of a spatial wrapper" (Meisenheimer, 2011, p. 626).

Thresholds – Interstitial Spaces – In-between Spaces

The architectural threshold is a space that encapsulates a change. It is the vestibule of experience. It initiates a movement, a transition, or a transformation from one state to another that could imply a sense of contingency – and it thus affects the experience of architecture. Thresholds connect different spaces, and they also have an identity and spatial character of their own. They are anthropological invariants that represent one of humanity's fundamental relations to space (Sensual City Studio, 2018). The threshold has been an operative transdisciplinary metaphor, and discussions of the notion of threshold span many disciplines in the humanities (e.g. anthropology and the arts), social sciences, and applied sciences such as architecture.

Arnold van Gennep (1908) was the first to theorize the notion of threshold, and he divided it into three rites: separation (preliminal), transition (liminal), and incorporation (postliminal) (Gennep et al., 1960, pp. 1–14). He argued

that both individual and communal life involve passing through a series of thresholds that fit in the aforementioned categories. The threshold thus has a liminal position that affects how it is perceived and experienced. Like the notion of threshold, liminality is "a polysemous concept;" in psychology and physiology, "*limen* is a threshold between psychological and physical experience" (Mukherji, 2013, p. xix). Thresholds emerge from relations and interrelations between other binary spaces and carry a sense of temporality. They are indeterminate and adjustable, and in the context of this dissertation, receptive to the exterior environment. The threshold is Janus-faced, "looking not only in and out, but behind and ahead" (2013, p. xxii). The experience of thresholds incorporates not only the physical boundary definers (e.g. a door), but also abstracted conditions such as spiritual rituals and sacred territories.

"In sixteenth century Italy, a convenient room had many doors" (Evans, 1997, p. 64) allowing for an inner connection between adjacent rooms and between a broader range of rooms. Each room was not only a defined space, but also a passage, "making the house a matrix of discrete but thoroughly interconnected chambers" (1997, p. 64). Contemporary passages and staircases generally connect only one space to another and "never serve as general distributors of movement" (1997, p. 64). The consecutive succession of doors to various rooms unfolds a spatial depth that creates a continuum whilst also retaining a boundary line between the layered spaces. The doors thus define the boundary and the threshold of both physical or visual connections within the inner life of the building and are the means for identifying the entity and character of each individual room. In the succession of departure and entry, as van Eyck argues "[one] cannot leave a real place without entering another", and therefore, threshold cannot exist between two abstract spaces, but only between two real places where "departure means entry" (Eyck et al., 2008, p. 56). According to van Eyck, the reality of a door in this departure and entry is "the localized setting for a wonderful human gesture: conscious entry and departure;" "a vital experience" for the one(s) who comes or goes and the one(s) who is encountered or left behind;" "a threshold made for an occasion that is repeated millions of times in a lifetime between the first and the last exit" (Eyck, 2008a, pp. 204–205).

Van Eyck argues that architecture must extend past the narrow borderline of the doorstep and instead coax it into an articulated in-between realm (Eyck et al., 2008, p. 55). He uses the doorstep concept to capture "the moment when the meeting between two polarities acquires concrete shape," or when "their opposite forces are so attuned that they interlock like gears"

or complete one another. "It becomes a place where architecture 'breathes in and out'" (Strauven, 1996, p. 11). Regarded thus, the in-between space is by no means a leftover space or a void between built spaces and main functions, but it is equivalent to a substantial place with specific (or flexible) functions. "The idea of design as 'site-specific', 'time-centered', 'poly-centered', 'ludic', 'path-based', [… and] all means of creating a world of 'inbetweenning', is one of the major achievements of the postwar period" (Lefaivre & Tzonis, 1999, p. 131). In-between spaces allow for the coordination of various design factors, e.g. daylight penetration, spatial organization and disclosure of architectural elements, to carefully prepare the visitor for the desired spatial experience of departure and entry between two other (architectural) places. Contemporary architecture often falls short as regards sufficient intermediary spaces, and it is predominantly defined by the preference for effective division; as a result, the threshold as a space is disappearing (Meisenheimer, 2011, p. 627) and the emphasis is placed on a plain visual connection of the exterior and interior via transparent façades.

The notion of in-betweenness has been used in many ways when referring to different aspects of architecture in different scales and presence, ranging from a non-physical space that creates the wholeness in the body of architecture by connecting its physical elements, to inhabitable, physical spaces. That is the experience of architecture by seeing and feeling the elements and components through which architecture is presented to the physical world – such as parts of walls or rooms, streets, ideas, and more. Tschumi calls these *fragments* and elaborates on the space in-between them:

> These fragments are like beginnings without ends. There is always a split between fragments that are real and fragments that are virtual, between memory and fantasy. These splits have no existence other than being the passage from one fragment to another. They are relays rather than signs. They are traces. They are in-between. (Tschumi, 1996, p. 95).

According to Tschumi, in-betweenness is what generates the integrity of architecture in which architectural experience is implicit and ingrained. The experience of architecture is an act that includes the ensemble of body and mind, with visual perception at its core. The experience of in-betweenness incorporates a perceptual and cognitive understanding that is part of the mental and physical ensemble of experiencing an architectural space, and in-betweenness thus offers a spatial reality that is situated between two physical realms, providing an atmospheric or climatic in-between condition. This experience is therefore correlated to the sequence of series of spatial

experiences, and corresponds to other felt spaces before and after the in-between space.

In-betweenness brings together conflicting polarities, reuniting them by providing "the place where they can interchange" to "re-establish the original dual phenomena" (Eyck, 2008a, pp. 204–205). According to van Eyck, the dual (or twin) phenomena is "a unity of two opposites which are reconciled into complementary halves that reinforce each other so as to form a dynamic whole" (Ligtelijn & Strauven, 2008, p. 275):

> Take an example: the world of the house with me inside and you outside and vice versa, there is also the world of the street – the city – with you inside and me outside and vice versa … two worlds clashing, no transition. The individual on one side, the collective on the other … architects in particular are so poor in spirit that they provide doors two inches thick … between such fantastic phenomena … Every time we pass through a door like that, we are split in two – but we don't take notice any more (Eyck, 2008a, pp. 204–205).

In-between spaces must strive to reunite their adjacent spaces in order to offer inhabitants what they might be lacking, both in terms of spatial functions and experiential aspects. The role of in-between spaces in creating the integrity and affecting the experience of the building positions them as a key design consideration for both the inner spatial relations and envelope design.

Peter Eisenman defines the interstitial as an affective difference rather than an articulated presence (Eisenman, 1998, p. 32, 2003, p. 100). He describes them as "spaces in between" or "zones of undecidability" and refers to poché as the rhetorical term for the relationship between solid and void (Eisenman, 1998, pp. 30–32). Interstitial spaces range from leftover spaces between property lines to voids between major functions (Fjeld et al., 1987, p. 126). They are unexpected and emerging; "opened by disconnection between skin and structure" (Zizek, 2009, p. unpaginated cited in; Nadir, 2016); they "could be a void within a void, an overlapping within space of space, creating a density in space not given by the forming of a container with a profile" (2003, p. 100).

This PhD project differentiates thresholds, interstitial- and in-between spaces by the way in which they relate to the space adjacent to them – i.e., whether they are dependent, auxiliary, or facilitating – or their functional

role in relation to their scale. Thresholds and in-between spaces are comparable notions that can be often used as equivalent despite their implicit and subtle differences, while interstitial spaces differ considerably from the other two notions because of limitations in scale and use, and could also be referred to as auxiliary, usually with an aesthetic function. The threshold's position is both conceptual and functional, and its spatial construct is expected to evoke the desired experience. The entity contained by a threshold can therefore be independent – a complementary space to fulfill the integrity of the design – or dependent; this varies with design objectives. This dissertation considers the architectural threshold to be not only a space of transition, but also a metaphor that encapsulates the experience from an individual's ensemble of thinking, feeling and bodily memory. Moreover, it sees the architectural envelope as providing the spatial construct that encourages (and empowers) the experience of the threshold in its authoring of the transition from the outside to the inside of the built form. In-between spaces are mainly required to accommodate a certain function or condition, and while they – like thresholds – create and influence architectural unity, they also have their own spatial reality, hosting functions and inquiries that the main spaces might lack or be seeking to provide. Thresholds and in-between spaces in architecture are often coupled with the notion of transition to accommodate a specific effect and/or function through their spatial construct.

The Transition – The Inhabitation

The process of transitioning through the envelope characterizes and affects the experience of the place of departure as well as the place of arrival. Here, place is an inclusive definition of the composition of the form (or the non-form), consisting of a defined boundary (e.g. the site) in its expanded surrounding context; as such, space is of contributes to place, and place, of the local context.

The envelope is experienced as something in-between the two realms of inside and outside; it is neither one nor the other, but includes both. The in-betweenness of the envelope positions it as an unsettled space, experienced as temporal, and perhaps even occasional, with adaptable functions. The nested spaces of envelopes are where the sequence of moving from outside to inside takes place. Depending on culture and context, the notion of transition in design considerations is usually employed to emphasize concepts ranging from religious or moral impressions to existential and philosophical aspects. Transitive spaces are relay areas, reminding the

inhabitant that the world is not absolute but temporary and diverse in character.

Examples of inhabitable transitional spaces in traditional architecture are the *iwan* in Islamic architecture, the veranda, balcony, or the *engawa* in Japanese architecture. Considerable in size and use, most of these spaces are inhabited seasonally as an extension of the interior space. Other examples include smaller-scale elements, such as poché or niches that are utilized as inhabitable pockets or interstitial spaces. Engawa and iwan are direct, semi-open spatial extensions of the interior spaces and are either level with or slightly lower than the interior. They are directly accessible through (sliding) doors and openings. In the case of engawa, these sliding doors can also be removed during the warm seasons to allow for a continuous space. Although the spatial quality and openness of these two examples differ, both function as living spaces with different patterns of seasonal use for the interior (for further reading see Article 2, pp. 9-10). An iconic architectural element of a house that defines the entrance is the porch. A porch can provide similar living or storage spaces as an engawa or iwan, yet with different spatial connections and adjacencies. Passing through a porch to enter a house prepares the inhabitant for entering the interior space; the same is true when exiting the house. Through this transition, the physical and climatic changes define the range of experiences, and to some extent, the expectations of the inhabitant.

Inhabitation of In-between Spaces

Van Eyck's use of in-between spaces allows for breathing spaces, spatial transitions between various functions, and a spatial dialogue between the inside and outside. In the Orphanage project (Amsterdam, Netherlands, 1960), he attempted to "break away from the contemporary concept … of spatial continuity and the tendency to erase every articulation between spaces; e.g. between inside and outside, [or] one space and another" (Eyck, 2008b, p. 319). Instead, he sought to achieve transition "by means of defined in-between places which include simultaneous awareness of what is significant on either side […in order to provide a] common ground where conflicting polarities can again become dual phenomena" (Eyck, 2008b, p. 319). Another example is the Congress Building in Israel (1958), in which he brings together the binary nature of the design "composed of two different and complementary buildings [that are] joined by a shared open-air entry loggia" (McCarter, 2015, p. 123). For van Eyck, the eight open courts of this building were places "where groups can sit outside at any time of the day,

season, or year … so that each participant can change rooms according to mood, weather or time of the day" (Eyck, 1999, p. 114).

Van Eyck's approach to incorporating in-between spaces was a way to build a close relationship between the interior and exterior life of a building, be it in a rich natural landscape, such as in the Protestant church The Wheels of Heaven (1963-64, unrealized) or in an urban context, such as in the Amsterdam Orphanage. When integrating the inside and outside, he frequently chose to open the building in all four directions; this made it possible to extend the inside to the outside, or the outside to the interiorized living spaces in a variety of ways by: (a) allowing visual connection in all directions, as in the case of the Congress Building in Israel; (b) providing sheltered spaces, as in the Four Tower House, designed for his family in 1958-60 (unrealized); (c) or facilitating access by allowing sheltered passages in all directions, as in The Wheels of Heaven. The first two of van Eyck's approaches could be compared to Wright's "breaking the box" approach, discussed in Article 2 (p.3). By breaking the box, Frank Lloyd Wright opened up the corners of the intersecting walls to allow the interior to merge with its surroundings, and employed walls as a means of spatial extension: an "extended topography" (Leatherbarrow, 2009, p. 145 On F. L. Wright's projects). In comparison, van Eyck created a similar spatial openness by keeping the corners closed but removing the dividing mass of the enclosing walls. In the Congress Building, "[b]oth buildings are a cruciform-in-square in plan, are closed at the corners, are opened in all four directions through portals with projecting roof canopies set on the central axis of each façade, and have central rooms that are connected to the earth and the sky" (McCarter, 2015, p. 125). A similar approach was applied in the Four Tower House; four sheltered exterior terraces or patio spaces carved out of a rectangular volume open the outer masonry walls in all four directions while keeping the corners closed. "Looking outwards in whatever direction, part of the house is always incorporated in the view" (Eyck, 1999, p. 111). Van Eyck described these semi-enclosed spaces as an "interiorization of the exterior [that] draws into the house what belongs to the outside" (1999, p. 111).

In The Wheels of Heaven, van Eyck sought to shape an interior experience of both outside and inside spaces through the design of the church (McCarter, 2015, p. 135). The design was thus accessible from all four directions, and the church's entrances incorporated existing paths through the woods – this allowed the building to become the daily passage that van Eyck described as one of the aims of the project. The in-between spaces shape the passages and inner accessibility between the main cylindrical

volumes, as well as the relationship between inside and outside through the spatial experience of the project, which simultaneously frames the inner spiritual life of the building and the wilderness and freedom of the surrounding woods.

Thickened Wall

According to Aires Mateus, an interior space can be defined through the demarcation of the exterior, where the thickness of matter in defining the boundary "remains coherent, and even becomes substantial, complex and meaningful" (Aires Mateus, 2017). In Aires Mateus and Associates' house designs, the boundary is manifested through the idea of thickness of the matter and the resulting spatial depth (2017). The designs represent an idea for the building envelope that goes "[b]eyond the more or less two-dimensional plastic values that are traditionally associated to the façade" [… by allowing it to become] a spatial entity within which the possibilities to live at a different scale can be recognized and at the same time explored" (2017). This living boundary provides the space in which auxiliary spaces are "conceived as a thick inhabitable wall" and are carved out of the mass. In the firm's approach, auxiliary and main spaces coincide in the thickened wall and the "interstitial space and habitable walls [persist] as containers of spaces with different hierarchies and use values" (Cacciatore, 2017, p. 119).

Daylight and Envelope

Daylight and views are key design factors that must be addressed and integrated in envelope design. In the words of Louis Kahn, "[a] wall is built in the hope that a light once observed may strike it again in a rare moment in time" (L. I. Kahn, 1991a, p. 252); this highlights the mutual dependency of architecture and light for becoming visible. In architectural design, the qualities of daylight are focused on the aesthetic (the visual and atmospheric qualities) or comfort aspects (strategies against or in favor of solar gain). The aesthetic potential of daylight in architectural space can give rise to powerful spatial moods.

Today, demands for more light have led to higher control level of lighting and standardized systems on the scales of both buildings and the city itself. The aesthetic and environmental impacts from intensive use of electricity in contemporary cities has had a significantly effect on our living environments in ways of which we are not always aware on a daily basis. "[W]e have grown accustomed to viewing the satellite night view of the planet [earth] as marked with luminous cancer of consumption that threatens human life instead" (Steane, 2011, p. 1). The need for electrical light is unquestionable,

"[b]ut architects in planning rooms today have forgotten their faith in natural light" as well as "the endlessly changing qualities of natural light, in which a room is a different room every second of the day" (L. I. Kahn, 1991a, p. 252).

When discussing (interior) lighting in contemporary architecture, there is a common tendency to automatically assume that the lighting design in question will rely on artificial rather than natural light – perhaps this is further evidence of our dependency on electrical lighting and the shortcomings of our daily living spaces when it comes to providing the consistent experience of (visual and spatial qualities) of daylight. Daily experiences teach us that "the quantity of light is not nearly as important as its quality" (Rasmussen, 1964, p. 189). Although natural light has remained a thematic interest, what we need to consider in today's architectural practice is reintroducing the focus on natural light as the main source of lighting for interior spaces during daytime hours, rather than relying on common engineering strategies that lead to "spaces baked in uniform lux" (2011, p. 1). As Kahn pointed out: "[t]he electric bulb fights the sun" while "[t]he most wonderful aspects of the indoors are the moods that [natural] light gives to space" (L. I. Kahn, 1991a, p. 252), and "[a]rchitecture appears … when the sunlight hits a wall" (L. Kahn, 2013, p. 26). Kahn also placed emphasis on the position of architectural/ structural elements:

> [S]tructure is the maker of light, because structure releases the spaces between and that is light giving. It could be a matter of an entrance or a window … because the distances between columns are so resourceful that you cannot cope with the generosity of such a construction using concrete (L. Kahn, 1972).
>
> A column and a column bring light between them [by which] we realize a simple and beautiful rhythmic beauty evolved from the primitive wall and its openings (L. I. Kahn, 1991a, p. 252).

Daylight happens to the room and re-narrates it – like a presence that lingers briefly, then disappears. Rather than imposing itself, it impacts the room by reshaping and restructuring it through its various rhythms and patterns. James Turrell speaks of the "thingness of light," saying that he seeks to "basically make spaces that capture light and hold it for your physical sensing ... a realization that the eyes touch, that the eyes feel. And when the eyes are open and you allow for this sensation, touch goes out of the eyes like feel" (Turrell, 2000, pp. 1–2). Turrell's insights draw attention

to architectural envelopes as the boundary that accommodates the interaction between daylight and architecture.

Steen Eiler Rasmussen distinguishes three types of space and light relations:

> [T]he bright open hall, the room with a skylight and, most typical of all, the room with light entering from the side" (Rasmussen, 1964, p. 187). By examining various European examples, Rasmussen developed design strategies that resulted in specific spatial qualities, transformations, and experiences of natural light in his projects (1964, pp. 188–214). His analysis highlighted the relationship between the interior and exterior by pointing out the coordination of various influential elements in relation to natural light. Carlo Scarpa stated that "[m]odern architecture, abstractly stereometric, destroys all sensitivity to framework and de-composition … we have created a void around things … to achieve anything we have to invent relationships (Scarpa et al., 1986, p. 282).

Le Corbusier is among the modern architects who believed that light is "something to be structured rather than accepted as given" (Steane, 2011, p. 12). He often utilized the side penetration of natural light through *fenêtre en longueur*, or horizontal windows. The room was thus filled with a fine light, that together with the open plan and free façade, offered spacious, open and airy rooms with generous visual contact to the exterior. Le Corbusier also worked with the atmospheric capacities of daylight to intensify the emotional power of daylight in his chapel at Ronchamp: "the key is light, and light illuminates shapes, and shapes have an emotional power" (Le Corbusier, 1957, p. 27). His conception of openings (windows) in Ronchamp chapel manifest a rather different approach to the earlier fenêtre en longueur, which flooded the room with sunlight and panoramic views (2011, p. 27). Here, the window is rethought parallel to the evolution of Le Corbusier's constructional preferences and material vocabulary. Mary Steane analyzed three spatial features for the openings at Ronchamp as noticeable changes in Le Corbusier's approach in designing windows (2011, p. 27): First, their three-dimensional depth in the deep windows of the north and south walls; secondly, an aspect for qualifying the perception of form and weight by featuring gaps or fissures – represented as the gap between the plaster walls and the concrete roof. Thirdly, Steane explores Le Corbusier's realization that windows are capable of performing as screens when distributed in various depths, opacities, and weights. Design features and arrangements of the openings focus on orchestrating daylight penetration to

achieve specific atmospheres in various spaces and corners of the church. Le Corbusier choreographed the atmospheric performance of daylight in the chapel: the equally-sized openings that pierce the thick wall, creating a hollow breathing wall; the narrow opening between the plastered walls and the massive ceiling that offsets the heaviness of the roof; or the elegant and captivating light that finds its smooth way down the curved apse through the openings in the roof are but a few examples.

David Michael Levin's words: "I am all that I see" and "through vision we [literally] touch the sun and the stars" (Levin, 1993, p. 14) emphasize the existential importance of vision as the primary means of perception and stimulation of the imaginative mind. It is important to note that "light is not the only condition of visibility … [although it is] the condition for seeing; [yet] darkness is, in interaction with light, the condition for seeing something [driven by] delimitation, articulation, and certainty" (Böhme, 2017, p. 148). Concepts of brightness and darkness must therefore be incorporated simultaneously to create atmospheres through the articulation of the exterior wall and its relation to daylight.

It is through darkness that we understand the treasury of light, and through light the sublime presence of darkness. Frank Lloyd Wright highlighted that strong co-dependency when he noted that "[s]hadow itself is of the light" (Wright et al., 1991, p. 284). Kahn reemphasized this notion in the context of an architectural space when he said that "[e]ven a room which must be dark needs at least a crack of light to know how dark it is" (L. I. Kahn, 1991a, p. 252). Kahn also noted how the perception of materials and forms in the environment is primarily dependent on light, saying that light is "the giver of all presences, [and] is the maker of a material [… that] casts a shadow, and the shadow belongs to light" (L. I. Kahn, 1991b, p. 235). Sigurd Lewerentz – a key figure in Scandinavian architecture as regards using the qualities of Nordic light to achieve specific ambiences and moods – stated that "the world of things emerges from shadow" (Steane, 2011, p. 75). Lewerentz' tendency to create a soothing darkness is arguably his most influential design inclination – it leads the mind to concentrate first on the experience of the entire space, and then on the orchestration of all the details of a beautifully articulated space. The dark, rough texture of the bricks in his St. Peter's Church (1963-66) in Klippan, Sweden, manifest the mediation between darkness and light; and the levels of darkness in the room vary within the different zones of the space. Sverre Fehn – another Scandinavian architect known for his work with Nordic light qualities – believed that "[e]ach material has its own shadow. The shadow of a stone is not the same as that of [a] brittle autumn leaf. The shadow penetrates

material and radiates its message" (Fehn, 2012, p. 65). This quote highlights how the qualities of light and the setting to which the light is exposed and with which it interacts, or by which it is displayed, transform its qualities to other curated sets of qualities; depending on the choice of openings, forms and angles, materials and finishing, ambient colors, and functions of the space.

Human scotopic vision, or dark-adapted vision, allows for sharp and focused vision in spaces with low light. Although it may take up to half an hour to attain optimum night-vision in full darkness, depending on the degree of darkness and possible illuminating sources, this adaptation could be minimized to only a few seconds. As Juhani Pallasmaa pointed out, the evolutionary process has calibrated the human eye for twilight rather than bright daylight (Pallasmaa, 2012, p. 50). On this note, the essential role of peripheral perception and the ensemble of human bodily experiences (Pallasmaa, 2011, 2014a; Robinson & Pallasmaa, 2015) is key in the discussion of experiencing architecture. According to Pallasmaa:

> The eye is the organ of distance and separation, whereas touch is the sense of nearness, intimacy and affection. The eye surveys, controls and investigates, whereas touch approaches and caress. During overpowering emotional experiences, we tend to close off the distancing sense of vision; we close the eyes when dreaming, listening to music, or caressing our beloved ones. Deep shadows and darkness are essential, because they dim the sharpness of vision, make depth and distance ambiguous, and invite unconscious peripheral vision and tactile fantasy (Pallasmaa, 2012, p. 50).

Contemplating the lacquerware used traditionally for serving meals in Japan, the author Junichiro Tanizaki describes how the ensemble of the dim half-light of the candlelight and dark finishing colors of lacquer reveals and intensifies the experience of dinning in lacquerware:

> With lacquerware there is a beauty in that moment between removing the lid and lifting the bowl to the mouth when one gazes at the still, silent liquid in the dark depths of the bowl, its color hardly differing from that of the bowl itself. What lies within the darkness one cannot distinguish, but the palm senses the gentle movement of the liquid, vapor rises from within forming droplets on the rim, and the fragrance carried upon the vapor brings a delicate anticipation. What world of difference there is between this moment and the moment when soup is served in Western style, in

> a pale, shallow bowl[!] A moment of mystery, it might almost be called, a moment of trance (2001, p. 25).

This sensory description incorporates vision, olfactory, and haptic senses to illustrate a moment of drinking a soup in which darkness is the essence of activating and affecting the sensory experience. These examples seek to highlight the essential position of incorporating the bodily and peripheral perception in addition to visual perception when designing the atmospheres of natural light in envelopes.

Daylight in the Inhabitable Wall

Kahn actively engaged the massing of the wall to bring daylight into the spaces of the building and to develop inhabitable spaces; this included duplicated walls, hollowed columns, and folded walls (Cacciatore, 2016, pp. 97–105). By duplicating the wall, Kahn formed a hollow space inside the wall with different inner and outer profiles; this was done e.g. in the Meeting House of the Salk Institute in La Jolla, California (1962). In the design of the Philip Exeter Academy Library in Hampshire (1965-1972), the double frame theme is shown by defining a concrete inner frame to accommodate stacks of books and a brick outer frame as a huge hollow ring to accommodate the reading areas (2016, p. 106). The idea of applying different materials and the careful positioning of the library's two main spaces – the reading area and the book storage – are essential to the building's particular character. Kahn moved the inner frame to the core of the building and designated it a structural and archival role. The reading areas – well-lit interstitial spaces – were positioned along the thick, hollowed outer wall. This expression of user-centric design focus highlights the functional capacities of a thickened envelope. "Here the wall's thickness and the mass of matter have definitely become space, giving both human being and objects a full possibility of existence" (2016, p. 110).

Another design strategy that Kahn utilized to form in-between spaces comprised redirecting the organization of the wall to effectively channel light into the core spaces of large-scale structures, as in for example the National Assembly in Dhaka, Bangladesh (1962-1983). The possibility of folding the outer duplicated wall by 90 degrees by turning it deeply inwards produces a clear impression of an interior interstitial space that can be furnished for a comfortable rest (2016, p. 105). This creates an inhabitable space that can adapt to suit the needs of the inhabitants, as well as to seasonal changes; an example of this is Fisher House in Hatboro, Pennsylvania (1967).

In many traditional buildings, loadbearing walls and thick masonry structures were necessities that provided the opportunities for small pockets of space. These structures also defined the relationship between the interior and exterior, the mass and the void – as poché possess two skins – interior and exterior – and are "separated by elements embedded in the thickness between them" (Meisenheimer, 2011).

Atmospheres and Experiences of the Envelope

Atmosphere – Ambiance – Mood of the Envelope

A variety of factors, such as culturally-rooted preferences and characteristics and geographical or climatic conditions, influence built environments and contribute to their particular characters, identities, and originality. Currently, many architectural practices show a preference for utilizing global technologies and material solutions, which marginalizes craftsmanship and local material – this is particularly true in public buildings and large-scale projects. There is an excessive emphasis on generic material or technologies that downgrade the architectural space to the primacy of functional means or definitions of contemporary ornamentation trends of the built environment, and authentic atmospheric qualities are gradually disappearing. As a result, the spatial, spiritual, and poetic aspects of architecture are directed at specific functional and representational features. "Architecture has to speak back to us without becoming merely invisible, acting like a numbing drug or like the perfect fit dreamt by functionalism [or currently] by architects who design increasingly more "intelligent"– e.g., comfortable and efficient – buildings" (Pérez-Gómez, 2015, p. 226). But what defines the authenticity of an atmosphere or the ambiance of a space? What is it that makes some buildings more memorable? What affects our spatial experience and remains in our (bodily) memory? The identity and meaning of an architectural space unfold through a human experience by which space is felt and perceived; that is, via a conscious, bodily experience of an architectural atmosphere. Architectural experience thus arises directly from being and acting in the space either passively (through physical presence and mental engagement) or actively (through physical interaction). George Howe stated that "to feel space, the observer must flow through it, he must go in and come out, become conscious of the indoor and the outdoor as related parts of a continuous whole" (Howe, n.d.).

Although they are not synonymous, atmosphere, mood, or ambiance of a space are frequently used interchangeably to refer to the (spatial) sensation a

space evokes in the person who experiences it. The following paragraphs seek to detail how these terms differ in the context of this dissertation.

Ambiance or mood of space essentially refer to the prevalent feeling in a space at a point in time. Because both describe a spatial quality and sensation, the terms ambiance or mood are frequently used interchangeably. Both the ambiance and mood of a space can perhaps be best defined as the prevailing "emotional climate" (Böhme, 2017, p. 118) that contributes to feeling one's presence by being-in-something (Böhme, 2016, p. 138). In contrast to ambiance however, mood is also often used in a broader sense to refer to a variety of other aspects in architecture, e.g. associating certain moods with specific colors. Spatial ambiances and moods transform and are affected by changes of programs, objective arrangements, the time of the day, season, human interactions, weather, and the surrounding context.

Framing and discussing architectural atmospheres is a difficult task, perhaps because of the challenging nature of speaking about the qualities that distinguish architecture. However, "[t]he notion of atmospheres always concern a spatial sense of ambiance" (Böhme, 2018, p. 25). These can be defined "as tuned space, i.e. a space with a certain mood" (Böhme, 2016, p. 3). "Atmospheres fill spaces; they emanate from things, constellations of things, and persons" (Böhme, 2018, p. 25) and are "experienced as an emotional effect" (2018, p. 27). They are therefore a fundamental factor in human perception in terms of how people get a sense of space in relation to their physical presence and their disposition (Böhme, 2017, p. 71). Pallasmaa foregrounded atmospheres as the main attributes of quality in architecture; that is, as the ambiance of a space that fuses and heightens the sensory experience of architecture (Pallasmaa, 2014a, pp. 18–41). He defines the experience of the atmosphere as "the overarching perceptual, sensory, and emotive impression of a space, setting, or social situation … 'the common dominator', 'the coloring' or 'the feel' of the existential situation" (Pallasmaa, 2014a, pp. 20–21).

In building architectural atmospheres, the main features are usually framed around specifications regarding materiality, proportion, tectonics, and details (Pallasmaa, 2014b; Zumthor, 2006) and the relation between the equalities of surroundings and dispositions (Böhme [1993] cited in Böhme, 2014, p. 58). The experience of the atmosphere is dependent on both the subject and the object and the relationship between the two; therefore, "aesthetics of atmosphere must also mediate between the aesthetics of reception and the aesthetics of the product or production" (Böhme, 2014, p. 43) of architecture.

Moving through the envelope is a transcendent walk that manifests a corporeal perception and the lived experience of being in the threshold. The domain of atmosphere mainly incorporates the visual aspects of the experience of the threshold. Here however, the lived experience refers to the corporeal and multi-sensory experience, which also includes the visual. If architectural design is predominantly focused on the visual aesthetics of the representation, it is endangered by a single, framed focus that can fail to incorporate an inhabitant's overall physical experience. The design of envelopes must therefore take into account multiple sensory experiences – physical, tactile, and sensual. These are part of the experiences that are integrated into the aesthetics and atmospheres of the building itself, and not merely its representative presence. As Pallasmaa said, "authentic architectural experiences consist of … confronting a building rather than the façade, the act of entering and not simply the frame of the door, looking in or out of a window rather than the window itself" (Pallasmaa, 2011, p. 47).

When describing or expressing the atmospheres and prevailing feelings in a space, people frequently use adjectives related to visual perception. While there are certainly references to other sensory perceptions, the descriptive vocabulary about atmospheres relies heavily on the visual. The author also had to remain within the range of descriptive terms pertaining to the visual while defining the atmospheric aims of the dissertation's design experiment; this was due to the focus of the design for creating atmospheres with daylight (see Article 3).

Of the five senses, vision is arguably the dominant sense, and architecture as a discipline places great emphasis on visual aesthetics, demands for visual stimulus and signifiers to constitute identity and significance for the built environment. This partially explains the disproportionate emphasis on the facial representation of architecture through façades that are often strongly disconnected from their local contexts and can even appear absurd. Emphasizing the inquiry for a specific manner of perception for architectural atmosphere, Pallasma expressed the difference between focused as opposed to peripheral vision thus:

> [O]ne reason why contemporary spaces often alienate us – compared with historical and natural settings which elicit powerful emotional identification and engagement – has to do with the poverty of our peripheral vision. Focused vision makes us mere outside observers; peripheral perception transforms retinal images

> into a spatial and bodily involvement and gives rise to the sense of atmosphere and participation. Peripheral perception is the perceptival mode through which we grasp atmospheres … The role of peripheral and unconscious perception explains why a photographic image is usually an unreliable witness of true architectural quality (Pallasmaa in Böhme, 2014, pp. 38–39).

Peripheral and sensory perception are design aspects that strongly impact the experience of envelopes, and they must therefore be incorporated into the envelope design process. Along with studies on affect theory (Deleuze & Guattari, 1987; Gregg & Seigworth, 2010) that are focused on the role of materiality and tectonics in the experience of architecture (a few examples of which are Kipnis, 2011; O'Donnell, 2011; Bech-Danielsen et al., 2012; Lavin, 2012; Beim et al., 2014), peripheral and sensory perception can provide valuable insights in the further developments of this research's discussions on the atmospheres of envelopes.

3

Methods and Approaches

This chapter outlines the methods used in this dissertation. The pragmatic investigation approach applied concurrent mixed methods correspondent to the inquiries at different stages; included are qualitative and quantitative analyses and theoretical and design investigations. The theoretical component comprises literature- and case studies that formed the foundation for the design studies, which in turn included workshops conducted by the author in Master-level design studios and a self-tailored design experiment. The design studies utilize common computational design approaches to reflect on their analytical position in the design process. The chapter also incorporates a discussion of the strengths and limitations of the methods, tools and techniques utilized.

Revisiting Common Computational and Parametric Tools

Today, an increasing number of approaches to architectural design rely on information-based systems and computational design approaches such as parametric modeling, simulation, and analyses. "We are learning that computers can work better and faster … and we increasingly find it easier to let computers solve problems in their own way" (Carpo & Davidson, 2017, p. 7). When utilizing computer-aided design approaches with automated form-generation, there is a risk that architects will enter a blind state of sorts and become distanced from reflective and critical thinking about generated design outputs.

The number of architects who have changed their design approaches to computational design continues to rise; this is especially true for architectural practices that work under time constraints on large-scale projects or competitions that demand complex design solutions. A common tendency in such design processes is to use existing source codes, or to utilize a limited number of analytical tools depending on the individual's preferences and knowledge. "If architects do not recognize the underlying logic of the interfaces and displace the given source codes of algorithms to create their own, their work is trapped by a predetermined set of ideas, cultural projections, and aesthetic agendas contained within those interfaces" (Lorenzo-Eiroa, 2013, p. 12). Consequently, software constraints leave architects with predetermined design ideas, and few architects can modify these on their own. Therefore, the indeterminacy of design in such processes leads to various questions, not least design authorship (2013, pp. 19–20). When architects develop customized algorithmic procedures however, or can edit given codes to meet their needs for a project, the generative approach shifts to a more critical and reflective mode of design investigation in which the architect is the author of the form and not the

script. The collaborative platform of parametric and digital tools is a notable advantage here; working in this way enables more deliberate design and allows adjustment and combination of various open-source tools simultaneously in a conscious interdisciplinary mode of investigation.

Research Methods

Research through Design

Research through or by design (RTD) is a mode of scientific and artistic research that is often conducted via design and explorative inquiry (Hensel & Nilsson, 2016, p. xiv). RTD actively and consciously engages design thinking in all stages of research investigations. The explorative process of design research is "interpretive and conditional, at least when design is seen as projection, not production" (Leatherbarrow, 2012, p. 11). RTD is also a means to explore different techniques and tools by which a design is carried out, including sketches, mappings, and more (De Queiroz Barbosa et al., 2014). Design techniques (and tools) in the design practice process are part of research methods for producing knowledge (Morrison & Sevaldson, 2010).

Allowing design research through design practice as RTD does, enables "reflecting on and in action" (Schön, 1984, pp. 49–69) and is related to action research (Kemmis & Wilkinson, 1998). The structure of these approaches allows for simultaneous, progressive and effective development and exploration of investigations. Reflection-in-action is an effective part of the design process in which knowledge is achieved through intelligent action (1984, p. 50), and informed by the knowing-in-action and decisions of the designer throughout the process. The researcher is thus no longer constrained by pre-established theories, methods or techniques, but can construct them anew for each individual case (1984, p. 68) by maintaining a reflective analytical exploration. Design processes with an explorative structure provide systems of implications that constitute a discipline – or break an initially established one – by offering resolutions to a certain design situation or problem. Frequently however, the process of reflection-in-action demands a "stop-and-think" (Arendt, 1981), which could temporarily interrupt the action of design for critical reflections.

Concurrent Mixed Methods

Pragmatic research conducted by the author proceeded via a design approach that combines concurrent mixed methods (Creswell, 2014, pp.

203–225) to develop investigative tools for the design inquiry. These tools and methods were built through critical reflections and systematic analyses. The flexible mixed methods structure allows for adjustments and the application of various techniques and methods at various stages based on the inquiries. Additionally, it enables building dependencies, connections, and interrelations between the various methods used in the iterative design process. Of the RTD methods, pragmatic RTD has the highest significance, using pluralistic approaches to derive new knowledge about a problem and its solution (Lenzholzer et al., 2016, p. 60). Part of methodological pluralism is deriving value from a variety of sources of information (Barker et al., 2016; Barker & Pistrang, 2005). Mixing data is the merging of data or the integration or comparison of the results from two databases (2014, p. 213) to facilitate analytical reflections supporting or contradicting information from different quantitative and qualitative datasets. Mixed methods are used in a pragmatic approach firstly because the diversity of data types is used to form the framework of the dissertation as well as the recursive evaluation of its objectives. Secondly, mixed methods enabled the combination of different design tools ranging from conceptual views and typologies to instrumental measurements and simulations.

Positioning

This dissertation has sought to find a way of working in which the definitions that comprise the theoretical framework for new ways of defining envelopes can be assessed and evaluated using a systematic approach that includes literature and design studies – the design studies using RTD enabled an exploratory approach and the application of diverse methods and techniques. The author actively integrated design thinking in the investigations in order to continuously build the methods needed throughout the process. The methodological steps of the dissertation included formulating the question based on the problem statement and developing various analytical tools for envelope design through:

i. literature studies and the subsequent mapping of design concepts and design approaches studies – in short referred to as concept mappings throughout this thesis (Fig. 5)
ii. the production of a taxonomy of envelopes through a subjective analysis of selected built projects (Fig. 4)
iii. examination of the taxonomy and concept mappings through workshops in Master-level design studios (see Articles 1 and 2 and the workshop reports)

iv. formulating design principles for a selected type of envelope, as well as analysis of selected case studies (Fig. 7)
v. developing a systematic approach for integrating qualitative and quantitative methods in designing envelopes through the design experiment of the PhD project (see Article 3)
vi. proposing a design approach as a possible way of working to design performative envelopes.

The design studies involved two main tools: concept mappings through literature studies, and a taxonomy for building envelopes. These tools facilitated the progressive development of other operative tools such as design principles concerning variations of a selected type of envelope for the design experiments during the investigation. Techniques applied in the design process included: sketching, design thinking through diagrams, mind-mapping, 3D- and parametric modeling, data parsing, computational analysis and simulation, recursive critical and reflective thinking on the outputs.

In this dissertation, the author has attempted to apply computational and parametric tools in design investigations as means to facilitate critical evaluations of the architectural design concepts in early stages of the design process. Computational tools for modeling, simulation, and analysis were utilized to evaluate the design experiments with the aim of illustrating a way of combining qualitative and qualitative approaches. The methods and tools developed encouraged the progressive establishment of the main definitions of architectural envelopes, as reflected in the published articles. These tools were chosen firstly in order to utilize methods that many architectural practices currently apply as analytical means for design assessments and atmospheric visualizations, and secondly, as a way to challenge their current application by linking them to critical thinking and qualitative research.

Mixed – i.e. qualitative and quantitative – methods were utilized in the design studies. As mentioned earlier, the explorative mode of the investigations made possible a pragmatic approach and offered a variety of advantages, e.g. flexibility. One challenge of using concurrent research approaches is resolving the potential discrepancies between various methods and forms of data (Creswell, 2014, p. 214). Finding correlations and interdependencies between different types of data and tools requires that the researcher maintain a critical stance throughout the process. The author thus continually strove to reflect on the tools employed in the investigations and sustain a progressive development and relation between them; an example of this concerns the relationship between outputs of daylight

simulation to evolutionary algorithm optimizations, which led to the decision to use iterative plugins and set up a more flexible structure for the daylight simulation inputs (see Article 3). This demonstrates the experimental efforts in developing individual methods during the process that corresponded with inquiries at various stages of the investigation.

Research Techniques and Tools of Investigation

The process commenced with a positioning of the investigation's focus areas in relation to the problem statement, research question, and the dissertation's definition of envelopes as the core of the design focus. The definition of building envelope interconnected with discussions on the notion of performance in building envelopes that focused on location-specific, climatic designs, and atmospheric and experiential aspects of architectural envelopes. These themes provided the framework for the systematic identification of inputs for the design studies. As mentioned earlier, the investigations resulted in two main operative tools: a proposed taxonomy of envelope types based on the analysis of built projects, and selected concept mappings to the notion of envelopes through literature studies. These tools were simultaneously and progressively developed throughout the PhD project period and facilitated other analytical investigations including case studies, design studies in workshops (see Workshop reports and Articles 1 and 2), and the design experiment (see Article 3). In addition, public presentations and studio-based lectures facilitated further clarification of the arguments and helped position the relevance of the topic to today's architectural practice, thus contributing to the development of the investigations.

Taxonomy of Envelopes and the Selection Criteria for the Case Studies

The taxonomy of envelopes was progressively developed and advanced simultaneously with mappings of concepts and design approaches to envelopes based on literature studies. The case studies, some of which the author visited, were selected primarily on the basis of the author's analytical understanding of the design features of certain projects that could aid in conceptualizing the subjective interpretation of various types of envelopes. Most of the selected projects are internationally recognized buildings or known building typologies. This facilitated analytical insights about their spatial features as exemplary built works for this dissertation's taxonomy of envelopes.

Selected Conceptual Approaches to the Notion of Envelopes Based on Literature Studies

The literature studies included mapping existing conceptual approaches that dealt – directly or indirectly – with the notion of building envelopes. The mappings initially included a more extensive list of concepts that was shortened for the purpose of application in the design process for the studio workshops. Non-discrete envelopes were linked with concept mappings to facilitate building relations and dependencies between types and concepts. The correlation between concepts and envelope types was sharpened further through extensive analysis of the case- and design studies and the design experiment. This led to the selection of a few key concepts in correspondence with the extended threshold, which was the selected type of envelope for the three aforementioned design studies (case studies, design studies, and the design experiment). The deductive process of concept mappings in relation to the selected envelope types was significant in identifying and clarifying the design objectives of non-discrete envelopes (see Article 1).

Case Studies and Design Principles

The case studies were conducted firstly in order to position the exterior surroundings of the built form as criteria for designing envelopes via projects in which this has been successfully done (see Article 2, pp. 7-17). Secondly, these analytical studies attempted to further clarify and conceptualize the dissertation's classification of various types of envelopes. Although the taxonomy of envelopes provided examples of built work to elaborate on interpretations of various types, the selected case studies provided an opportunity for additional analysis of extended threshold types. The investigations focused on extended thresholds, especially in the design studies and the design experiment, because of their spatial articulations and design potentials, which correlate with the dissertation's notion of architectural envelopes. The case studies also facilitated the production of diagrammatic design principles for this type of envelope as a guideline for the design experiment.

Workshops and Design Studies

The taxonomy of envelopes and selected concept mappings were used as tools for design investigations in the workshops led by the author in Master-level design studios at The Oslo School of Architecture and Design (AHO). Students were introduced to the taxonomy of envelopes, concept mappings, and the dissertation's notion of envelopes through lectures. Most of the workshops presented two types of envelopes (extended thresholds and

multiple envelopes) as typologies for design studies, as well as selected concepts that corresponded to the selected types. Typically, the students chose a type and concept(s) that best corresponded to their design ideas and aims and focused on integrating the project into its local context via the envelope articulation. The design studies were beneficial for the investigation in that they identified the main concepts and types, as well as ways of building design-oriented interrelations and interdependencies. One main design question remained unexplored, however. This concerned finding a design process for early integration of qualitative and quantitative methods. The iterative evaluation of design concepts during the design process also remained unexamined, the reason being that each workshop had time constraints concerning the studio brief and student's individual projects. It was in response to this that the dissertation's design experiment was deemed necessary.

The Design Experiment

The predominant aim of the design experiment was to develop a systematic approach to enable the integration of qualitative and quantitative methods in the design of architectural envelopes. The design experiment explored the extended threshold type to design transitional spaces between inside and outside environments. Creating specified intermediary climatic conditions with desired atmospheres was the specific focus (see Article 3 and Fig. 9 & 10). Local climate and site-specific information were important parameters for the explorations, and daylight was considered a central criterion for the creation of different qualitative (atmospheres) and quantitative conditions. Design sketching, mapping techniques, and computational design methods were utilized in the explorative design process to investigate the project's conceptual aims. A range of qualitative and quantitative methods and tools were applied iteratively at different stages to evaluate the architectural concepts using computational parametric modeling and daylight analyses in conjunction with visualizations of the design's spatial qualities – in order to convey and elaborate on the perception of atmospheres. The design process proved an invaluable opportunity to gain insight into setting up and identifying inquiries and demands at various stages of a tailored design process. Among other things, this included: determining the data necessary based on the project's aims; identifying the tools of analysis and simulation and their respective setups; deeming the appropriate types of input- and output data for specific types of analysis and evaluation, as well as facilitating critical interpretation, evaluation and assessment on the analyses' outputs; and identifying dependencies and correlations of various types of outputs.

Feedback on the PhD Topic and Methods

Constructive criticism and feedback from scholars and peers are invaluable to a researcher during the inevitable bouts of uncertainty that strike as regards the choice of methods and ways of conduct at various stages of the investigations. Peer-review comments and feedback offered following public presentations confirmed the project's relevance for the architectural discipline and practice. The dissertation received positive attention for its holistic view of the architectural envelope and the dependency and close relationship between the various stages of the investigation that facilitated development of the dissertation's definition of the envelope (Fig. 3). The author's open lectures in Master-level studios offered an additional opportunity to clarify and refine the arguments and concepts, and the discussions and feedback that followed the lectures facilitated identification of the investigation's strengths and shortcomings at different stages, which in turn helped with planning and framing of the workshops.

Limitations and Difficulties

A persisting challenge throughout the investigation process was maintaining a critical, self-reflective position with regard to the tools and methods developed and the resulting output. While sustained criticality may seem an impossible task, supervisor's comments, public presentations, studio lectures, and comments on peer-reviewed articles proved very helpful ways to recursively reposition and maintain the necessary critical stance.

The tools developed in the scope of this dissertation represent a design thinking approach that was crucial for the design studies. As a generically applicable design approach, however, it is not without challenges. The taxonomy and selected conceptual approaches are limited to the mapped literature and the author's subjective interpretations, and thus remain within the dissertation's range of interest to assure that they will facilitate development of the arguments. However, the framework and method are generally applicable, and the concepts and taxonomies could be developed further by other researchers. In a broader perspective, these tools have the potential to open the possibilities of their applications beyond explorations practiced in this dissertation via alternative propositions of more inclusive shared concepts.

One limitation ascertained during the design experiment concerned the used open source plugins, which are bound by the logic of their developers.

Overcoming this requires that the architect has coding and programming knowledge and is able to perform edits at will and enter an open-ended mode of design modeling and analysis. Due to the time constrains of the project, acquiring these sets of knowledge was neglected by the author. In spite of this, the conducted analyses provided valuable outputs and insights for the design process and development of the research arguments. The applied computational analyses in the design experiment would greatly benefit from being combined with other modes of design or practice-based investigations, e.g. photometric or tectonics analyses, which in turn would provide further insights and facilitate the development of the tools.

Another challenge concerned possible contradictions between the nature of the exploratory design approach and the inquiries in setting up a computational simulation and analysis. The importance of these contradictions can vary depending on the design and tools of analysis. While exploratory design experiments are generally time-consuming and unpredictable, clear settings and restrictions are essential when setting up an informed computational analysis. An informed computational analysis requires a set of restrictions as inputs to limit the range of explorations for certain design objectives; in contrast, a generative explorative approach doesn't necessarily define restrictions for the design analysis. Clear project aims and restrictions to the degree of change in the computational model must therefore be specified.

During the design experiment, significant difficulties were encountered when trying to obtain a coherent, locally-collected dataset for a full annual cycle from on-site weather stations for the purpose of climatic analysis and daylight simulation. The incomplete dataset was the result of technical issues including operative malfunctions and network interruptions; these will perhaps become more efficient with time. Due to issues regarding access to the site, quick, on-site troubleshooting at the weather stations was not an option. The collected data was thus disregarded in the iterative simulation and analysis of the design experiment. This phase also demanded that the author acquire skills in the transfer and translation of data between mediums in order to render possible the input of custom data for the computational simulation and analysis. The skills required included building a good understanding of the components, dependencies, and sequences within the experiment's tailored design process. For instance, data processing – that is, converting raw data into meaningful output, i.e. information – precedes data analysis and includes transferring data from one medium to another, dealing with missing data, identifying possible errors or technical problems (during data collection), handling extreme or confidential data, discovering

relationships (and interdependencies) between data, etc. (Tobi & Brink, 2016).

An interdisciplinary design research team would have greatly benefitted this dissertation's design studies; as incorporating a broader range of disciplines can elicit a deeper understanding of a project's demands early in the design process, rendering the design research process a progressive tool for both design development and knowledge production through the act of design. Contemporary architecture practices must contend with the increased complexities of architectural designs (processes) that result from current cultural, societal and political aspects in urban contexts; many practices have thus begun building different organizational structures in an attempt to resolve complex requirements through an interdisciplinary mode of research and design investigations.

The case studies that were chosen for this dissertation were occasionally questioned during the public presentations of the research material. The selected cases were seen as limited, in particular because of a lack of Nordic built examples to indicate further directions for developing the taxonomy of envelopes. In addition, valuable suggestions were offered about systematic studies of tectonics and materiality as further topics for developing the investigations. The choice of the term *envelope* was questioned – specifically its effectiveness for conveying the intended definition in the dissertation. While the author was cognizant that the term had a number of shortcomings, more satisfactory terminology was not established before the end of the PhD project.

Summary and Discussion of the Chapter

Theoretical studies and design thinking were brought together to help build suitable tools for the RTD experiments. The methods and tools outlined in this chapter were developed progressively throughout the research, and they made it possible to identify the components of a possible design process for non-discrete envelopes. The objective with these tools and methods was to find ways to integrate and assess qualitative and quantitative design aims early in the process. The concept mappings and taxonomy of envelopes are the reflective lens necessary for evaluation and improvement of the design methods. During the design studies, the data collection, analysis, interpretation, and reflections shaped the framework of the iterative assessment and reflective thinking about the design process. The explorative mode of RTD allowed for data mixing in both conceptual and analytical phases by integrating various datasets – here, integration refers to the way in

which the taxonomy and concept mappings were utilized to create an initial structure for the design studies. In the design experiment, the simultaneous integration of qualitative and quantitative data aimed to systematically develop the qualitative (atmospheric) aims of the design experiment through quantifiable measurements to facilitate data comparison and interpretation. These tools facilitated the building of a framework for the exploration in which computer-aided design and analysis was a driving design research method for assessing the validity of the design concepts.

While the tools developed and selected for these investigations proved suitable means to address the research questions, the investigations could have benefitted from analytical physical experiments during the design process. Furthermore, despite attempts to employ such experiments as an inquiry within the conducted workshops, the physical design explorations of individual projects did not progress beyond a simplified analysis of mock-up models in constructed climatic conditions. Nevertheless, the dissertation opens for a number of essential discussions and identifies relevant tools and methods of investigation that could lead to a more specific design approach to envelopes with further development.

4

Reflections and Discussions

Results and Findings

This research aimed to systematically emphasize the spatial realization and local integration of buildings into their settings by rethinking the position of the envelope as non-discrete. This was intended as an alternative approach to the common practices that often lead to discrete architectural envelopes and generic design solutions.

The dissertation critically examined object-oriented approaches to envelope designs that emphasize the independent entity of the building in its local context; instead, it sought to rethink the position of the envelope as a threshold that is integrated into its surroundings. This approach is what the dissertation refers to as non-discrete envelopes, which are subdivided into four types (Fig. 4). The main emphasis of these types is on the spatial construct of the envelope, which offers various sheltered and inhabitable transitional spaces. Their characteristic of correlating, responding and interacting with their surrounding environments lead to predicted and unpredicted changes, including atmospheric, climatic, and programmatic changes resulting from the daily and seasonal encounters of architecture with its contextual conditions. The various spatial enclosures of transitional spaces in non-discrete envelopes create microclimates that enable various possibilities for different patterns of inhabitation and use. The microclimates themselves are determined and regulated by construction materials, spatial dimensions, vegetation, airflow, outdoor climatic conditions, etc. The envelope's spatial construct is decisive for the modulation of comfort conditions through microclimatic thresholds that range from the most exposed to fully enclosed spaces. Fig. 3 represents the evolution of the notion of the building envelope over the course of the PhD project. The final image shows different microclimates of the envelope. The first threshold represents the outermost materialized bounds of the envelope, while the second shows the in-between space articulated by one or several layers of materialized boundary that define(s) spaces with differing microenvironments. The third is the innermost boundary, which acts as the insulating layer for defining the enclosed interior space. The in-between thresholds provide different thermal comfort conditions through architectural design provisions as a result of the architecture's interactions with its surrounding climatic elements and contextual factors.

The non-discrete approach to the architectural envelope provides functions to the urban context of the building that are considered less frequently in contemporary densification policies. Such semi-public spaces can also be incorporated to help address challenges associated with social life in

developing cities by increasing and encouraging opportunities for social interaction and spaces that encourage shared living.

The three published articles address specific themes and areas of focus that progressively build the overall framework of the argument and approach to non-discrete envelopes. The focus of each articles aims to forward the various key notions and discussions, as well as the progressive development of the methods, envelope taxonomy, and concept mappings. The following paragraphs are a critical reflection on the findings, limitations, and shortcomings of each article, and will be followed by further discussions and reflections.

Article 1 positions the notion of non-discrete envelopes through discussions on performance and local specificity. Through these discussions, it also defines and discusses the differences between discrete and non-discrete envelopes. The discussion framework is closely focused on the envelope's role and its effects on interior spaces, and it is subdivided into three thematic categories: (a) Environmental conditioning and climatic design consideration to position interiority and exteriority; (b) Conscious and unconscious architectural experience; (c) Co-authoring performance through flexible design provisions. The themes emerged from literature readings on the existing notion of envelope in the discipline of architecture and the contemporary discourse on performance in architecture. The first two themes were narrowed and developed further through concept mappings, more focused literature readings, and case- and design studies. However, as mentioned earlier, the lattermost theme was eventually eliminated, as including it would require extensive discussions of subject matter that was beyond the scope of this PhD project.

The taxonomy of envelopes and concept mappings were initiated and developed during the research for Article 1. Investigations of the position of location-specific envelopes identified transitional spaces as a necessary design strategy for non-discrete envelopes. The concept mappings were thus categorized and shortlisted into three main groups. The first consisted of concepts that define the spatial notion of the envelope; the second addressed concepts related to surface treatment and material organization, and the third dealt with the flexible use of space upon inhabitation. The selected key criteria and design approaches include the main concepts spatial organization, permeability, layering, spatial continuity, proximity, particlization (see Article 1, p. 31), and transparency.

Article 2 focused on positioning the correlation between the envelope and its exterior environment. The article distinguishes between dissolved and extended threshold typologies by highlighting their differences and similarities. Based on specific case studies, the article suggests design strategies and principles for creating extended thresholds by a gradient of spatial enclosure as the spatial extension to the interior. The studies examine how design considerations can specifically single out an aspect of the exterior and successfully incorporate it into the envelope design. Additionally, they facilitate the identification of architectural elements for the extended and dissolved thresholds, which is usually the result of a mass subtraction of the form to generate a (sheltered) conditioned space; e.g. courtyard, iwan, veranda, or piloti. The workshop held by the author during the development of this article encouraged the preliminary framework of an iterative design process that promoted better understanding of the role of local data in information-based processes.

Article 3 examines the previous findings via a systematic design process that incorporates both the theoretical and methodological aims of the dissertation. The design is focused on simplified, semi-enclosed forms in which the climatic conditions and perceived atmospheres are modulated by local climate and site-specific features in order to examine the dissertation's focus on extended thresholds as the pivotal feature of non-discrete envelopes. The experiment aimed to create transitional spaces using varying thicknesses of and distances between walls to achieve specific intermediary and daylight conditions. The design process included integrating design sketching with computational parametric modeling and analyses (i.e. evolutionary optimization and automatized iterative analyses) for architectural concept evaluation and development. Additionally, the analyses incorporated a qualitatively-oriented assessment by selecting rendered illustrations that sought to convey the perception of atmospheres. Theoretically, the design experiment elevated the discussions on experiential aspects of envelopes whilst also outlining an iterative design framework that integrated unquantifiable design concepts and quantifiable parametric analysis methods.

Challenges and Reflections

Subjectivity, Self-reflection and Criticism

The manner of conduct in this PhD project has guided various steps of the investigations, from selecting methodologies, building customized tools for design, identifying design inputs, interpreting data and critically analyzing

outputs, and formulating a design approach, and it ultimately provided the flexible structure needed for the investigations. The subjective mode enhanced the investigations with deeper insights drawn from personal experience and analytical reflections. However, it also made maintaining a critical distance at different stages somewhat difficult, thus giving rise to questions regarding the superficiality and oversimplification of the developed arguments during the investigation process. In such instances, the various literature studies and mappings of the investigations facilitated complementation with external knowledge to balance subjectivity.

The taxonomy of envelopes is an analytical classification built on the author's architectural experiences of built case studies. The analytical literature studies facilitated the critical assessment of suitable mapped concepts for the proposed non-discrete types of envelopes. While the developed taxonomy could be criticized for being limited to subjective analysis and interpretations, the objective has nevertheless been to guide the design processes of the investigations, which evaluated and elevated the argument. The tools can be utilized for other design studies and investigations as an inspirational guideline that can be developed and customized further upon application.

Reflections on the Notion of Atmospheres and Environment

Isolating certain parts of the envelope to determine which elements of architecture contribute to the creation of architectural atmospheres in building envelopes is a difficult task. Every element of a defined space could also have an impact on the atmosphere of that space. Determining the actual explanatory power of a concept of atmosphere is rather hard, and the notion is possibly simpler than the theory that attempts to explain it. This dissertation attempts to define the notion of atmospheres within the theme of the envelope and define the range of atmosphere's perception through sensory and corporeal experiences. However, these discussions are rather all-encompassing and make it difficult to conclude the dissertation's arguments for the atmospheric performance of the envelope. One way to address this is by positioning the interdependent relationship between the inhabitants' activities and the required atmosphere within the building envelope. Therefore, the discussions in this section examine the interdependency between the inhabitant and the envelope through an analogical analysis of the concept of affordances (Gibson, 2015). In doing so, the arguments aim to identify the criteria that define an atmosphere as conducive to or supportive of particular user activities.

To elaborate the concept of affordances, it is necessary to define the notion of environment and milieu as terms that are commonly used in various disciplines to refer to the surrounding environment of a subject. Spritzer defined the notion of milieu as the "aggregate of influences or conditions which shape or determine the being, development, life, or behavior of a person or a thing" (Spitzer, 1942). Developing this further, Uexküll (1980) distinguished between the environment of behavior specific to an organism (*Umwelt*), the ordinary geographical environment (*Umgebung*), and the universe of science (*Welt*) (1980, p. 11). However, in Canguilhem's view, Umgebung is "precisely nothing more than a [hu]man's Umwelt" because it is "centered, ordered, and oriented by a human subject" and in its value systems (1980, p. 11). This dissertation's definition of environment is in favor of Canguilhem's view and defines environment as that which is relative to the being to which or whom it belongs and by which that being is affected. Just as there can be no organism without an environment, there can be no environment without an organism (Gibson, 2015; Lewontin, 1982, p. 160). Another important characteristic of the environments is that "they are never complete [because they are] forged through the activities of living beings, then so long as life goes on, they are continually under construction [as are the] organisms" (Ingold, 2000, p. 20). A tendency in the contemporary conception of the environment positions it "as a world which, far from being the ambience of our dwelling, is turned in upon itself, so that we who once stood at its center become first circumferential and are finally expelled from it altogether" (2000, p. 204). This is perhaps affected by something to which Ingold draws attention in his attempt at distinguishing the environment from nature, which he does via the differing perspectives between "seeing oneself as a being within a world" (as environment) and "as a being without it" (as nature) (2000, p. 20). Through this, he explains that the world can exist as nature only for a being that does not inhabit it, whereas through inhabitation, "the world is constituted in relation to a being as its environment" – thus, they become two inseparable entities that mutually shape each another (2000, p. 40).

As Ingold reflects on the ecological theory of visual perception of Gibson, within the experience of an environment, "[p]erception is not the achievement of a mind in a body, but of the organism as a whole in its environment, and is tantamount to the organism's own exploratory movement through the world. [The mind] is immanent in the network of sensory pathways that are set up by virtue of the perceiver's immersion in his or her environment" (Ingold, 2000, p. 3). Lévi-Strauss argues that information crosses the interface of the mind and the world, yet it remains unchanged (Levi-Strauss, 1973), whereas in Bateson's account, "the world

opens out to the mind through a process of revelation" (2000, pp. 18 & 9). In Bateson's view, stable features of the world remain imperceptible unless we move in relation to them: "if the blind man picks up surface features of the road ahead by sweeping his cane from side to side, people with normal vision do the same with their eyes" (Bateson, 1980, p. 107). Gibson calls this "a process of information pickup involving the exploratory activity of looking around, getting around, and looking at things" (2015, p. 139). Therefore, the experience of an environment is only possible when an organism is present in it, interacting, impacting, and changing the affordances.

Addressing Bateson's question on the definition of the notion: "organism plus environment"(Bateson, 1972, p. 455), Ingold states that:

> For conventional ecology, the 'plus' signifies a simple addition of one thing to another, both of which have their own integrity, quite independently of their mutual relations […] Indeed the ecology of the textbooks could be regarded as profoundly anti-ecological, insofar as it sets up organism and environment as mutually exclusive entities (or collections of entities) which are only subsequently brought together and caused to interact. A properly ecological approach, to the contrary, is one that would take, as its point of departure, the whole-organism-in-its-environment. In other words, 'organism plus environment' should denote not a compound of two things, but one indivisible totality (2000, p. 19).

The affordances of the environment are what it offers, provides or furnishes to an animal (either for good or for ill); this implies the complementarity of the animal and the environment (Gibson, 2015, p. 119). Both are subjective and objective property, and they both point at the observer and the environment (2015, p. 121). Affordances have to be "measured relative to the animal," which means that their unity is relative to the "posture and behavior of the animal" (2015, p. 120). This being so, they attempt to define a good fit between the animal and its environment. As behavior affords behavior (e.g. what the buyer affords the seller cannot be separated from what the seller affords the buyer, and so on), the perception of mutual affordances between the observer and its environment is based on the collection of stimulus information (2015, p. 127). The observer usually pays attention to what the object affords her/him; therefore, the object's special combination of analyzable qualities (that also characterize the object) is usually not noticeable (2015, p. 126).

The author argues that once the architectural elements and materials, or an object or set of objects, are placed or arranged in space with the intention of triggering a certain emotion, they become, as Kofkka said, "behavioral" rather than "geographical" (Koffka, 1935). He argues that a mailbox or door handle becomes attractive to the subject only when the observer needs to mail a letter or enter/exit through a door. He further explains that when things "tell us what to do with them," they get a character specific to them (e.g. a door handle wants to be grasped, and a postbox invites the mailing of a letter) which he calls the "demand character" of things (1935, p. 353). Reframing Koffka's concept, Gibson states that the valence of an object is bestowed upon it in the experience of an observer's need, meaning that its value is in flux and corresponds to the need of the observer (2015, p. 130). He reflects on the relation of affordances to the demand character of things:

> The concept of affordance is derived from these concepts of valence … [but differs from it in the sense that] affordance of something does not change as the need of the observer changes. The observer may or may not perceive or attend to the affordance, according to his [or her] needs, but the affordance, being invariant, is always there to be perceived … The object offers what it does because it is what it is (2015, p. 130).

This could be compared to a musical piece composed to evoke and color a certain emotion in the listener. This may or not be achieved, depending on the listener's "readiness" and mood at the moment when s/he hears it. This readiness can change, and the listener might experience the music differently each time it is heard. The experience may or may not correspond to the specific targeted emotion; but can nevertheless be within the same emotional palette as the intended emotion. Here, then, the music possesses its own independent character, built by the way each note is orchestrated and arranged – yet, the experience of it differs in various individuals, or even in the same individual depending on time and space.

Atmospheres offer a set of stimuli to their inhabitant that are also affected by the inhabitant's behavior and being-in-the-space. This being so, atmospheres are addressed to humans and are arguably a subset of the human environment. As an environment, atmospheres provide a context in which humans inhabit and perform (act); however, the difference between environment and atmosphere is a structural one. Environment is more inclusive and encompassing, while atmospheres are more specific, and perhaps even adjusted. The setup of atmospheres equips them with set of affordances offered to humans. To borrow Gibson's terminology, these

affordances are both subjective and objective properties of the envelope, and they initiate an interdependent relationship between the atmosphere and the inhabitant. Affordances of the envelope can be regarded as the spatial stimuli that provide a certain mood in the space. The resulting atmosphere must thus not only correspond to the type of activities and functions of the space, but also provide a corresponding spatial ambiance for those activities. An example is a church or a library, both of which have certain atmospheric and functional demands (usually in relation to daylight; see Chapter 2, pp. 39–45), and evoke certain sensations and behaviors. Spatial stimuli are among the most powerful ways to render a space both memorable and comfortable. Commonly, when people speak of the memory of a space that "moved" them (Zumthor, 2006, p. 11, see Article 2, p. 6), or suitably met their expectations, they use adjectives related to emotions to describe the atmospheres of those spaces. This simple indication reflects the role of atmospheric features in accommodating psychological and functional means together by provoking certain behaviors (in relation to functions) and emotions (in relation to moods and ambiance) in the inhabitant. Therefore, as the mediator between inside and outside environments, the envelope allows atmospheres to emerge from the interactions between the two realms and reveal their own spatial entity. Atmosphere affects the inhabitant, and conversely, the inhabitant impacts and changes (at least to a certain degree) the atmosphere.

Reflections on the Tools Developed (Taxonomy and Concept Mappings of Envelopes)

Despite certain shortcomings, the tools developed were important in elevating the inquiries into arguments on the envelope's spatial recognition and performative aspects, and they were effective for systematically organizing the investigations in order to render them operable for the design process. This made customized applicable tools for design studies possible, thus facilitating the examination and development of the methods. Another advantage of organizing information in this way was that it allowed a good overview of the investigations conducted at all times. On a theoretical level, the taxonomy of envelopes and the selected concepts from the literature studies elevate the key discussions in the field to a systematic argumentation on context dependencies and the performance of architectural envelopes beyond their representative functions.

However, difficulties were encountered when it came to examining the distinguished typologies of envelopes through the selected and developed methods in the investigations. The tools chosen for computational analysis of the semi-closed transitional spaces proved informative, but not entirely

sufficient for providing a more accurate estimation of their climatic performance. Another shortcoming of the taxonomy of envelopes that was revealed concerned the difficulty of positioning the proposed design principles for non-discrete typologies in large-scale buildings. These principles are suggestions extracted from the small-scale case studies within which the domain of interest and arguments of the dissertation are addressed. This specifically accounts for extended and dissolved thresholds that can lead to broader discussions on energy regulation and programmatic adjustability in relation to the arguments. Potentially, shortcomings as such could be discussed through a reframing of the envelope elements' functional aspects; e.g. factors of spatial openness in relation to dimension that determine the performance and applicability of the types. Another way to address the questions of principles' scalability could be a partial application of the principles for specific sections of the building. Nevertheless, depending on the building's size, the solution might prove inefficient or undesired. With this in mind, the question is whether the developed tools and design approach examined can be a guideline for inspiration, demonstrating a way to design envelopes for practice and research – despite their shortcomings. If so, who might be interested in using them? Considering their current limitations, what is their range of applicability? One response is that these tools gave students an opportunity to examine, expand and ground their individual design arguments – and determine their potential value for further design investigations – in workshops with the author.

Coupling Quantitative and Qualitative Methods (the Subjective – Experimental – Critical)

Certain challenges in the design process were brought to the fore by the design experiment, e.g. the coupling of quantitative and qualitative methods and discussions. Significant differences in conduct and analysis (including identification, collection, analysis, and evaluation of data) through qualitative and quantitative methods make it difficult to examine one by means of the other.

After defining the framework for the qualitative inquiries, the investigations focused on developing a design approach that could integrate both qualitative and quantitative objectives early in the process of designing envelopes. The approach led to some challenges, one of which was the definition of the design experiment's qualitative goals to allow their further assessments in relation to quantitative aims and the available analytical tools. This required the identification of commonly available tools in practice that

best corresponded to the types of input and output inquiries to suit the quantitative and qualitative goals. In addition, the tools were selected to allow for a goal-based iterative design process whilst also providing means for qualitative and quantitative evaluations. Interpreting these goals was another challenge, and it could potentially reveal conflicts with the tool's inner logic; for example, the degree of light intensity (dark vs. bright) could potentially contradict with established standards. Thus, the simulation had to be set up in such a way so as to enable a certain level of control over the analytic process in relation to the subjective goals. This facilitated the comparison and identification of relationships between various sets of analysis outputs. It should be noted that the experimental nature of the design investigations resulted in unpredictable changes and outcomes, and these in turn led at times to considerable delays or obstructions. Adhering to a schedule during the design experiment was thus only possible through the inclusion of leeway and buffers for addressing unforeseen problems.

In spite of the difficulties and limitations, the examined approach illustrated a way of working that can be an inspiring guideline for a design approach that seeks to bring hypothetical and abstracted concepts closer to reality by examining them with real world (local) data.

Overall Strengths and Shortcomings

Having a holistic perspective to architectural envelopes that strove to include both qualitative and quantitative aspects required a consistently broad view of the investigation, which occasionally made it difficult to conduct rigorous studies on specific aspects (e.g. the resulting atmospheres from applying one selected concept to various types of non-discrete envelopes). Consequently, there was a certain level of insecurity regarding the quality of the investigations that remained a struggle throughout the process. On the other hand, as a subject, envelopes require a holistic view that seeks to find interrelations and dependencies rather than optimizing single features. Focusing on one sole aspect represents a risk, as there is an increased probability that the broader view of the envelope's incorporative role will be lost. Furthermore, the chosen conduct allowed for inclusive discussions through which the dissertation could unfold the arguments necessary to position the notion of envelopes based on theoretical references, observations, and case studies. This was pivotal for the redefinition of envelopes as opposed to façades or building skins and for the identification of essential design criteria such as the exterior environment.

The pragmatic approach of the investigations made it possible to select the most suitable methods and tools of analysis at various stages. This experimental bent occasionally led to delays however, as the development of methods and tools depended on the findings from the design studies and the design experiment. The author's practice-based experience proved an advantage, as it enabled reflection on the investigations that also considered the requirements and expectations of architectural practice. In short, the design studies aimed to facilitate understanding of the requirements for non-discrete envelope design that would enable conscious development of the design concepts throughout the design process. In doing so, fewer significant changes to concepts would be necessary at later stages of the process, during more extensive structural and energy evaluations.

Conducting the design experiment through the developed tools was a key step in advancing the investigations on types and concepts. The design approach also deepened understanding about how the setup of the qualitative and quantitative goals (atmospheric and climatic focuses) must be framed in order to provide an overview of the iterative design process. The author's subjective analytical position on various output types led to setting up the range of inputs to define the desired output domain in the automated iterative process; which incorporates the role of architects into the decision-making processes of automated design setups that are becoming increasingly popular in architectural practices.

5

Conclusions and Future Prospects

Contributions

The approach to envelopes in this dissertation comprises a set of questions and a provocation. The views on the performance of envelopes in relation to their local context in architectural theories are many. Notable views addressed in Chapter 2 of this dissertation include discussions that rely heavily on aesthetic, environmental, and sociopolitical aspects and include a broad spectrum ranging from style preferences and representational features to building regulation-based checklists for energy optimization strategies. These frequently result in what this dissertation refers to as discrete forms that are divorced from their local context.

This PhD project attempted to address the aforementioned issue with a holistic view that redefines the building envelope and its spatial organization as defining climatic and atmospheric conditions for the built space. The dissertation's pivotal contribution is the proposed notion of envelopes that reestablishes the forgotten role of building envelopes as more than a mere insulating material boundary. It also prompts further discussions in the field. The discussions seek to draw attention to the possibilities building envelopes can offer when realized as space rather than as walls that separate inside from outside. The dissertation thus contributes to the architectural discipline by repositioning and reemphasizing the importance and relevance of the topic, which can be considered critically important for contemporary architectural practice and issues related to energy consumption and urban densification. It also reemphasizes the building envelope's capacities to provide the spatial construct for a flexible use of space that corresponds to inhabitants' individual needs and climatic (seasonal) changes. In addition, it proposes using the building envelope as a semi-public (or public when on street level) space that contributes to its urban environment.

The other contribution of the dissertation is made through its proposal for a way of working (by its research through design studies) that enables the application and assessment of the notion of envelopes in a self-tailored, systematic design process. The approach includes possible ways to integrate existing theoretical concepts into the architecture practice, and it illustrates a systematic approach that can be utilized as a guideline for other self-tailored design processes of envelopes. The dissertation's taxonomy of envelopes and concept mappings are tangible outcomes that were essential for the tailored design studies. They offer an initial discourse of the operative concepts and systematic formal typologies within the framework of non-discrete envelopes to the discipline of architecture. The dissertation's design experiment sought to move towards coupling qualitative and quantitative

approaches in architectural design that can facilitate reflections and discussions on critical evaluation of abstracted concepts in the early stages of the design process.

Prospects and Further Research Questions

The taxonomy of envelopes distinguishes two existing approaches in current architectural practices: discrete and non-discrete. Discussions about non-discrete forms' capacity to encourage more social interactions, vegetation, and climatic shelter for the urban realm were incorporated late in the process of the PhD project. These discussions could potentially be assimilated into a larger arena that considers the combined impacts of non-discrete forms on the resulting built urban environment, beyond the building and its street scope; they could also provide valuable insights for studies on urban comfort and social spaces and be incorporated into urban- and landscape design and planning. In addition, in the long term, non-discrete forms would arguably have a lower environmental impact than built forms that rely heavily on mechanical systems because of their climatic design considerations, flexible construct for inhabitation, and their use of in-between spaces. The spatial and environmental impacts of non-discrete envelopes, when seen as the dominant typologies of the built environments, can lead to more sustainable cities in addition to providing more living urban environments.

The taxonomy of envelopes and concept mappings can be developed and utilized as inspiration and recommendations for envelope design processes in academy and practice. The analytical investigations of built case examples can be developed further through in-depth studies of their specific features and architectural elements. In some cases, the scope of these studies could be broadened by thorough comparative analyses of various types that share similar functional and spatial features and design elements. This would facilitate arriving at an enhanced taxonomy of envelopes in which concepts, interrelations, dependencies, and similarities are explicitly addressed and result in more extensive guidelines to assist decision-making about envelope type early in the design process. Another possible path for further developing the notions of discrete and non-discrete could be the investigation of alternative ways to discuss the discreteness and non-discreteness of architectural envelopes. This could also lead to discussions of global vs. local architectural forms through further comparative studies of possible but unfamiliar concepts of local, discrete forms vs. global ones, and global, non-discrete forms vs. local ones.

The developed tools could be developed further through the pairing of specific concepts and types of non-discrete envelopes and extensive iterative studies such as variations on types in relation to concepts, variations of design criteria in relation to determined concepts, or design modifiers (such as variations on size, distancing, orientation, etc.). The findings of this step could then be further examined in relation to the functional and conceptual objectives by redefining the design aims to identify the most influential factors of types and concepts with respect to various design objectives. Such in-depth investigations will facilitate more thorough guidelines for clarifying the relationship between local design objectives and proposed types and mapped concepts. There is a question that needs to be addressed in further research and in these possible paths of development: Is it possible to systematically expand these investigations to provide an explicit taxonomy of envelopes whilst avoiding increased complexity and the convolution of possible interrelations?

The discussions of atmospheres in the dissertation would have benefited from additional elaborations on affect theory, as well as on how various elements of climate, scale, tectonics, etc. can impact the perception and sensational experience of envelope atmospheres. These discussions were beyond the scope of this PhD project and were omitted from the investigations. Relevant sources for further work here are e.g. (Kipnis, 2011; Lavin, 2012; O'Donnell, 2011). The investigations could also benefit from other evaluation tools to complement the applied computational methods in the design experiment, including both digital and analog assessments – e.g. photometric studies of daylight in scaled models of the design experiment. An aspect that was excluded from comfort discussions of the dissertation (and the climatic design discussions of Article 3) is cultural influences on individuals' ranges of tolerance and forgiveness in free-running buildings. This could be investigated and included in extended discussions of climatic comfort and patterns of adaptability in relation to cultural backgrounds.

This PhD project began as an ambitious and passionate attempt to reimagine the position of architectural envelopes and bring them beyond their common role in contemporary practices. Perhaps the motivation was the author's personal curiosity about the possibility of breathing new life into the climatic design strategies experienced in traditional houses in Iran, the living environments of which remain exemplary even today. To arrive at the dissertation's notion of envelopes, the author found it necessary to maintain a holistic and inclusive view throughout the investigations and to avoid a narrow, single framed focus in order to build an understanding of the envelope's various roles via interrelated and interdependent themes of

performance in relation to the building's interior and exterior environments. Having achieved a holistic view on the notion of envelopes, the author considers it necessary to frame directed, narrow focus themes to further investigate specific design strategies and concepts for non-discrete envelopes.

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Appendices

Reports

Master-level design studio workshops:

Performative Envelopes Workshop Report
Interactive Envelopes Workshop Report
Productive Landscapes Workshop Report

Case Study Trip:

Inverted House Study Trip Report

R1

Performative Envelopes Workshop

September 28th – October 9th 2015

RCAT | ACDL Studio, Fall 2015
The Oslo School of Architecture and Design

Studio Tutors:

Prof. Dr. Michael U. Hensel
Asst. Prof. Søren S. Sørensen
Asst. Prof. Joakim Hoen

Abstract

This report describes the Performative Envelopes Workshop, which was conducted as part of the RCAT |ACDL Master-level studio at AHO - Oslo School of Architecture and Design, from 5th to 15th October 2015 as an integral part of the author's PhD research. The workshop was preceded by one week of design preparation and followed by a week of post-production. The workshop aimed at producing scaled models of part of the envelope systems that students designed in teams in response to the studio brief and project.

The report outlines the process of the specific development of the architectural envelopes that define the different schemes, and describes the contributions and limitations of the process for further development of the approach and methodology in connection with the author's research project Envelope as a Versatile Organizer of Space. The research investigates and seeks to redefine current notions of building envelopes based on a performance-oriented approach that transcends prevailing understandings of building envelope performance through related case studies and experimental design of small-scale projects.

RCAT | ACDL Studio Fall 2015 Studio Brief "Performative Envelopes - Rethinking Architecture from its Boundaries"

The studio brief asked for the design of a small building for two sites: first it would be positioned in Skansen, as a pavilion for the Oslo Architectural Triennial (OAT) 2016, and then on the island Langøyene, as an environmental research center/information pavilion that addresses the issues of landfill and pollution on the island. By addressing two sites, the design approach locates itself between the positions of the universal prototype and the one-off, tailor-made proposal for a unique site. This mobility and specificity within a range address the theme of the OAT 2016: "After belonging." The studio utilized the theme of multiple building envelopes as a means with which to organize space and to modulate the environment, and continued its investigation into the data-driven context-specific computational design. One team set out a design system consisting of a climate enclosure made of a range of transparent materials and an outer envelope from textile membranes that modulate the climate in the transitional space between the two envelopes, as well as that of the enclosed interior. In each case, the design system was arranged so as to meet programmatic requirements and associated interior climate demands, and was subsequently further elaborated based on computational analysis, and

environmental data measured on-site, as well as on data collected from scaled physical models.

Introduction

The form and language of architecture reflect cultural change and contemporary technological innovation and are thus constantly in flux. Today, many envelopes are constructed in layered structures and systems to fulfill environmental and sustainability requirements. This dominant approach often amplifies the division between the interior and the exterior. Many of the current built examples display globally generic features and are often not closely informed by the local context. The Performative Envelopes workshop attempts to draw attention to the importance of rethinking design approaches to envelopes by emphasizing the relationships between architecture and their setting.

The proposed expanded notion of the architectural envelope implies a spatial zone beyond the physical boundary and includes both interior and exterior spatial extensions that make specific provisions for inhabitation. This can also include interstitial spaces between multiple layered building skins.

The author's literature research regarding the articulation, as well as climatic and atmospheric performance of building envelopes, resulted in operative maps that were used in the workshop: [i] a Taxonomy of Envelope Articulations; and [ii] conceptual approaches to the question of the Architectural Envelope. The students selected and applied the envelope concepts and types to their designs with the aim of articulating the envelope as a threshold that provides the conditions required by their projects. The author's aim with the workshop was to examine the applicability of the approach and methods and identify their potentials and limits for further development throughout the PhD research.

Workshop Themes

Envelopes and Textiles Structures

A building envelope is typically understood as the outermost covering that generates a character, identity, and resonance for the built form, as well as providing it with functional aspects and qualities. In the workshop, the envelope was approached as a threshold that encompasses various tasks from expressive, communicative, figural, visual and aesthetic qualities to

environmental, material and functional ones. Therefore, to approach an integrative design strategy, it was necessary to consider a synergetic approach in which interrelated performances could be addressed. This was pursued through an iterative design approach and process.

A large number of structures and architectures from antiquity are usually characterized by massive constructions that primarily used solid materials like stone, brick, and wood. The resilience and durability of these structures limited the dissemination of lightweight materials such as textiles and confined to decorative elements or temporary forms of shelters like tents or mobile structures. The choice of multiple envelope configurations and textiles as a material for one of the layers was given by the studio brief. Students were asked to utilize a membrane structure as the outermost layer of their project design. The multiple envelope typology is among the types of envelopes that approach architecture in the manner of creating non-discrete architecture (Hensel, 2013, pp. 31–43) through their various layers of material arrangements. There are many examples that address the built form in this approach to some extent are Wall House by FAR, the winning unbuilt scheme for the Venice Cinema Palace by Steven Holl, Le Fresnoy by Bernard Tschumi, Maison à Bordeaux by OMA, to name a few.

Non-discrete architectures integrate with and correspond to their local conditions and surrounding environments through their design strategies and considerations. Multiple envelopes entail layers of building skins in various proximities. Positioning and proximity along with the material properties of these types of envelopes create in-between spaces that are often inhabitable, and through them the transition between enclosed to open space turns into a staged spatial progression. The use of textiles adds material properties such as transparency, translucency, and permeability to the ways in which interstitial spaces can be climatically modulated.

Envelope Performance and Location-Specificity

The research addresses envelope performance by establishing a specific and varied relationship between the building with its milieu.[1] One way to establish a context-specific design is by foregrounding its climatic performance. This includes the application of environmental factors not

[1] Marcellin Berthelot (1827-1907) defined *milieu* as the "element surrounding a given body;" and Auguste Comte (1798-1857) expanded the definition to "the total ensemble of exterior circumstances […] upon which the existence of a given organism depends" (Spitzer, 1942) – including both the organism's surrounding physical world and the external conditions essential to its existence. For further readings on the distinction between *Umgebung* and *Umwelt,* see von Uexküll, J. (1909). *Umwelt und Innenwelt der Tiere,* Julius Springer: Berlin. pp. xv.

only in regard to the spatial and programmatic requirements, but also by highlighting the presence of the milieu through the material exigencies of the built form. This includes the choice of material organization and properties in response to climatic design considerations determining the relationship between interior and exterior environments and incorporates the programmatic demands of the building. The integration of local climate, contextual and spatial information along with material specificity are essential parts of designing a synergetic system that redefines the position of envelopes in establishing local specificity of the built form.

The Design Brief of the RCAT | ACDL Studio – Fall 2015

The theme for the RCAT | ACDL studio in the 2015 fall semester was Performative Envelopes - Rethinking Architecture from its Boundaries. As mentioned above, the brief asked for the design of a pavilion for two different uses and locations: first, as a pavilion for the Oslo Architectural Triennial 2016 in a central location in Oslo during the summer and autumn months; after its relocation, the project would be used as a small environmental research laboratory located on an island with a large toxic landfill area in the Oslo Fjord. The pavilion was to use multiple building envelopes, aiming to articulate a heterogeneous space offering different degrees of enclosure and environmental modulation for various types of activities related to the program of the pavilion. The focus was on the detailed material articulation of the building and its site and season-specific environmental performance. The size of the project was circa 100sqm of fully enclosed space, and 50 to 100sqm of transitional space. The different zones of the pavilion – enclosed and open spaces, dark and bright zones – were to be articulated by the building envelopes organizing the space and its environmental modulation by the specific activities housed by the project. The outermost layer of this multi-layered envelope was specified as a textile membrane skin.

The Workshop's Objectives and Expected Outcomes

The Performative Envelopes workshop was held mid-semester, when the students had arrived at a preliminary design with detailing appropriate to the 1/100 scale. The workshop was aimed at the development and analysis of a selected part of the envelope with focused performative aspects to test and evaluate design ideas. This entailed an iterative design process that commenced with the choice of a particular envelope concept and progressed with recursive modeling and analysis. The analysis results and their degree of success in fulfilling the intended goals determined the

number of iterations required for further investigations in group's projects. The iterations employ a closed loop, starting with conceptual approaches that develop through their corresponding analysis until the design's intents were met and a satisfactory result was achieved.

The focus of the studies was to evaluate the scheme's effectiveness for meeting various spatial and functional intentions through the specific articulation of the envelope system. The workshop intended to provide students with a good understanding of an iterative design process and give them relevant knowledge, tools, and skills to test and develop their designs through reflective thinking. The computational data analyses of parametric models and environmental data-collection through custom-made measuring stations were conducted simultaneously and included scaled physical models to elaborate on the design intentions and clarify the properties of the material systems, as well as computational modeling and analyses of the interaction between architecture and the environment. The outcomes included: (a) a detailed design demonstration of the envelope system through a scaled prototype, (b) a parametric design model with conducted digital analyses (c) visualizations of the findings from both the physical and digital analyses.

Students were asked to examine their designs with attention to the view, light, and climate, and to develop their design concepts by focusing on one particular performative aspect (for instance light), and one material strategy (such as the textile skin in relation to other material layers). The workshop focused on exacting the work balance between both physical and computational domains, and later, on tools and materials by which the designs were developed.

The Workshop Outline

Aim: Full-scale fabrication of a part of each team's designed envelopes in ACDL studio, Fall 2015.
Process stages and time plan:

- Phase 1: Concept development of the selected part of the project, specifications, and aims
- Phase 2: Includes various dependent stages of an iterative design process that includes design development and modification, material organization, digital modeling, simulation, and analysis, detailing, fabrication and construction

- Week 1: Phase 1 and start of Phase 2
- Week 2: Completion of Phase 2

The Process: Concepts, Feedbacks, and Reflections

The preliminary week started with building mock-up models of each team's envelope designs. During this week there were several related literature readings and discussions undertaken to clarify the theme of envelope performance and local specificity in architectural design. Parallel to these was a studio lecture held by the author that dealt with examples of physical model experiments and built projects of various scales to provide insights on possible challenges and to familiarize students with the examined approaches to these themes and focuses.

All three teams chose daylight as the environmental factor that would operate to produce effects and conditions in various ways in their designs. The design intentions for creating specific atmospheres led to the teams' conceptual diversity, design processes, and outcomes. The importance of material organization in achieving each team's particular environmental and atmospheric concepts became apparent early in the first week of the workshop. This led to various investigations of digital, visual and physical data collection and analysis, with the aim to define the ranges through which the desired conditions could be achieved. The selected parts of the envelopes were developed with a focus on climate, structure, interactivity, flexibility, and questions regarding scales and spacing aspects in accordance with daylight. Each design was thus informed by multiple criteria.

The contribution of the workshop to the research was to evaluate the aforementioned mappings as operative tools for the design. The method practiced during the workshop elevated the research approach, testing how

different envelope concepts and types can be coupled with specific design methods and various methods of collecting data. The short duration of the workshop placed a clear limit on the number of iterations by which the designs could gain a higher resolution in their local specificity and performative aspects.

Design Methodology

Developing a performance-oriented design system and method made it necessary to address the integration of different conceptual approaches. This included, in particular, the articulation of Multiple Envelope arrangements. The design teams developed their conceptual approaches through aspects such as spacing of layers in relation to the required space and desired climatic conditions relative to daylight. The iterative process included various stages such as explorations of materials' properties, digital simulation and analysis, structural engineering, and fabrication detailing, all of which were correlated. The findings and outputs of each design stage and their interrelations informed the further modifications and adjustments of the process to achieve the intended performance for the designed envelope system. Figure 1 shows the workshop's design process diagram.

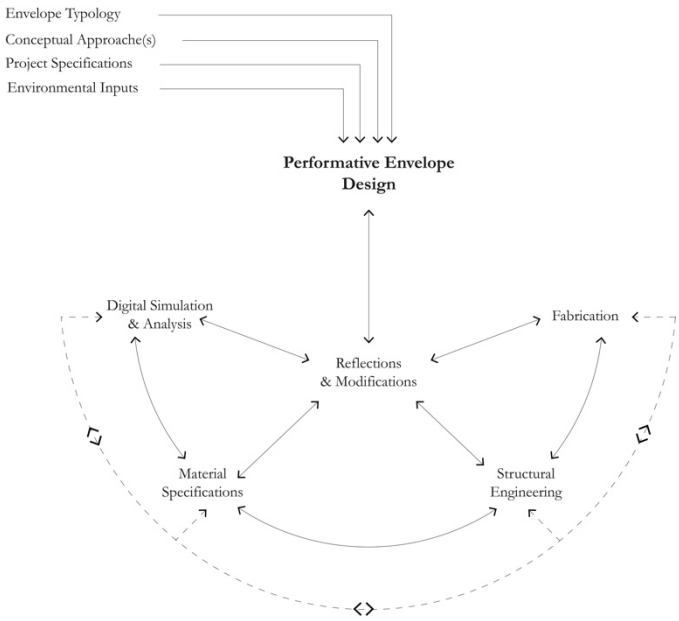

Figure 1: Design Process in the Performative Envelopes Workshop, ACDL Studio, The Oslo School of Architecture and Design, Fall 2015.

The Foci of the Teams (Mutual Investigations and Terminology)

The teams shared some key terms, such as orientation, Umwelt, milieu, and active/passive agency. All three projects addressed scaling, spacing, and structure as design considerations and inputs for developing the intended performance of daylight.

One of the main objectives of a built work is to generate a new identity, not only for the site in which it is located, but also for the context. Nevertheless, "[a] successful work is always part of and apart from its location." (Leatherbarrow, 2009). Auguste Comte (1798-1857) broadened the definition of the French term milieu by incorporating not only the physical environment that surrounds an organism but also the external conditions needed for its existence(Cuvier et al., 1969, pp. 2–3). It therefore seems necessary to distinguish between the general surrounding (Umgebung), the subjectively perceived environments (Umwelt) – and the relation of the living organisms to their environments and their topography (Leatherbarrow, 2005, 2015). This topic was approached in various ways in the workshop and in accordance with each design's multiple envelope specifications. Considerations of the park as the context of the pavilion in relation to inhabitants of the chosen space of the project as the active agents gave rise to interesting perspectives and factors in each team's design projects; these were included in the process not only from the early design configurations, but also as an emerging quality enriched by the process itself. By proposing two different sites in ACDL's project brief, the notions of orientation and communicative topography in architectural design come to the fore as driving themes within multiple envelopes as the primary constituent element of the design projects.

Team One[2]

Team One's selected space is a semi-open room that accommodates a reading- and workshop zone for the pavilion in which the seasonal transformation and changeability of the exterior's environment create a high dependency between the room and its exterior climate. The multiple envelope layers of this room include both horizontal and vertical material arrangements that consist of two arrays of louvers as the surrounding walls and a lamella structure shaping the roof as the room's boundary definers.

[2] For further project descriptions and information about the student teams, see (Saeidi Derakhshi, 2017, pp. 21–24).

The room's roof uses the park's existing trees as its outermost layer, which meets and filters the daylight before it reaches the roof's lamella structure, which constitutes the second layer. In the summer and autumn, the varying distances of the ceiling lamellas and the leaves of the trees provide layered visibility of the sky, modulated with fresh air and ambient light. The refracted sunlight from the trees and the lamellas creates a forest floor sensation on the sloped pathways of the room's floor. The pavilion not only reacts to its surrounding landscape by embracing the existing trees as an essential layer of its multiple envelopes' structure, but also by camouflaging its presence within its surrounding environment through the reflective glass plates of the pavilion's outermost envelope. This semi-open threshold is defined by two arrays of glass louvers; although these function together, each has a setup and design concepts of its own. The first series of louvers consists of twisting, sensor-based, mirrored glass plates that adjust to the direction of the sunlight throughout the day. This outermost layer reveals or conceals the exterior presence of the pavilion by the louvers' response to the sun's rays while allowing various degrees of brightness and visual presence in the interior. The inner array consists of enclosing smart glass louvers with varying levels of transparency, the opaqueness of which alters and adjusts to the proximity of the visitors. The distance between these two layers of louvers is defined as a transition space by a single 110-centimeter wide walking path for observing a filtered reality in-between the interiority and exteriority.

During the workshop, the light effects were tested by building mock-ups in various widths and simulating the sun hours by artificial lighting to observe and document the light and shadow interplays within the room. Based on comparative studies of sequential photographs taken from the physical simulation, the most desirable width was chosen in accordance with the indented spatial effect, which was built and tested in the larger scaled model in the second week of the workshop. Nevertheless, these studies were limited and arguably even inaccurate, as many vital factors are lacking in a built simulation of an environment. The glass lamella concepts were difficult to test because of issues with the cost and accessibility of a small purchase of the glass plates for the workshop's mock-ups. Students thus chose Plexiglas and reflective tapes to test their design ideas. Although this prohibited the test of transparency and opaqueness concepts, the louvers' interactive design concepts could be addressed and tested sufficiently. These tests included the sensor-based setups and light analysis of the interactive

twisting glass arrays that were scripted in Processing[3] and texted by Arduino-based[4] motion and light sensors. Parallel to the physical tests and measurements, the parametric model of the design was also simulated and analyzed to measure the daylight hours and radiation surface gain of the envelope's layers in Ladybug, which is a Grasshopper plug-in.[5]

Team Two[6]

Team Two approached the pavilion design as a continuous space and therefore developed an overall design for its multiple envelopes system. The design sought to manipulate the park's topography as the organizer of the pavilion space by designing an open plan arrangement and a dynamic section to active the terrain of the project. The team's design process was highly engaged with an experimental, reflective mode of investigation through a synergy of hand sketches, structural mock-ups, and parametric sketch models.

The pavilion consisted of two membrane layers that formed roof and floor structures and were held by many slender columns. The project embraced its milieu by its formal expression of abstracted trees and by elevating its light membrane from the terrain that becomes the floor level of the project. The emerging spaces beneath this lifted floor shaped long vistas across the park, and the grid structure of the columns resembled a forest submerged in the surrounding trees. Using distancing and proximity as the main envelope

[3] *Processing* is a flexible open-source software sketchbook and a language for learning how to code for the visual arts. It is a programming language, development environment, and online community. Since 2001, Processing has promoted software literacy within the visual arts and visual literacy within technology. Processing uses various interfaces such as Python, Ruby, JavaScript, ActionScript, and Scala, and is continually being developed. The software is credited to their dedicated developers and supported by various sources, the links to which can be found at http://py.processing.org (processing website).

[4] *Arduino* is an open-source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

[5] Ladybug is a Grasshopper plug-in that enables importing and analyzing standard weather data by drawing diagrams such as sun-path, wind-rose, radiation-rose, while providing the flexibility for customizing the visualization of various analyses like radiation, shadow, and view in different ways. Grasshopper is a graphical algorithm editor tightly integrated with Rhinoceros 3-D modeling tools. Rhinoceros is a commercial 3D-computer graphics and computer-aided design (CAD) application software developed by Robert McNeel & Associates. Unlike RhinoScript, Grasshopper requires no knowledge of programming or scripting, but still allows designers to build form generators from the simple to the complex.

[6] For further project descriptions and information about the student teams, see (Saeidi Derakhshi, 2017, pp. 24–27).

design concepts, the team adequately established the intended relations between the project's membranes and the terrain that provided various zones in the pavilion's open plan. The open-plan structure allows the integration and interconnection of the semi-open interior space to its wider surrounding exterior through its design considerations of materiality and openness. The differences in height between the two membrane systems that form the floor and the roof of the project result in an intriguing spatial flow and disparity that provide various zones that affect spatial ambiguity, visual openness and flow within the space. The adjustable modules of the roof's membrane provide the necessary flexibility to condition the space in correspondence to inhabitants' needs and based on the different use of each zone. These flexible modules provide the needs for light regulation, air ventilation, and atmospheric adjustments. The lower leveled openings allow or limit views to the surrounding environment, while the higher ones can provide ambient light or facilitate better ventilation.

The team realized and tested arrays of one single patch logic within an assemblage through physical and computational models. The tests included how factors on scaling and distancing affect collective and individual behaviors in the overall system. The examinations resulted in the structural logic of a regular grid system taking into consideration the material system and lighting needs of the pavilion while addressing ways of further developing the system into a more complex network of various scales and geometries. Although the team used Karamba structural analysis and physical models for testing the structural logic, the difficulties in utilizing force factors of various behavioral patterns of visitors for the floor membrane remained unresolved and limited to design assumptions. However, the roof structure results were adequately addressed and analyzed for light penetration, radiation analysis, and identification of static and adjustable patches based on the room's zoning and programs. The team worked on the detailing of joints considering the visitor's physical interactions in determining and changing states of patches' openness for light penetration through adjustable fabric-patches. The investigations also took water runoff into account.

The two layers of the grid, with various material properties, seek to interweave and form a unified structure that behaves collectively through tension and compression elements. The material proposals for the roof's patches are PTFE-coated glass fiber fabric and frosted Plexiglas. The team members thus tested the prototype with various elastic textiles of different thicknesses and both sandblasted and transparent Plexiglas of varying colors and opaqueness. The tests were aimed at comparing the degrees of light

penetration and the quality of the ambient light. Like Team One however, this team also faced difficulties when it came to building a reliable environment to measure the prototype in outdoor conditions. The model was placed in a bounding box that was open on the top and on one side to capture sunlight and tested several times with various materials. The choice of materials for these tests deliberately ranged from colored and opaque materials to transparent and colorless ones. The outcomes of this investigation indicated a good range of differences in the collected data sets. These findings led to the conclusion that for a valid analysis that can be applied directly in design iterations and decision-makings, the accuracy of a modeled environment must be in accordance with the data collection's precision.

Team Three[7]

Team Three's approach within its milieu was close to that of Team Two in terms of distancing from the ground; the difference lies in how the distance formulated and defined spaces for the project. Team Three specifically allowed the project to gain distance from the ground and allowed people to either only pass from under the pavilion's structure and outermost layer, or relied on the individual's will to enter it. The form is a small triangulated machine that glows at night because of the light sources placed between the multiple layers of the envelope, softened by the membrane layer to provide an ambient light inside, and glimmering from the perforated steel plates of the outer layer. The quality, intensity, and strength of the light shining through the steel panels – both the daylight entering and the implemented lights between the envelope layers that shimmer at night – is highly dependent on the spacing and distance between the two layers of the envelopes. The emerging in-between space varies in depth and provides enough spaces to be illuminated or to be inhabited and house various functions and activities.

The tetrahedron geometry and its stacking strategies provide a flexible structure that sets up the main space of the pavilion with enough flexibility to generate rooms of various sizes and enclosures emerging from synchronization of material organization, varying heights of structural arrangements, and spacing between the layered envelopes. The qualities of interior spaces emerge directly from the wrapping the tetrahedrons by fabric or metal sheets, or by simply leaving them bare. These structural functions

[7] Students: Jorgen and Milja Malika Tuomivaara.

of the frames also have redundancies that simultaneously result in added potentials and opportunities for spatial variety and functions.
The geometry of tetrahedrons creates small reading or resting pockets within the envelope for individuals to inhabit once it is open on one side, and structures that close or open the views differently, thereby directly affecting the quality and lightness of the rooms. In this pavilion, the role of the actor in modifying the spaces by rearranging the envelope's setting is a less noticeable concept than in the other two projects.

Discussions and Further Development

A Research-by-Design PhD demands an active, design-based engagement of the research throughout the allocated timeframe during which the researcher needs to sharpen her design research skills while building a strong theoretical and methodological foundation. This inquiry might increase the risk of the design component of the research falling short of the necessary objectives and developments for the design-based questions of the research. Therefore, I believe the strategy of combining teaching and research – conducted here in Master-level studio workshops – has been an essential component in the development of my research project. Engaging students in the research investigations resulted in a greater range of design outcomes within a short period of time from which the research benefited greatly in terms of developing its arguments and discussions. The duration of these workshops varied from 2 to 4 weeks, depending on the design stage of the projects, and there was one workshop held per semester in the first three years of my research project. A strong advantage of conducting these workshops on a regular basis was the constant design feedback and the diverse outcomes it generated for the PhD research. Apart from using the workshops as a testing ground for developing the methodologies, the constant variety of tangible outcomes provided a steady pace for developing the reflective and critical thinking aspect of the research project. This bypassed the common tendency of building theoretical and conceptual aspects of the research on assumptions and hypotheses instead of substantial design arguments.

The developed methodology utilizes the extensive literature studies of the research in order to build applicable tools for teaching purposes. These tools were then actively applied in intensive workshops to direct the design process. The theme-based workshops were closely arranged in a way to meet the interest topics of the research in relation to the studio's design project briefs of the. Several related lectures were held within the workshop period to ensure the clarity of the terms and concepts of the research that

were applied through methods in the workshops. The applied methods are progressive tools of the research, developed as part of the literature studies and critical thinking throughout the research period. The teaching-based research/research-based teachings built a mutual platform in which both the teacher and the students played a role in identifying and developing the components of the research by design process through analytical and reflective discussions.

The computational analysis and collected physical data within each group identified the inaccuracy of the measurements in exacting the operability of the design concepts. Nevertheless, the comparative reflections on the simulations and measured tests delivered reliable outcomes from which the design process gained a good understanding of the design contextual conditions. Although the collected measurements were constrained by the limitations of materiality and scale, the examined design process gave students an understanding of an iterative design process and the tools and methods needed for data collection, data processing and analysis, and reflective thinking. The recursive discussions in the workshop on the reliability of the various collected data sets clarified which type of data should be paired or paralleled with the other types at which stage to provide the information needed for different choices in the design modifications. The reflections and data comparison during the design process facilitated the abovementioned findings above on the strengths and weaknesses of the method. The PhD research investigations aim to further develop the workshop's examined methodology by filtering the mappings of Envelopes' Conceptual Approaches based on their level of effectiveness with regard to the theme of performance on which the research has focused. Furthermore, the investigation seeks to further elaborate on the mapping of Envelopes' Taxonomy to present an explicit definition of non-discrete architectures and its subcategories.

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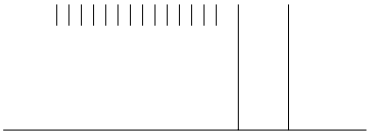
Appendix

Design documentations of the teams' projects in the following pages, produced by the team members of individual projects.

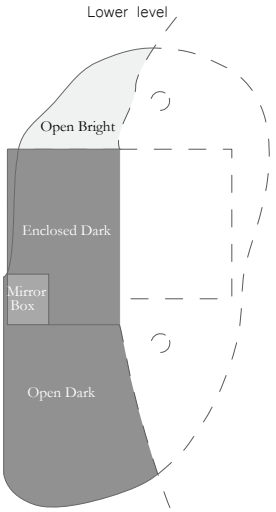
Team 1
Team 2
Team 3

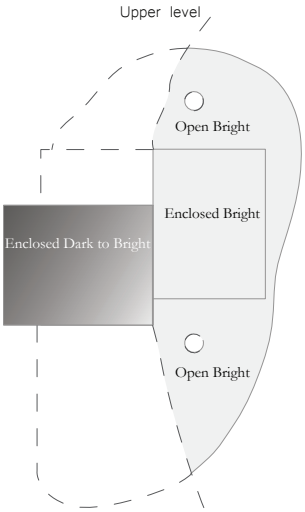
Team 1
Conceptual Approach -
Design Documentation

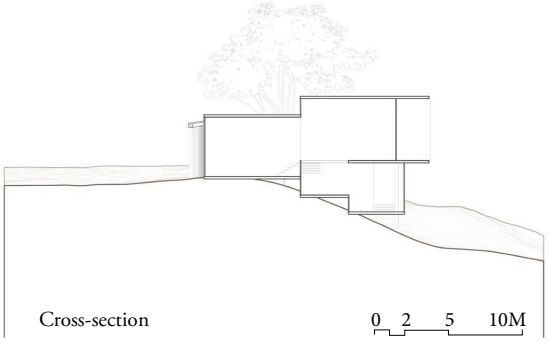


Diagramatic Organization of Envelope Layers

Enclosure/ Exposure Diagram

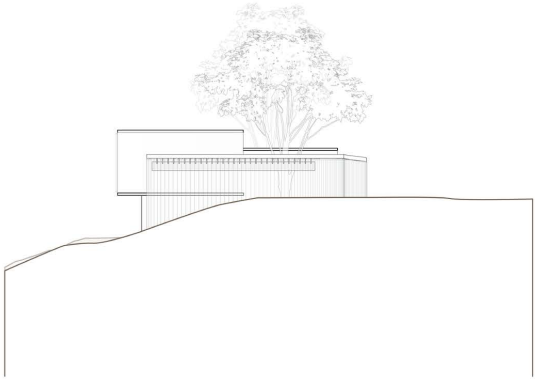




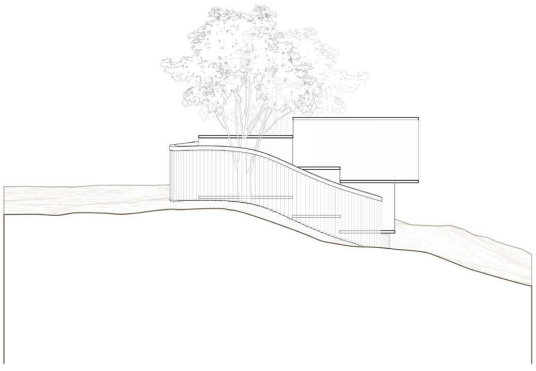


Cross-section

0 2 5 10M



South elevation



East elevation

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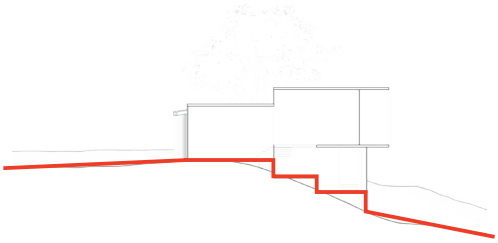
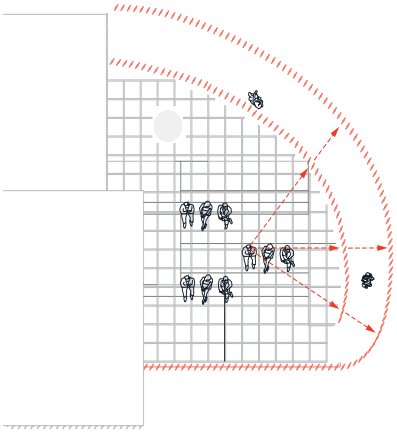
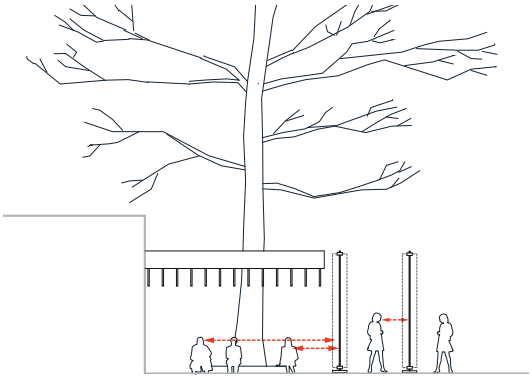
Team 1
Design Approach



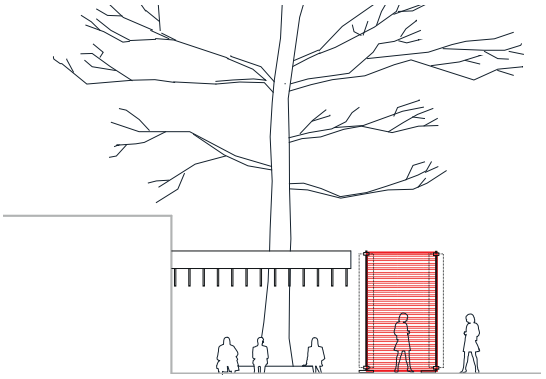
Relating to *Umwelt*: Orientation through variations in height and embracing the existing trees of the surrounding context



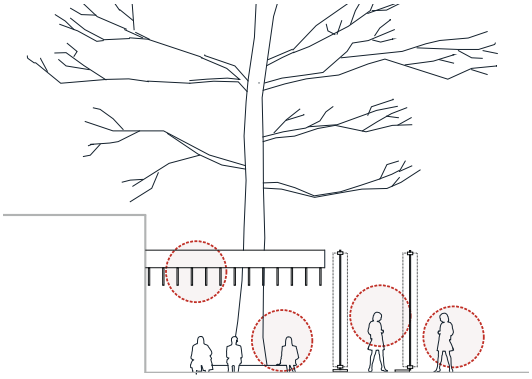
Using spacing and proximity, gradients of reflections and visibility, and degrees of enclosure to position the inhabitants within the space →



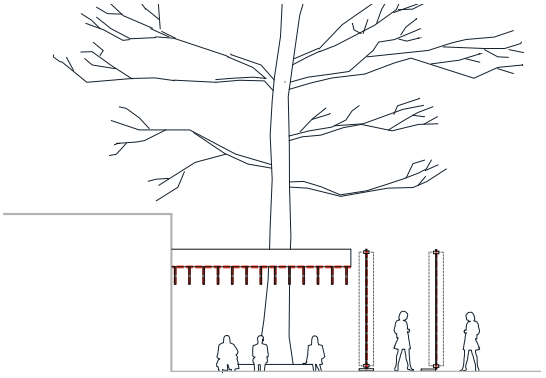
Distances and proximity to the kinethic elements affects the visibility and perception in the space



Transitional spaces/ In-between spaces created through the distance between the two layers of louvers
The kinetic set-up is inspired by the notion of Breathing walls



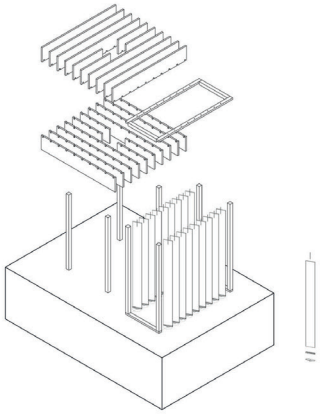
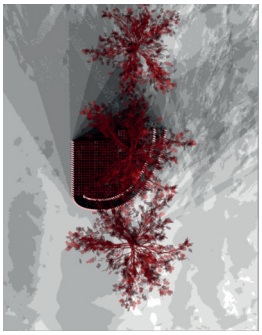
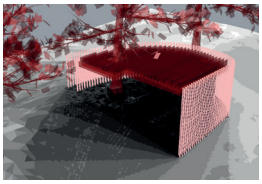
Creating various atmospheres and spatial conditions through degrees of enclosure, relativity, and visibility

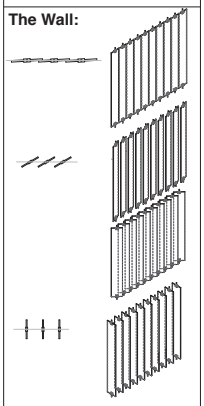
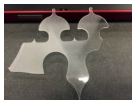
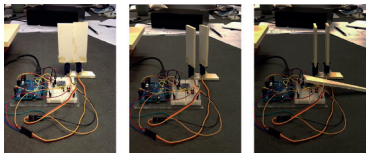
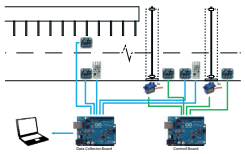
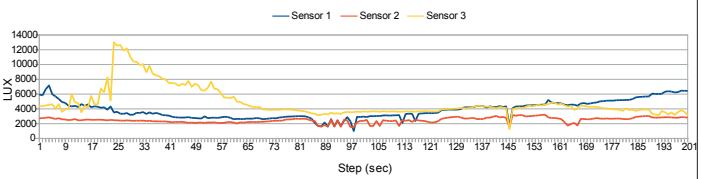
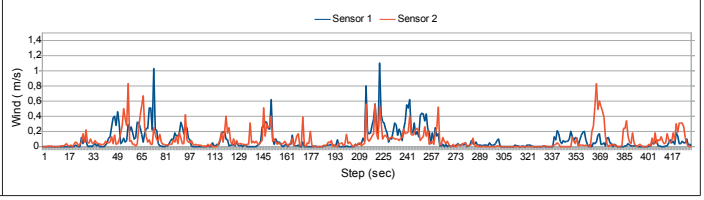
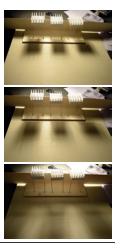
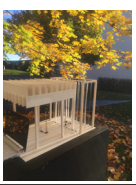


Static and movable elements of design inspired by “Device pradigm”

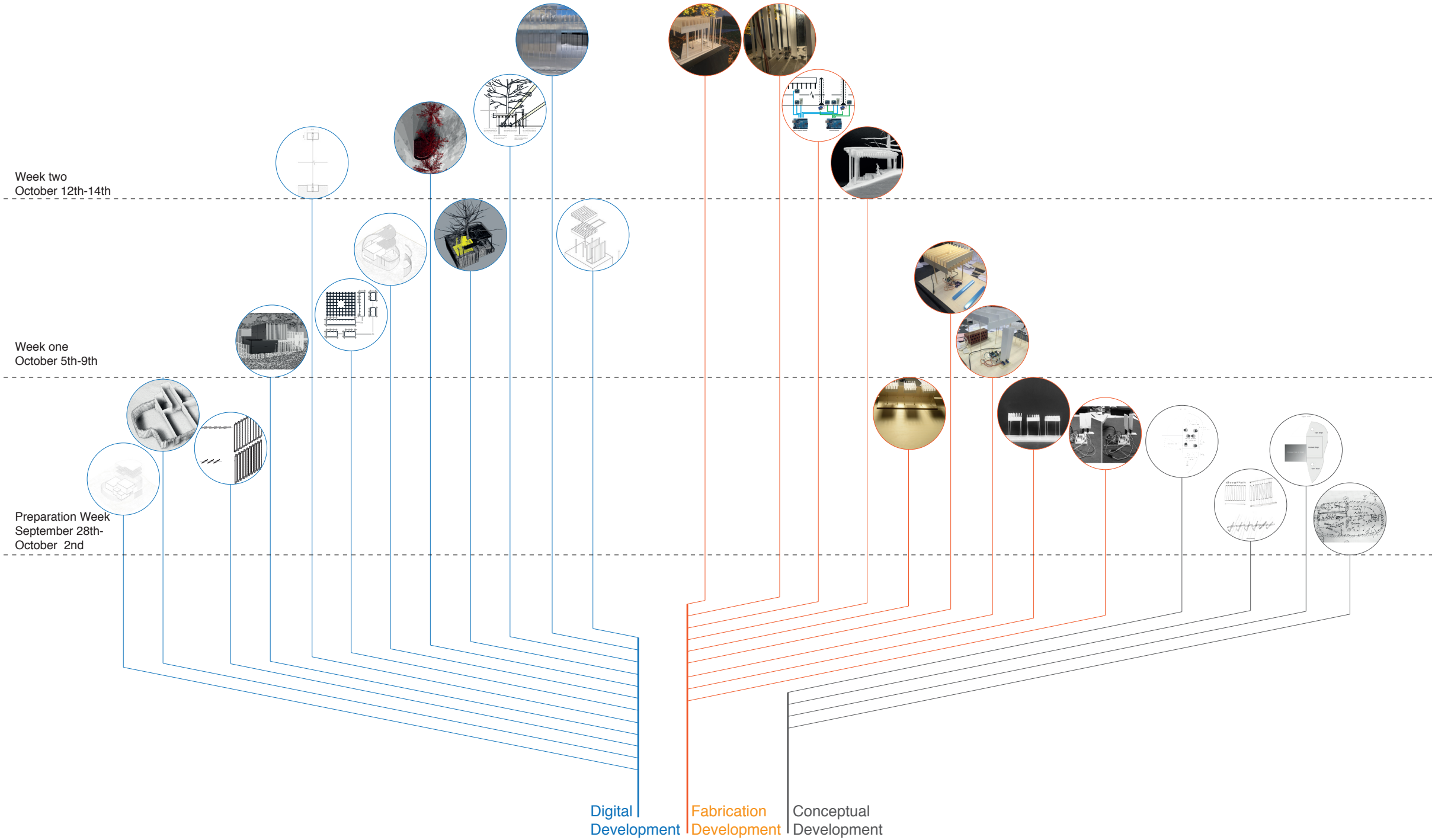
Team 1

Prototype's Simulation and Light Analysis

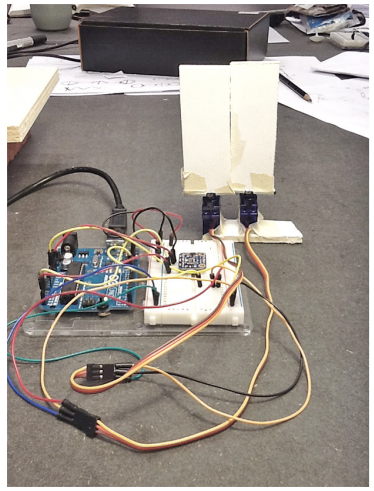
The Design Systems's ANALYSIS (Radiation & shading analysis through Diva – Rhino plug-in)	**PANELS' POSITION**	**MATERIAL SPECIFICATION**	**SOLAR RADIATION ANALYSIS**	**RADIATION (kWh/ m2)**	**DESCRIPTIONS & REFLECTIONS**
			 		

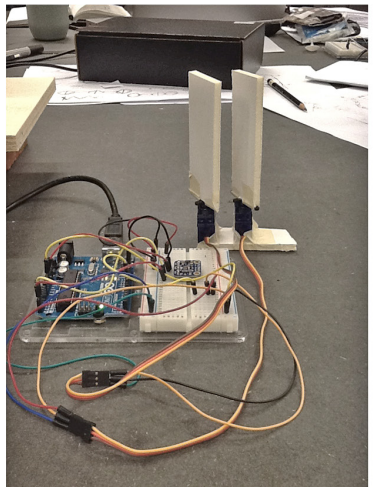
The Design Systems's ANALYSIS (Custom-made Arduino StationWeather)	**PANELS' CONDITION**		**RADIATION (LUX)**
	The Wall: 	Frosted Acrelic glass (Plexiglas ®) - Various densities for different panels   *Tested on:* Tuesday 13.10.2015 *Temperature:* Min 3.7° C Average 6.1° C Max 11.3° C *Precipitation:* 0.0 mm *Sky condition:* Fair	  TSL2561 Luminosity Sensor & Wind Sensor attached on an Arduino Uno Board  
The Wall: Testing onvarious depths of the roof louvers to get the aimed ambient light			

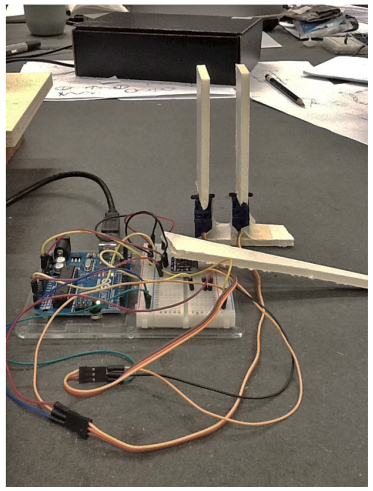
Team 1
Workflow Diagram



Team 1

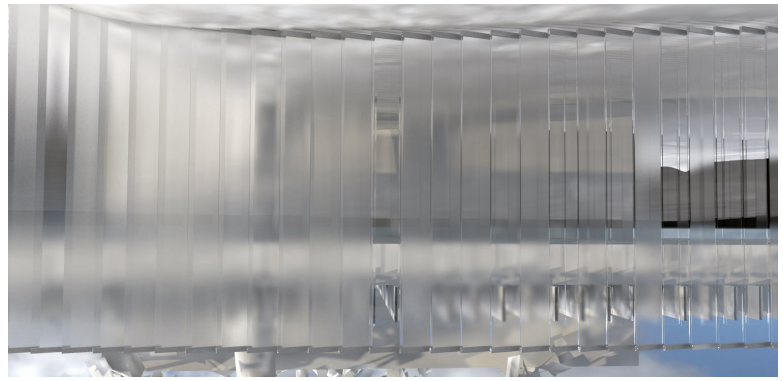




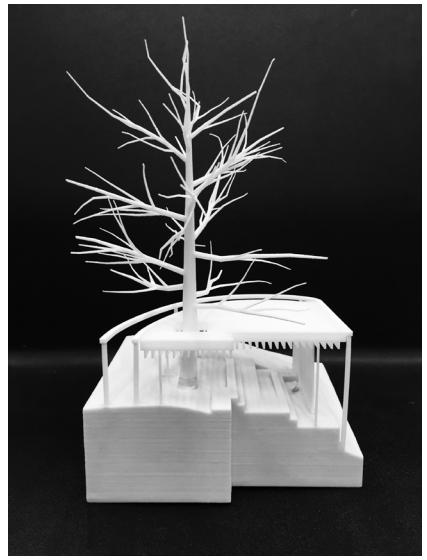


Arduino set-up for interactive louvers

Testing the model for light analysis and Arduino data collection. Both wind and light data were collected and analyzed through 5 light sensors and 2 wind sensor placed in exterior, interior, and the transition space.

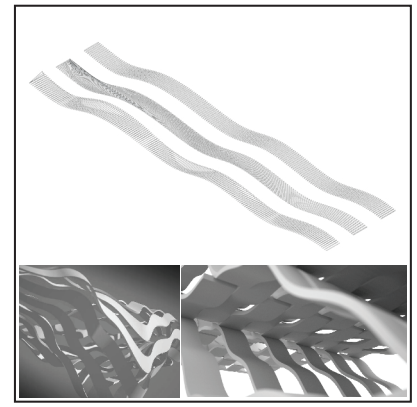


Levels of transparency in the interactive louvers – Render visualization

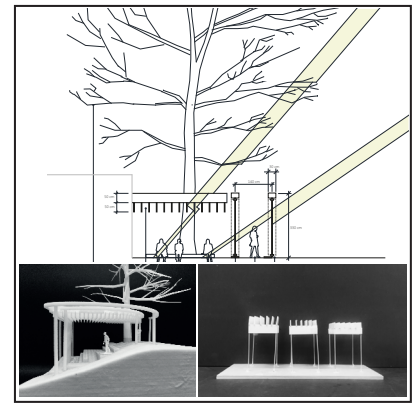


Design's Rapid Prototype

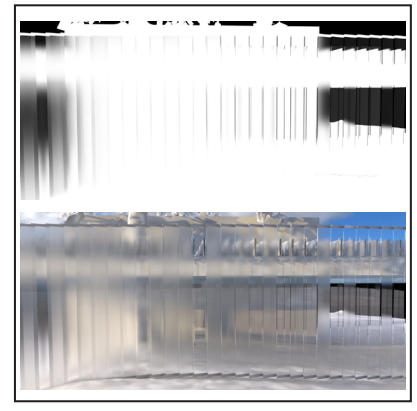
Design Progress Outline



Abstraction - Sketch of the first design idea

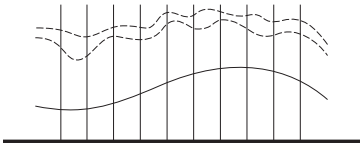


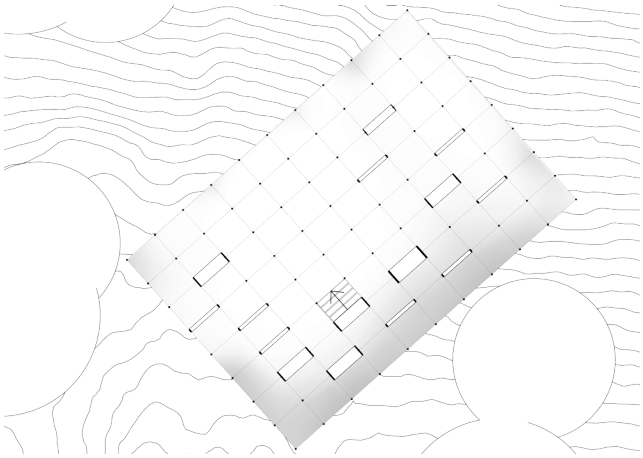
Development and detailing



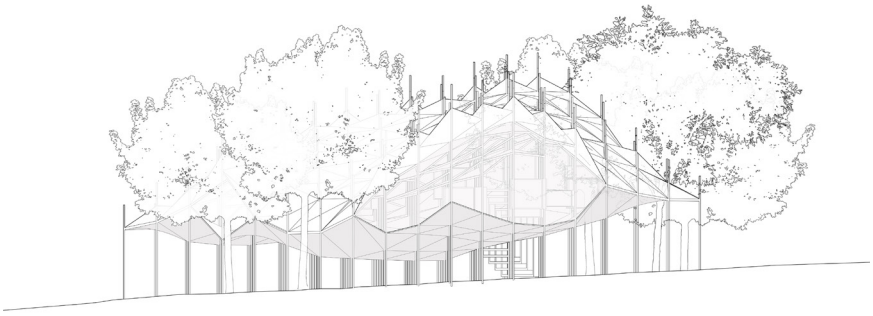
Final design and emerging atmospheres

Team 2
Conceptual Approach -
Design Documentation

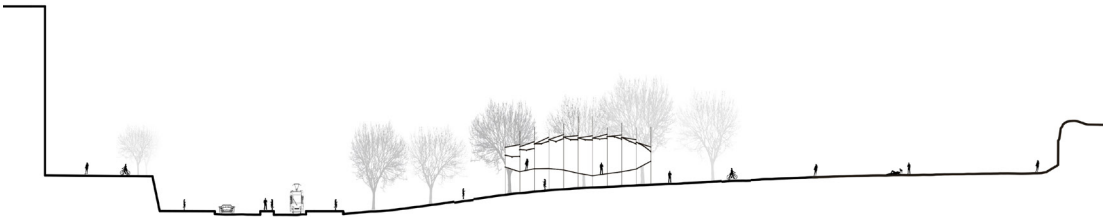




Plan 1:500



Elevation

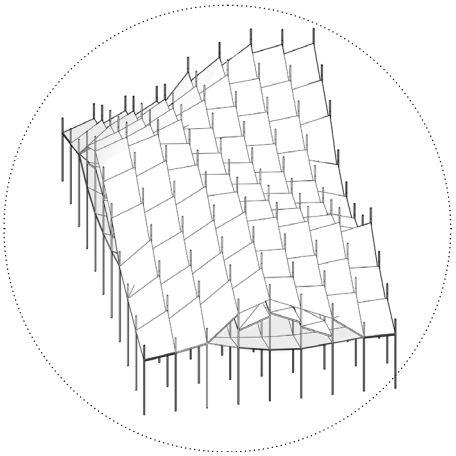


Site section 1:1000

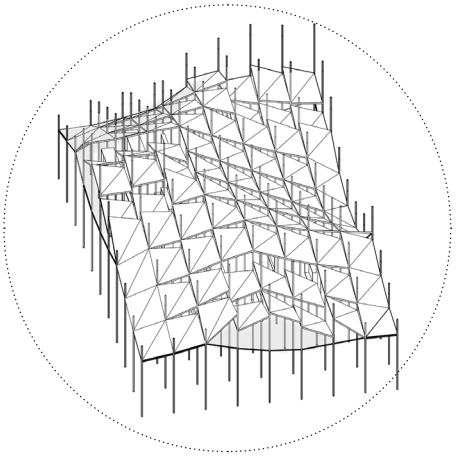
Team 2
Design Documentation

Section

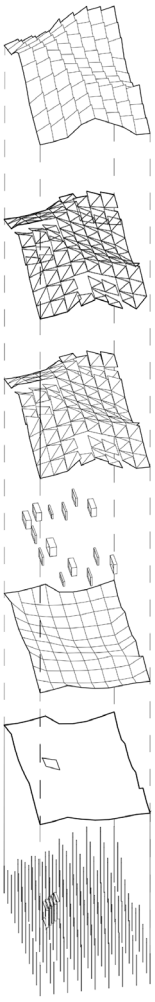
Axonometric
Drawings



Pavillion with all envelopes



Pavillion with textile removed



TEXTILE

BRACING

PANELS

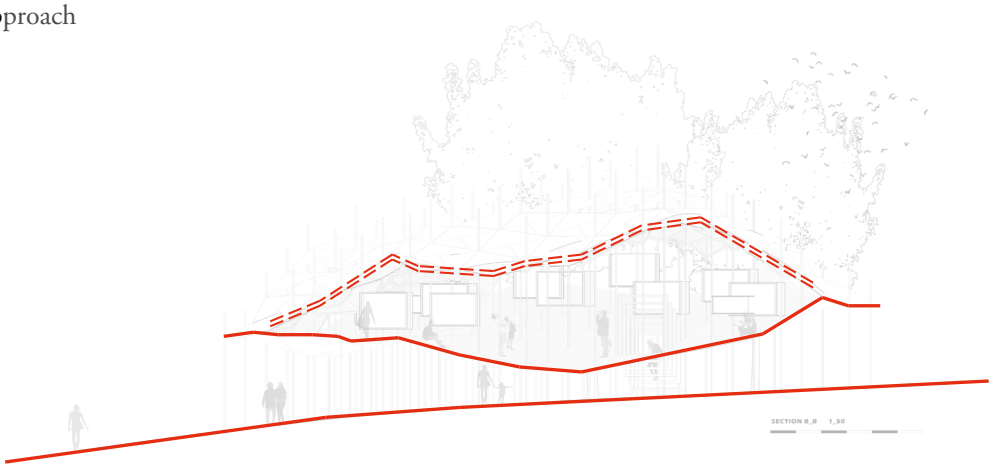
EXHIBITION
DISPLAY

TEXTILE
FLOOR

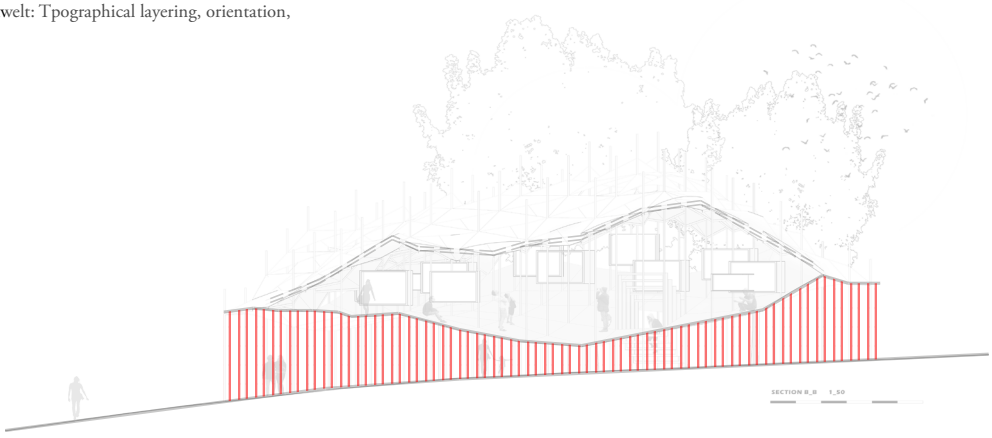
BRACING
FLOOR

COLUMN

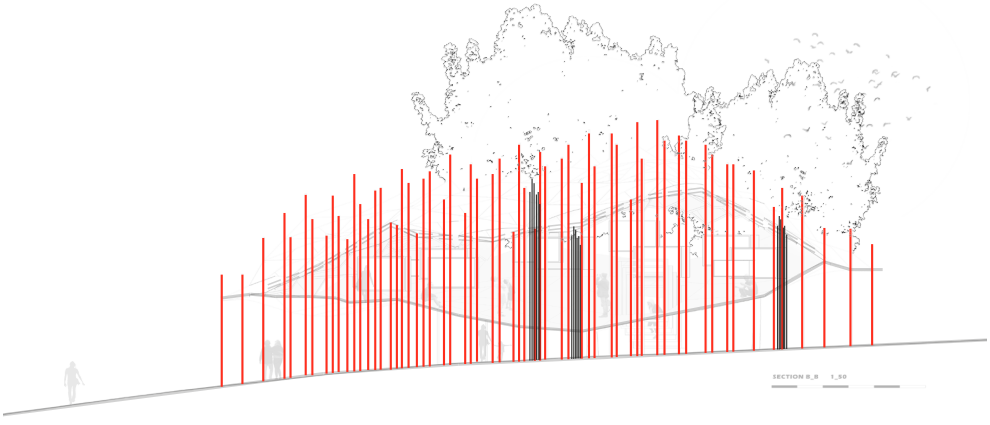
Team 2
Design Approach



Relating to Umwelt: Tpographical layering, orientation, local-specificity

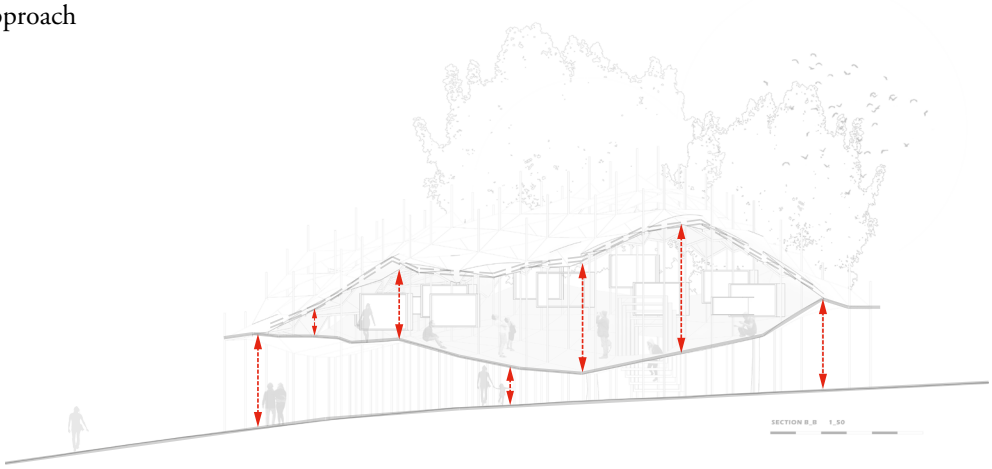


Transitional space: Creating in-between spaces

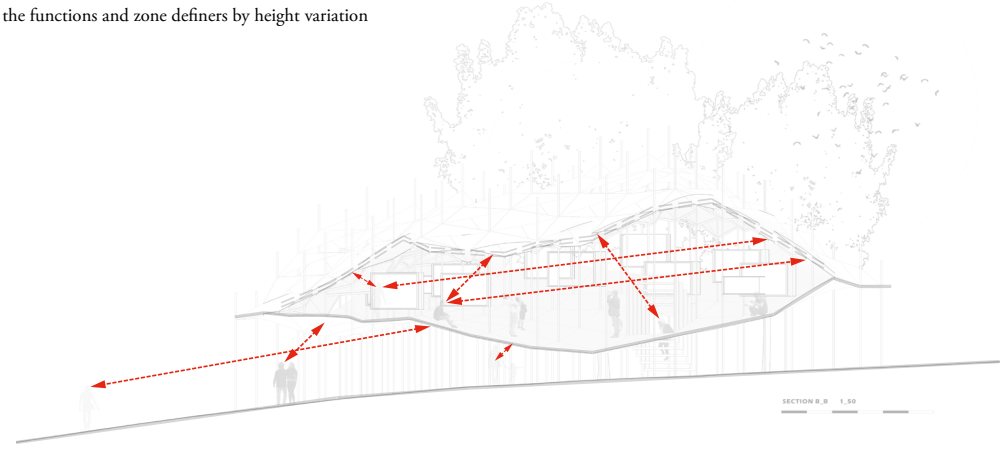


Conceptualizing the structural strategy by forest ambience

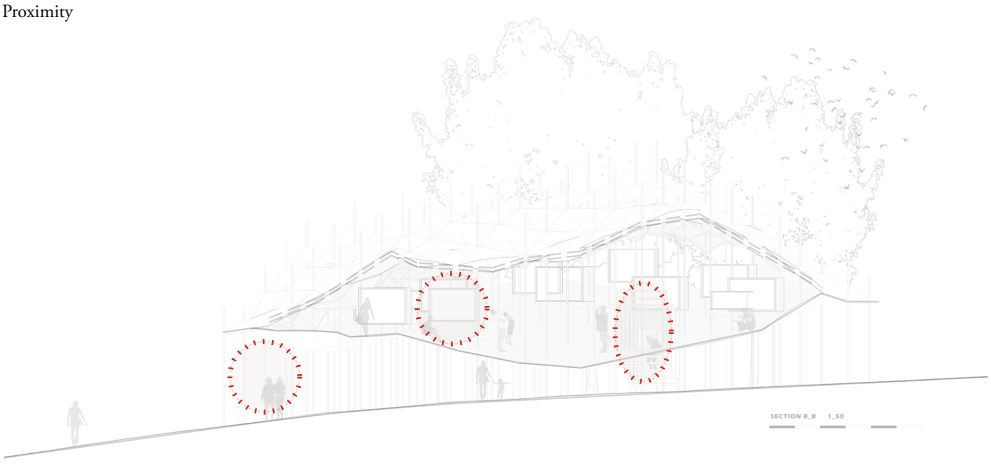
Team 2
Design Approach



Conditioning the functions and zone definers by height variation and spacing



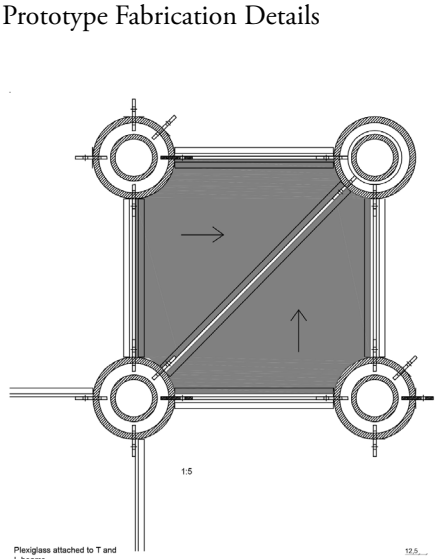
Distancing and Proximity

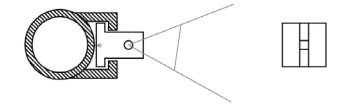


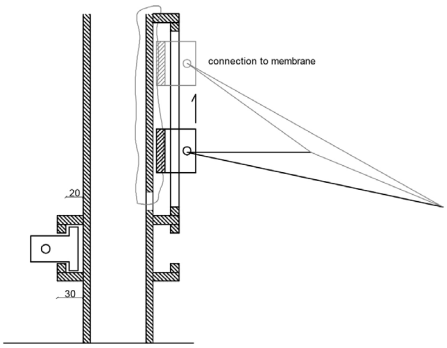
Creating various atmospheres and spatial conditions Degrees of enclosure creating various views & indoor conditions, Raumplan setting

Team 2

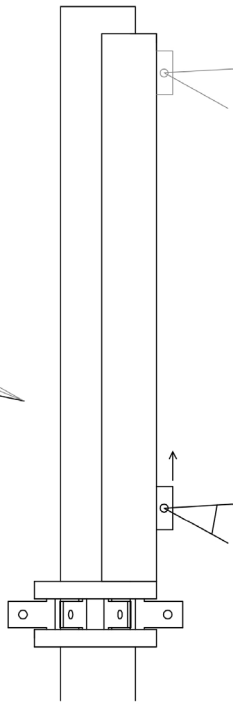
Prototype Fabrication Details

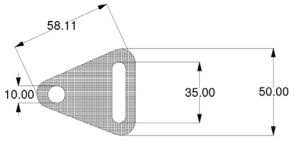


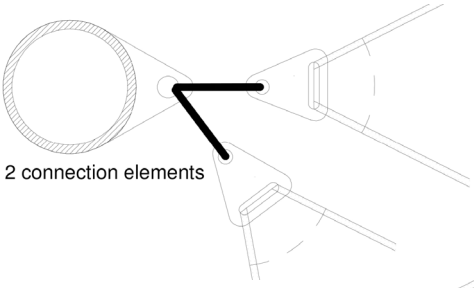


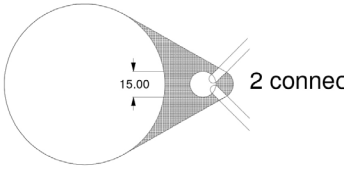


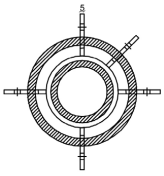
Sliding element will be used to test different conditions of light.in the space. It might be used for changing the lighting conditions depending on sun by help of arduino. System is similar to the one used for raising a flag.

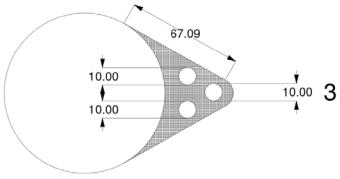


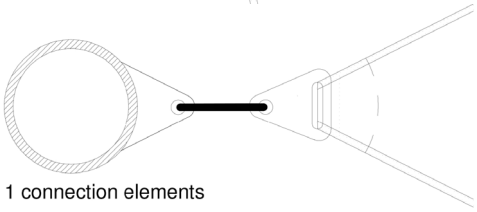


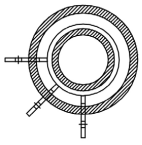






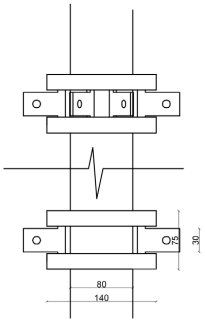






List of elements:

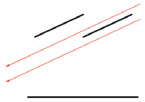
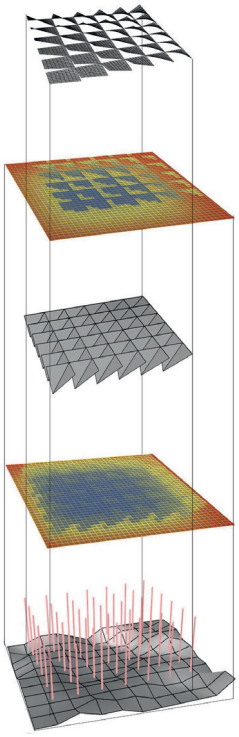
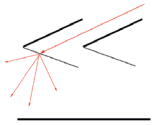
- 3 single connection elements
- 4 single connection elements, must be able to move up and down
- 2 double connection elements
- 1 tripple connection element

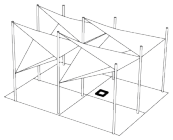
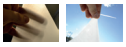
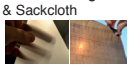
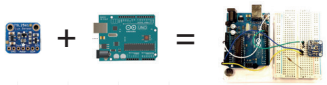
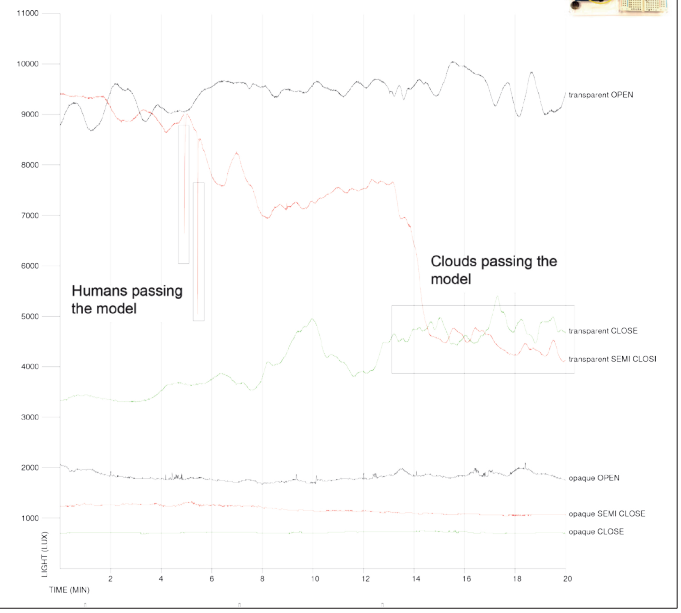


These details were made for the 1:5 model, in the end team 2 had to simplify all the details since it was too hard to replicate the detailes in a 1:5 scale. The bracings were welded to fixed points on columns and the custom-made (corner) plates were connected to them. The membranes that were connected to the corner plates were double-layered in order to handle and transfer the tensions.

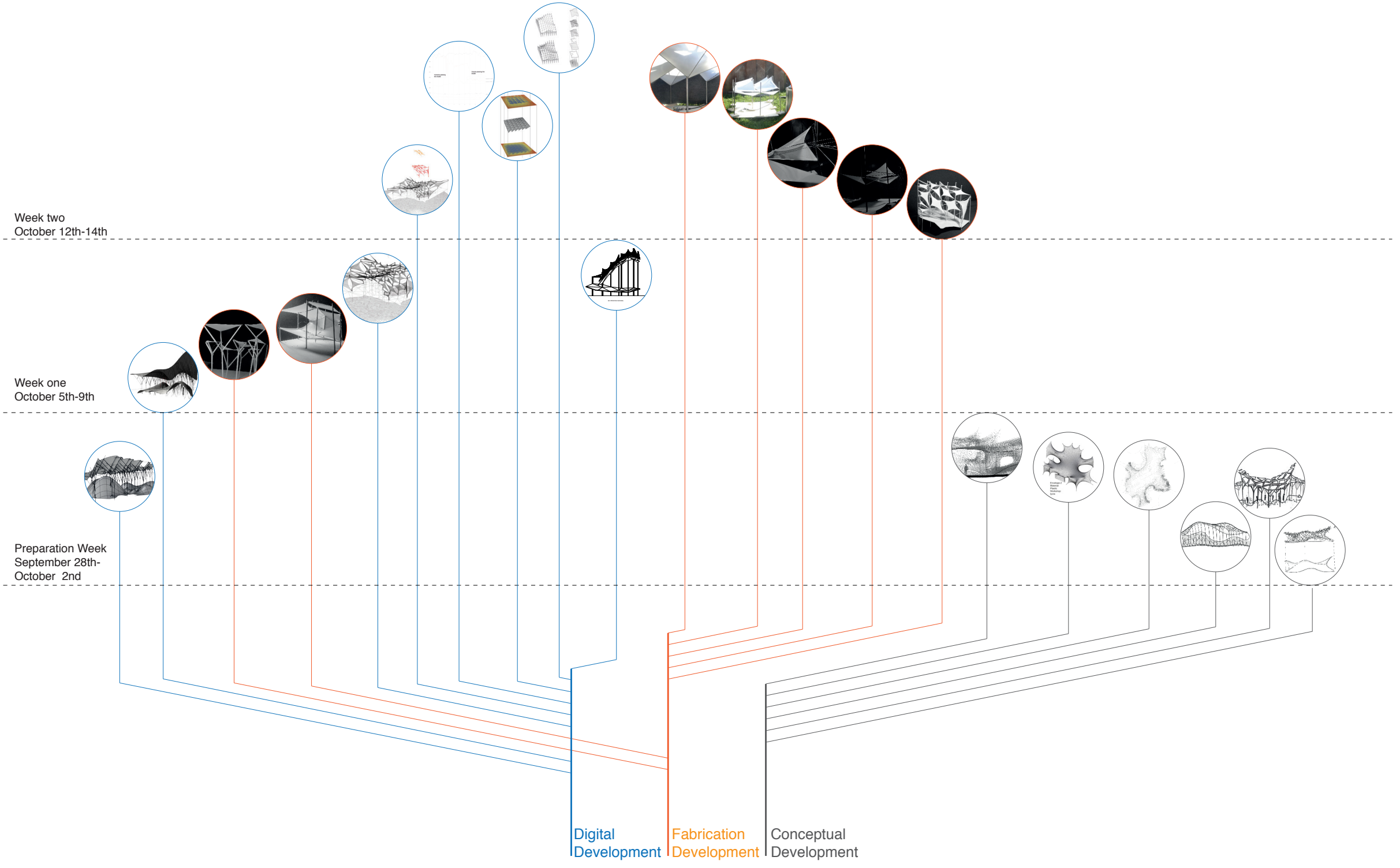
Team 2

Prototype's Simulation and Light Analysis

PROTOTYPE ANALYSIS (Radiation & shading analysis through Diva: a Rhino plug-in)	PANELS' POSITION	MATERIAL SPECIFICATION	SOLAR RADIATION ANALYSIS	RADIATION (kWh/ m2)	DESCRIPTIONS & REFLECTIONS
		PTFE Coated Glass Fiber (Frosted) 		**Analysis Period:** June 15th at 14:00	This layer is opaque textile which generated sharp shades.
		Plexiglas ® 			This layer is semi-transparent layer that diffuses the light. In such way the light condition dependent on opening size of fabric becomes local and can be experienced directly under the patch.

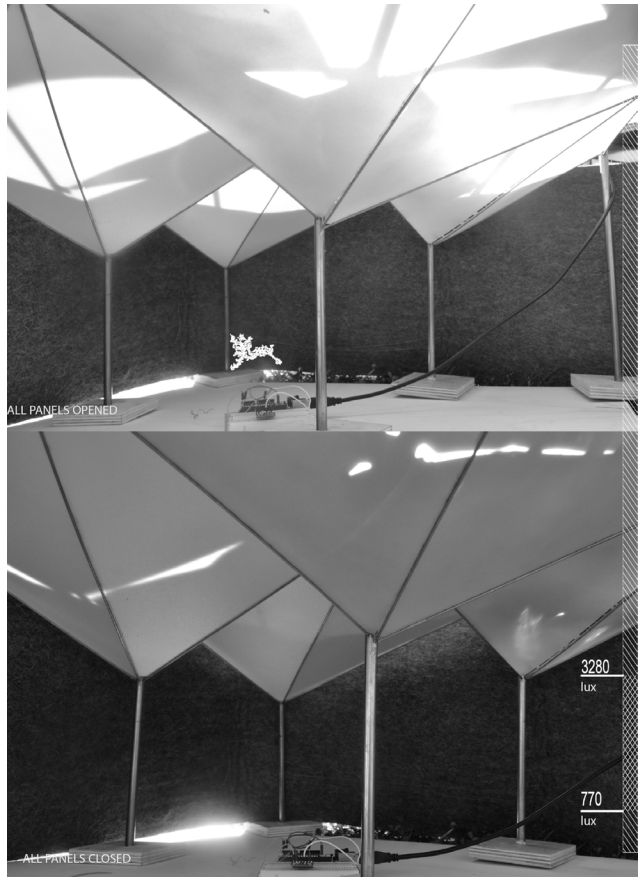
PROTOTYPE ANALYSIS (Custom-made Arduino Weather Station)	PANELS' CONDITION		RADIATION (LUX)
	Analyzed Grid 	*Transparent material*: Frosted Plexiglas ® & Lycra  *Opaque material*: Frosted Plexiglas ® & Sackcloth 	TSL2561 Luminosity Sensor on an Arduino Uno Board 
	Open 	 Opaque 3280 LUX Transparent 7700 LUX	
	Semi-open 	*Tested on:* Tuesday 13.10.2015 *Temperature:* Min 3.7° C Average 6.1° C Max 11.3° C *Precipitation:* 0.0 mm *Sky condition:* Fair	
	Close 	 Opaque 770 LUX Transparent 4700 LUX	

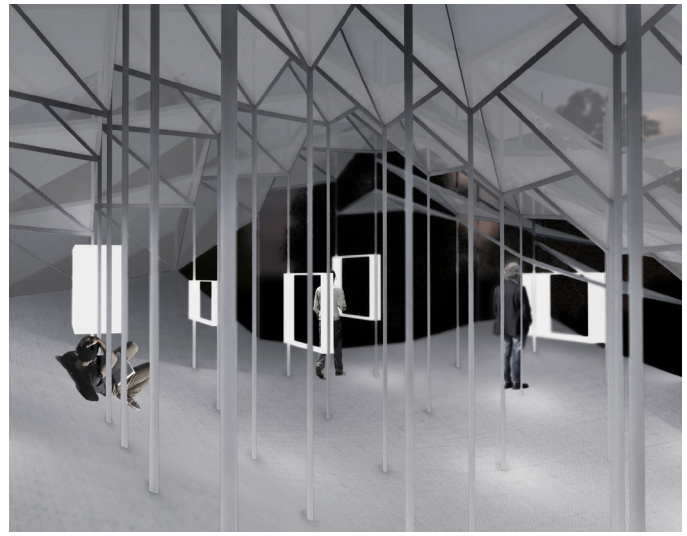
Team 2
Workflow Diagram



Team 2
Prototype's Collected Measurements and Analysis

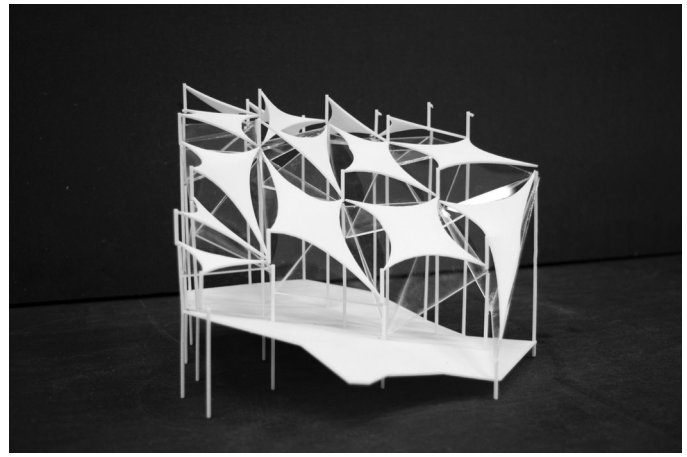
The paneling systems also provides enough flexibility for the design to test a sliding element by which light penetraton within the space could be regulated and controlled. The functioning system is similar to one of raising a flag.This was tested through manually changing the position of the fabric panel and collecting the light data through Arduino set-up sensors.

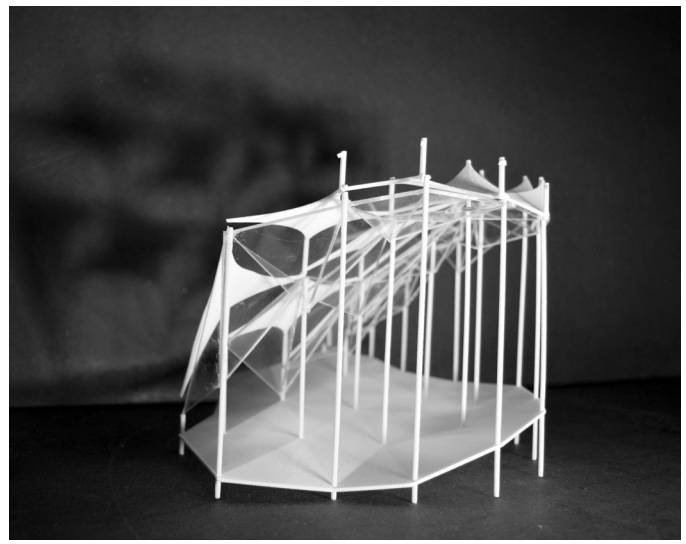


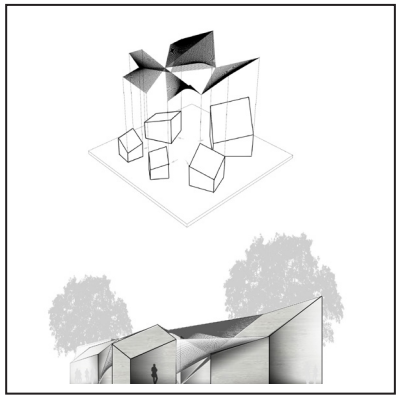


Design Progress Outline
Design Progress Outline

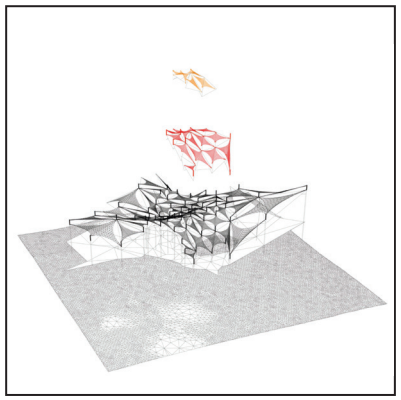
Design Progress Outline →



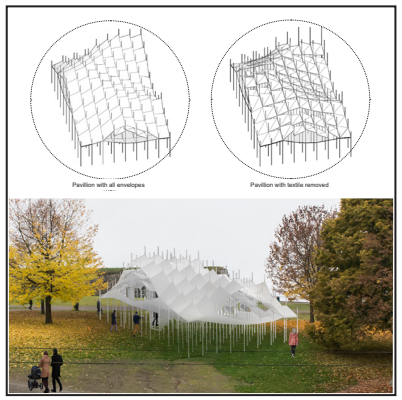




Abstraction - Sketch of the first design idea

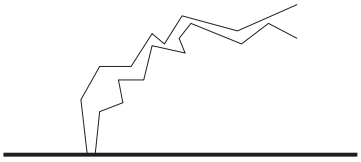


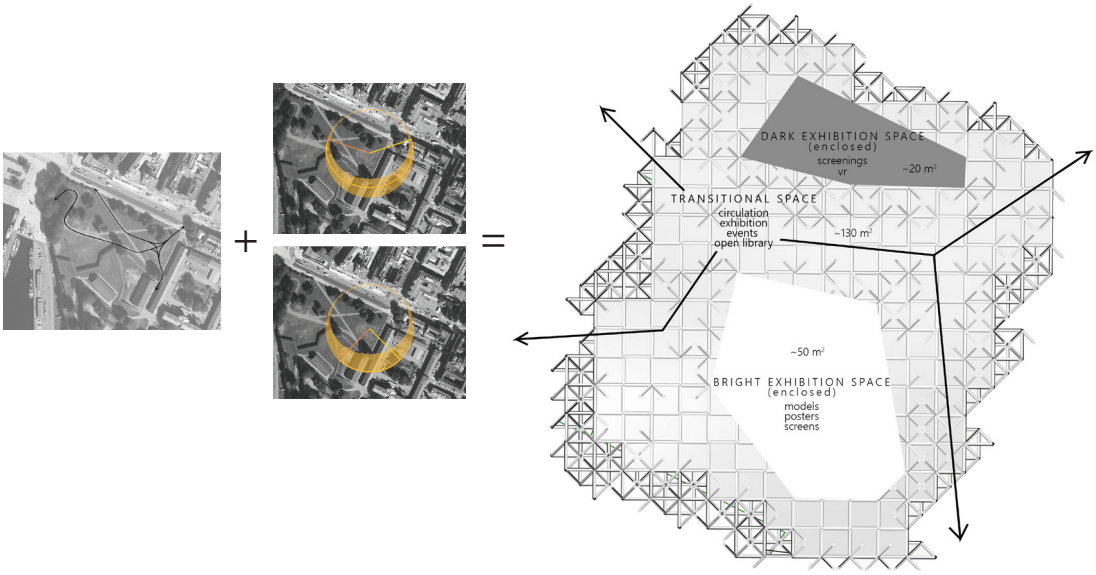
Development and detailing

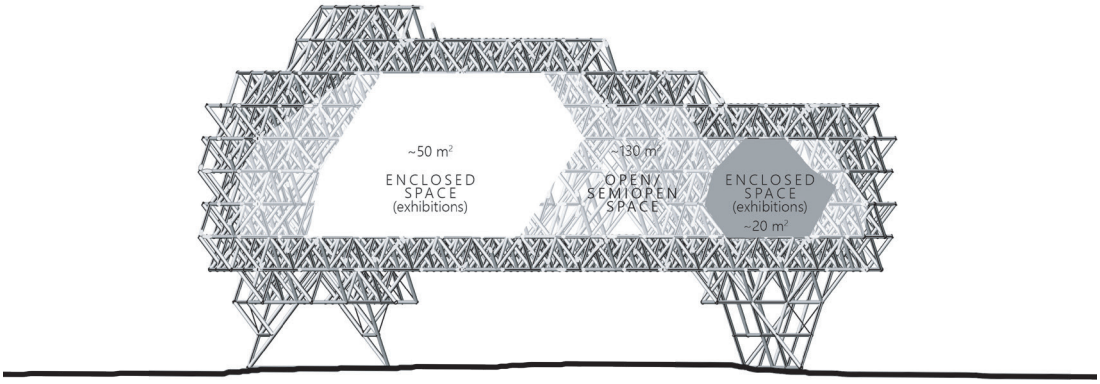


Final design and emerging atmospheres

Team 2
Conceptual Approach







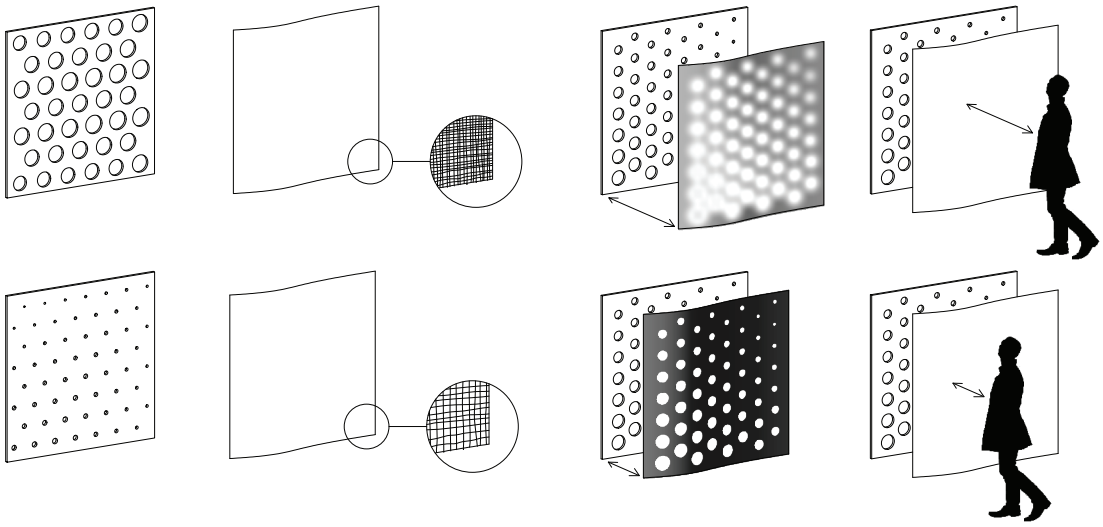
Team 3

Multiple Envelopes Materials and Organization

ENVELOPE PROPERTIES

INTERACTION BETWEEN ENVELOPES

INTERACTION BETWEEN USER AND ENVELOPE



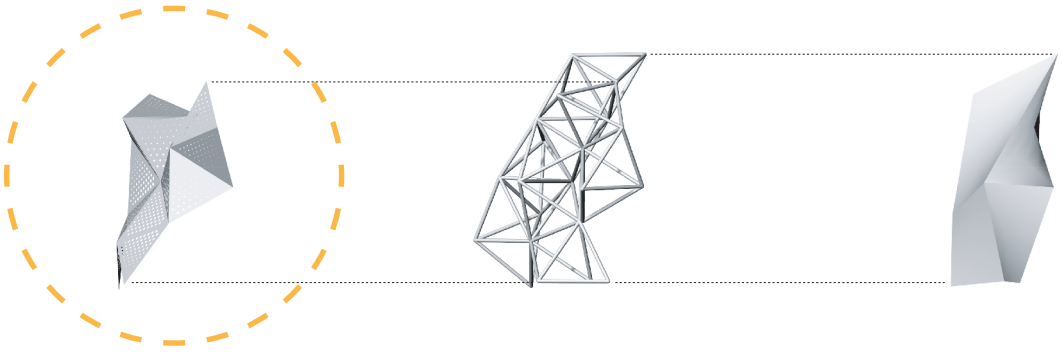
AMOUNT AND SIZE OF PERFORATION of screen: [some aspects to consider...]

PROPERTIES of veil: material, weave, thickness, diffusing qualities of the membrane, etc.

DISTANCE / SPACING between screen and veil has an effect on the sharpness of the shadow.

PROXIMITY of user to the envelope affects the experience: the greater the distance, the better the shapes or patterns of shadows are perceived...

SCREEN FRAME VEIL



ERFORATED METAL

he envelope of the transitional space folds along the faces of tetrahedra as seemingly ontinuous sheets, sometimes wrapping a tetra inside of it, sometimes leaving it outside. Different degrees of perforation result in different degrees of exposure according to the irection the envelope faces. Functions include providing shelter from rain or snow etc., nd controlling light and wind conditions, but alsocreating pockets of space.

ome aspects to consider regarding perforation (in arbitrary order):

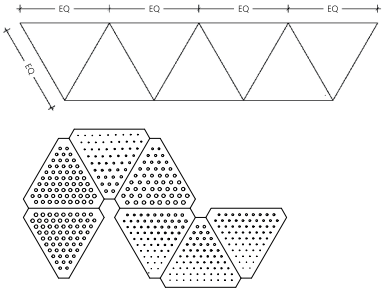
mooth variation between different sizes
equired level of shelter from precipitation
erceiving the inside–outside
patial program, functions
lare

laximum: Toward the edges of the transitional zone

ledium: On average eye-level (or right below on surfaces facing sun, to avoid glare)

linimal: On almost horizontal surfaces

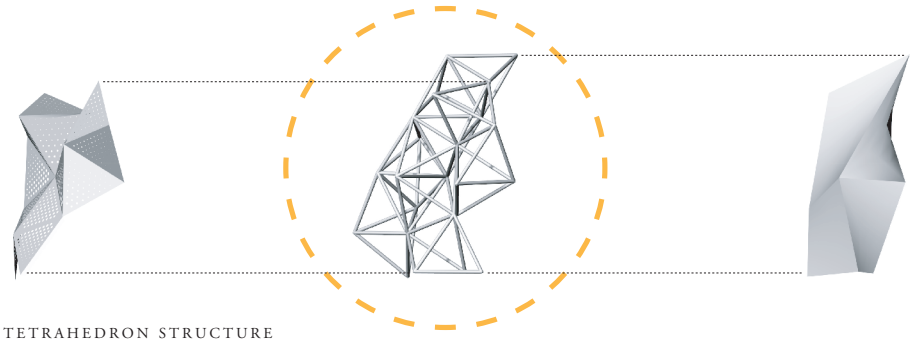
lin. to none: On horizontal surfaces right above exhibition spaces



Team 3

Multiple Envelopes Materials and Organization

SCREEN FRAME VEIL



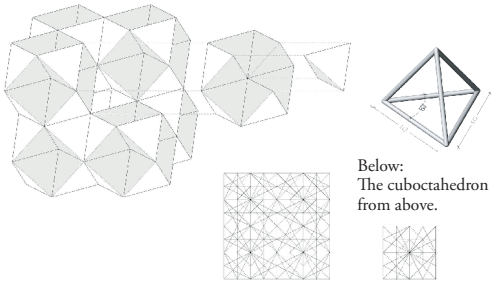
THE "EMPTY" TETRAHEDRON STRUCTURE

This metal structure gives form to the pavilion, bears loads and makes it possible to lift spaces and people off the ground . It also acts as a frame for attaching the envelopes or even exhibiting things. It is very exposed – provides minimal or no shelter, but defines an outside space nonetheless.

The tetrahedron as a form was chosen for its stability and ability to form a space by itself. Sizes of the tetrahedra vary according to their function and location in the pavilion, but the ones around the main exhibition space are of medium size.

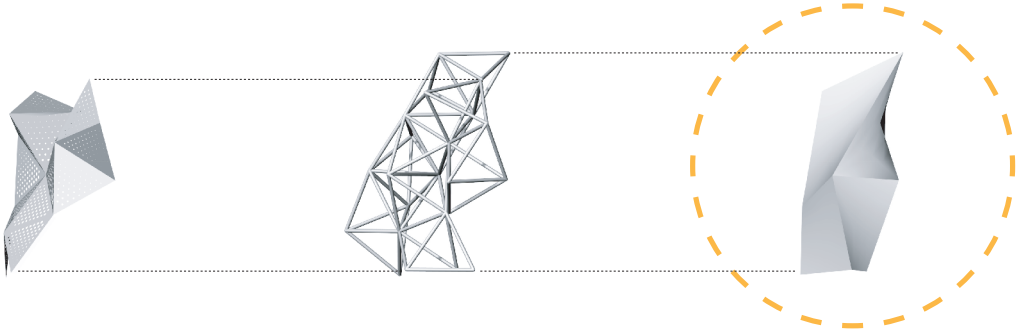
All tetrahedra are regular: All edges are equal in length and planar angles between adjacent edges are 60 degrees.

The tetrahedron stacking is based on the sharing of edges. The tetrahedron shape has 6 edges and 4 surfaces, by using only the edges as attachment points to other tetrahedrons we can create a cuboctahedron. A cuboctrahedron is a shape made out of 8 tetrahedrons stacked together with only the edges as combining points. The cuboctahedron has 14 sides and will be able to be stacked like a box.



Below:
The cuboctahedron from above.

SCREEN FRAME VEIL

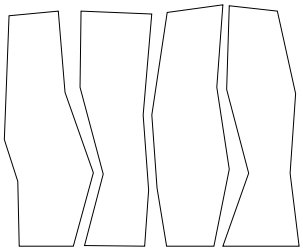


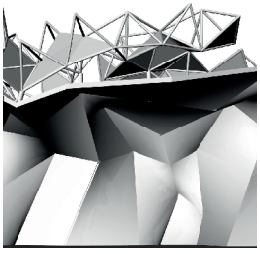
MEMBRANE

A layer of white, light-diffusing , uv-blocking membrane wraps around the exhibition space. It performs as a space divider , a guide or curator of the experience and makes controlled events possible in an otherwise open pavilion. Also, it helps controlling the lighting conditions, which is necessary to form a good exhibition space.

The membrane envelope is constructed of long pieces of fabric sewn together at edges, that follow roughly the tetrahedron faces.

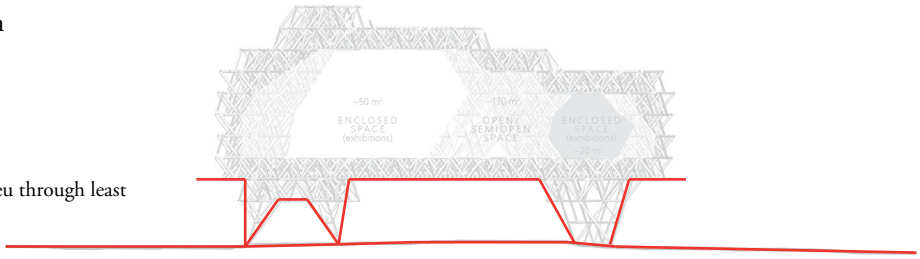
The membrane is attached to the frame with tension rods.



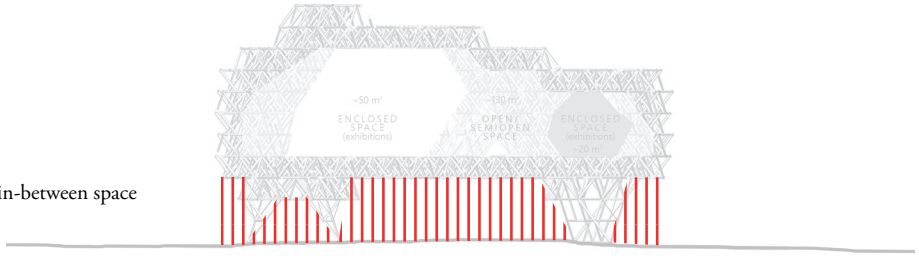


Team 3
Design Approach

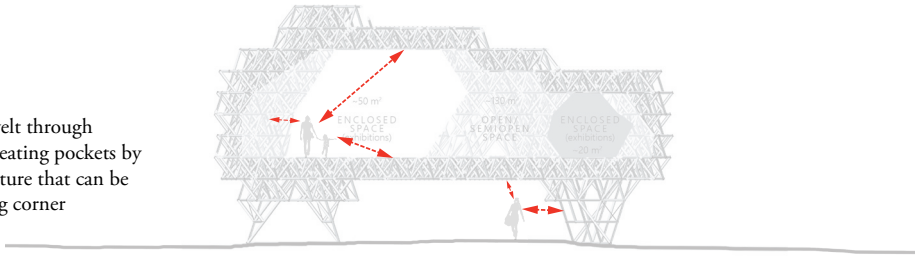
Addressing the millieu through least minimal impact



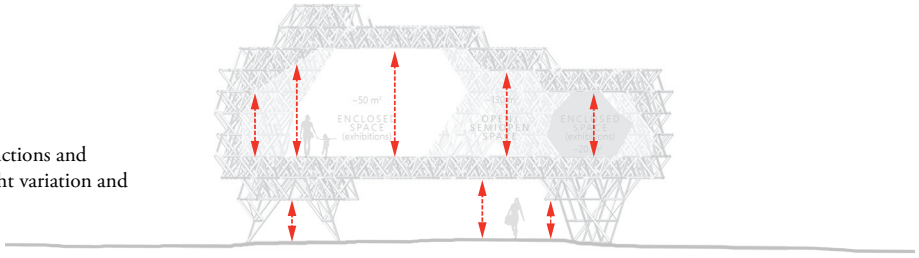
Creating a sheltered in-between space



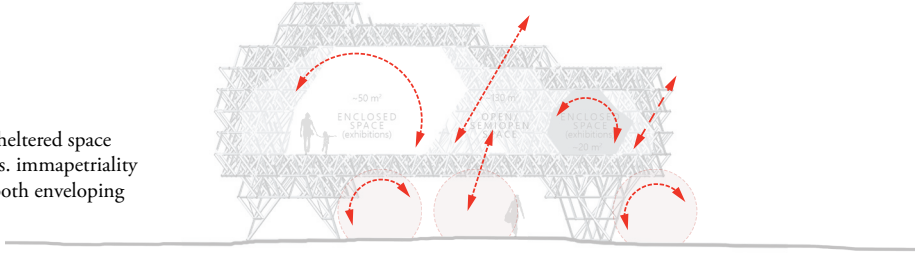
Addressing the Umwelt through structural scaling : creating pockets by big-ger units of structure that can be inhabited as a reading corner



Conditioning the functions and zone definers by height variation and dis-tancing

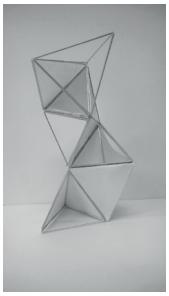
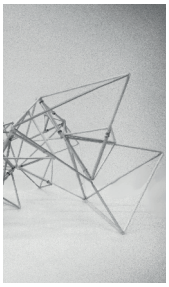
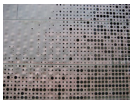
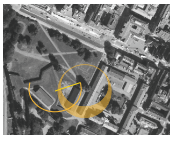
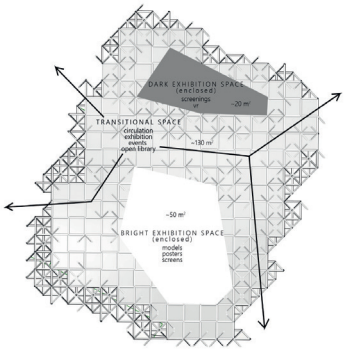
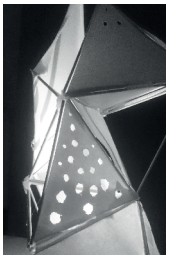
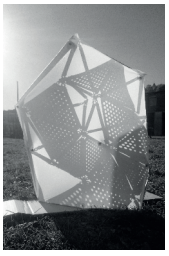
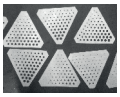
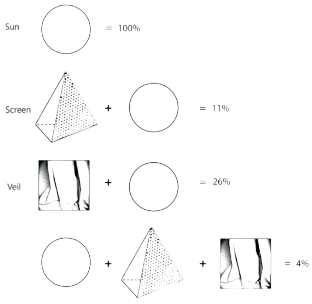
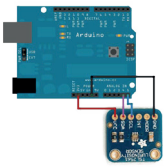
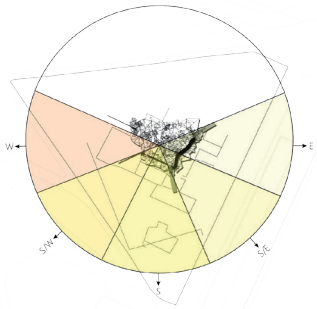


Defining degrees of sheltered space through materiality vs. immapetriality by removing one or both enveloping layers

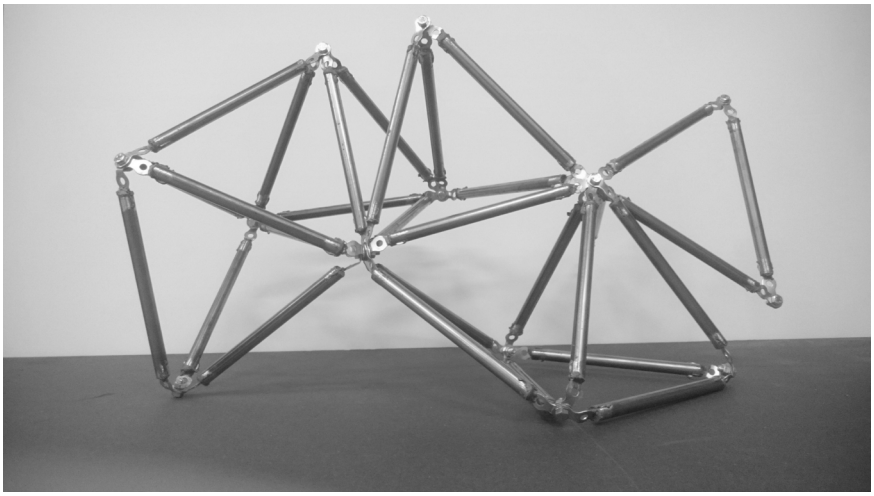


Team 3

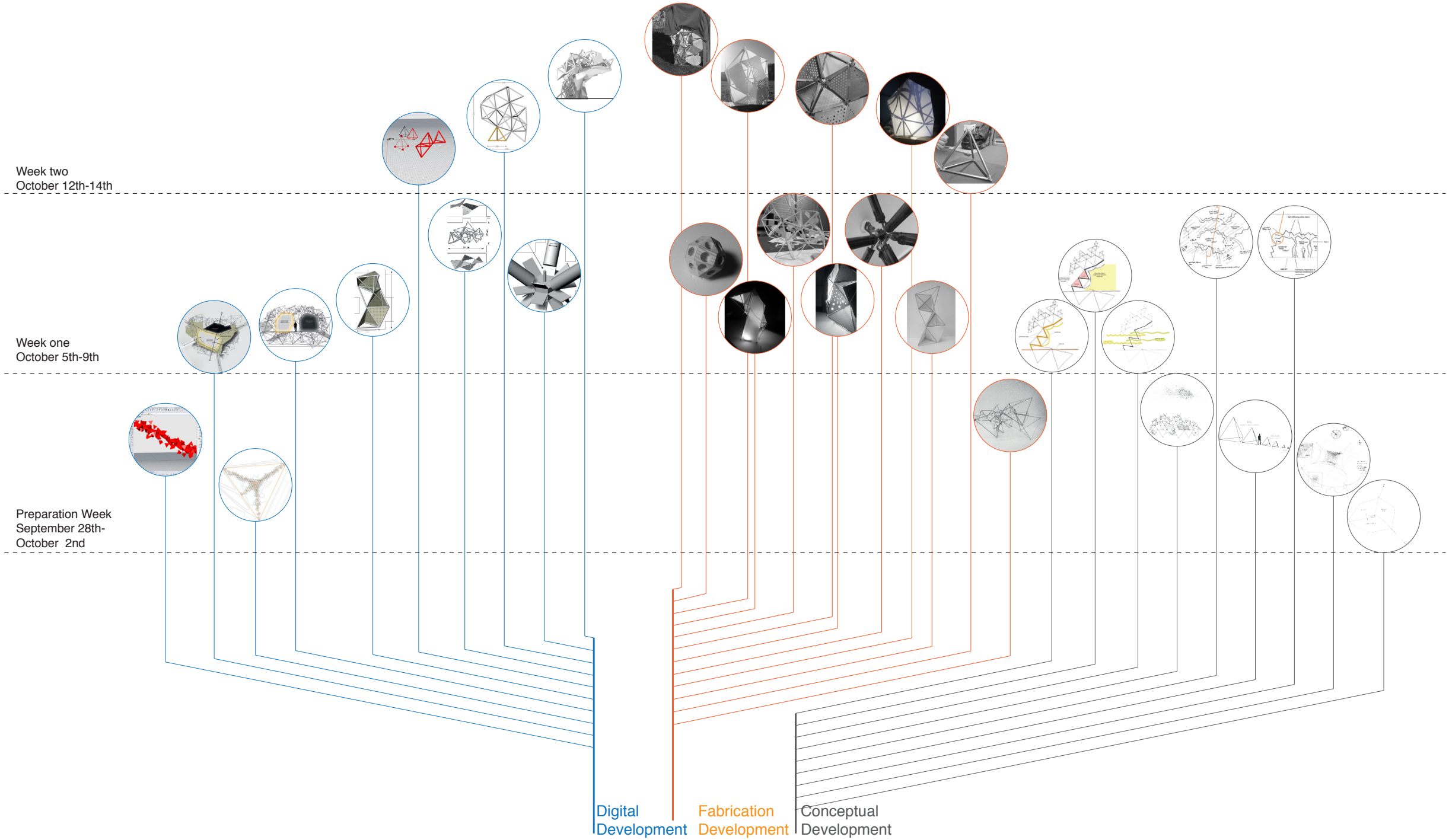
Prototype's Simulation and Light Analysis

PROTOTYPE ANALYSIS (Radiation & shading analysis through Diva: a Rhino plug-in)	**PANELS' POSITION**	**MATERIAL SPECIFICATION**	**SOLAR GAIN PERCENTAGE (with an average amount of perforation)**
	 	Perforated Metal Sheets & Membrane patches  	 +   = 
PROTOTYPE ANALYSIS (Custom-made Arduino Weather Station)	**PANELS' CONDITION**   	Perforated Plywood & Lycar patches   *Tested on:* Tuesday 13.10.2015 *Temperature:* 11.3° C *Precipitation:* 0.0 mm *Sky condition:* Clear	**RADIATION GAIN (PERCENTAGE & LUX)**   TSL2561 Luminosity Sensor attached on an Arduino Uno Board Lux value 930 60 degrees east 2360 30 degrees east 4890 directly southward 4116 30 degrees west 1363 60 degrees west  TESTS that don't show in the diagram: Sun setting down (through a tree) = 800-394 lux Sun hidden, full shade = 200 lux Lights off (inside) = sensor overload Indirect light = 3 lux Direct light = 10 lux Indirect light: through the blinds = 1 lux

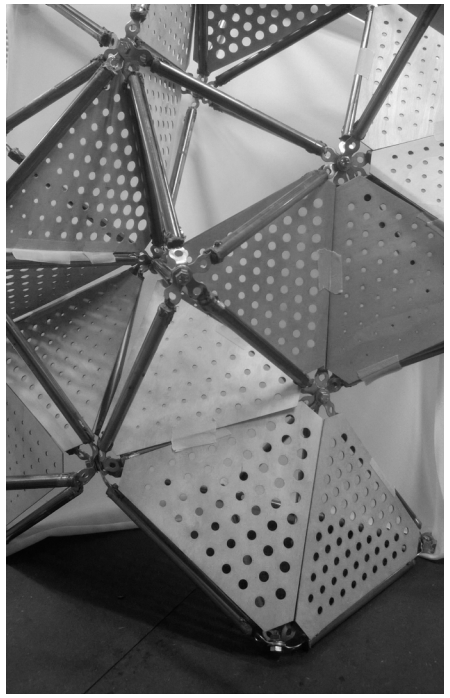
Team 3
Prototype Fabrication Process
and Details

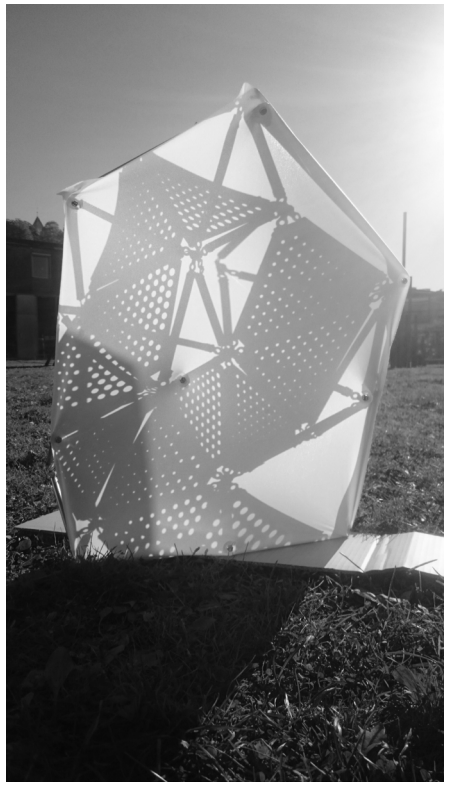


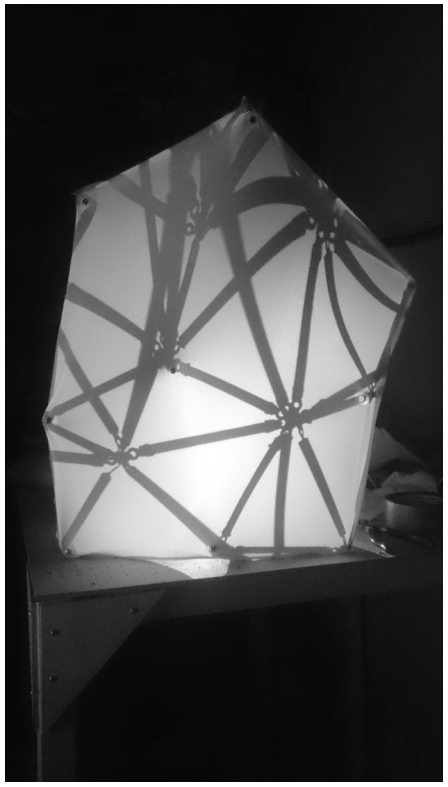
Team 3
Workflow Diagram



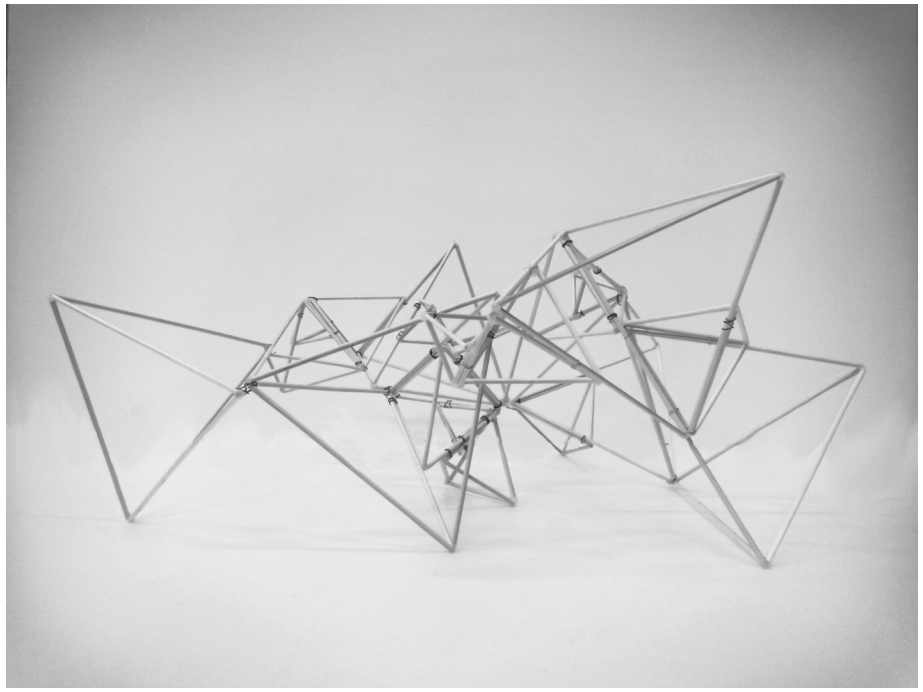
Team 3
Prototype light and shadow analysis

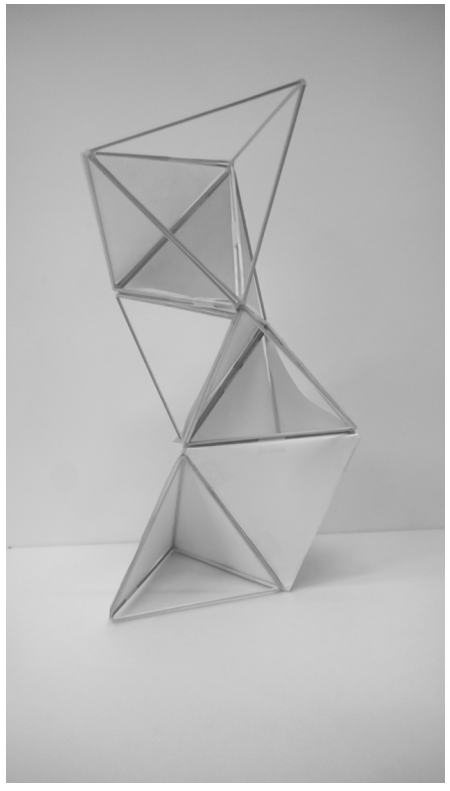


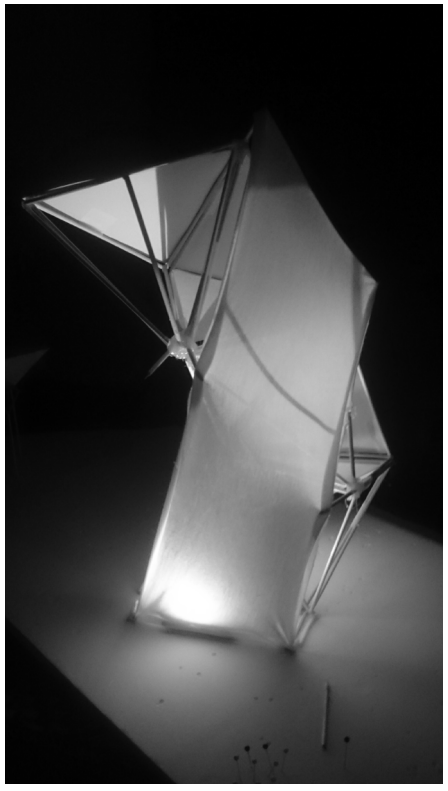


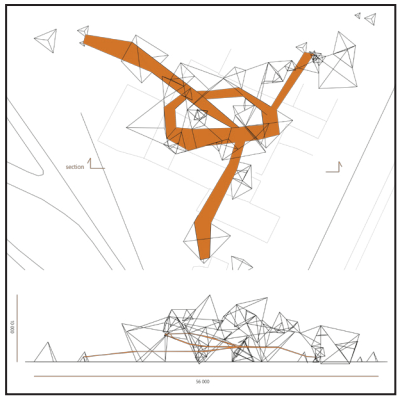


Tetrahedron Structure – First Prototypes Studies

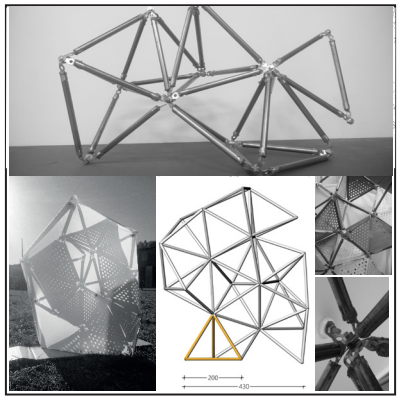




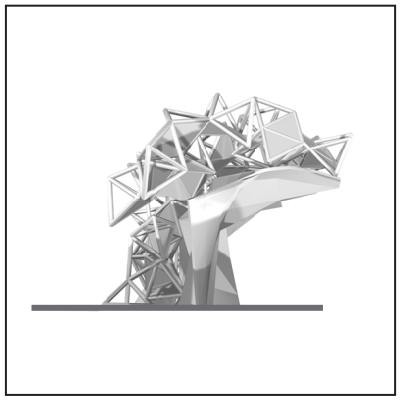




Abstraction - Sketch of the first design idea



Development and detailing



Final design

R2

Interactive Envelopes Workshop

April 11th – 20th 2016

RCAT | ACDL Studio, Spring 2016
The Oslo School of Architecture and Design

Studio Tutors:

Prof. Dr. Michael U. Hensel
Asst. Prof. Søren S. Sørensen
Asst. Prof. Joakim Hoen

Abstract

This report relays the activities and proceedings of the Interactive Envelopes Workshop, which was part of the RCAT | ACDL Master Studio (Research Centre for Architecture and Tectonics and Advanced Computational Design Laboratory) at AHO - Oslo School of Architecture and Design. The workshop took place from 11th to 20th April 2016 as an integral part of the author's research for the PhD project: *Inhabiting the Architectural Envelope – A Design-based Research on Redefining the Climatic and Atmospheric Performances of Architectural Envelope.* The PhD research focuses on redefining the notion of "envelope" in architecture so as to transcend common definitions of "building skin" or "façade" by focusing on an extended spatial zone and environment affected by the envelope; the research thus defines the envelope as an extended and inhabitable threshold that affects humans' experience. The investigations are framed within the context of contemporary discourse on performance in architecture, focusing mainly on the importance of location-specificity of the built forms. The workshop aimed to develop design ideas for envelope systems for the students' studio projects through digital- and physical simulation and analysis. The workshop was preceded by one week of concept design, modeling, and simulation, building scaled models that were further developed by the iterative analysis and design modification. Physical and computational environmental analysis was conducted in the workshop; this was based on custom-made Arduino measure stations and Rhino plug-ins, respectively. This report outlines the workshop and the development of the projects and includes a discussion of the findings and limitations that will be useful for further development of the approach and method.

Introduction

The Interactive Envelopes Workshop in the RCAT | ACDL studio focused on the role of the architectural envelope as a spatial activator of the design for the studio's Oslo-24 studio project. The project brief for Oslo-24 asked for the design of a multiple-use, 24-hour building with a minimum area of 400sqm. Students were asked to prepare a detailed project brief for a building that took into account demographic changes in Oslo (age, nationality and various urban cultures). The individually drafted project briefs required considerations of adjacent actors, activities, and programs, including those further afield but linked to a site selected from four options. The workshop focused on developing envelope strategies and designs in response to the selected site and building programs and desired environmental mediation. This entailed systemic adaptation of the envelope

design to the intended spatial, programmatic and environmental organization of the building, and more specifically the spatial flexibility necessary for the projected time-based, multiple-use arrangements that the building schemes would provide. Emphasis was placed on architectonic concepts that can enable the creation of productive atmospheres (Leatherbarrow, 2009, p. 33). Productivity here is the alteration and adjustment of what the milieu/ Umwelt provides the built form, but which is not necessarily sufficient. In other words, productive atmospheres strive to accommodate spatial performances by which the building operates effectively in its surrounding climatic and cultural context. These spatial performances could include e.g. architectural elements such as the Islamic sunscreens called mashrabiyah, or louver walls, which prevent direct sunlight whilst allowing ventilation and providing privacy for the interior space.

Creating interactive envelopes with an emphasis on their performative aspects required the definition of building envelope to be clarified within the scope of the author's PhD research project. The research distinguishes the notion of envelope from other terms used to define this threshold as the boundary between the built form and its setting, such as building skin or façade. The definition offered is: Unlike the building skin, which is the material division of exterior and interior (either operative or static) an envelope is the spatial zone and an active agent engaged in and affected by the interaction between the outside and inside of the built form. Therefore, the notion of envelope closely engages the contemporary discourse of performance in architecture. Defining envelopes as spatial zones not only includes the traits and attributes of the notion of building skins and façades, but also goes beyond them by including the affected extent of interior and exterior space. As such, this threshold emerges from the interaction of spatial and material organization and the provisions made for inhabitation.

Workshop Methods, Process, and Outcomes

Based on the series of lectures conducted in the studio[1] and other workshops[2] held before and during the interactive envelopes workshop, the students were expected to develop a clear understanding of a range of concepts and design approaches related to envelope performance. The first lecture on architectural envelopes introduced the taxonomy of building envelopes developed by the author (Saeidi Derakhshi, 2017, p. 15). This taxonomy uses existing examples for three proposed envelope categories based on how the built form relates to its surroundings: discrete; non-discrete; and envelopes with a dual reality.[3] The interactive envelopes workshop focused on non-discrete architectures, which are embedded in their surrounding contexts to establish a performance-oriented relationship between the interior and exterior environments. This integrity defines the built forms in such a way that changing the location of the building would disrupt its intended performance. Non-discrete envelopes can display extended thresholds or multiple envelopes, or both. While an extended threshold does not necessarily imply the use of multiple envelopes, the use of multiple envelopes can result in an extended threshold. Both extended thresholds and multiple envelopes represent approaches that extend the notion of the envelope from a material boundary to encompass in-between spaces that can accommodate various programmatic and atmospheric provisions. Extended thresholds are an example of architecture that provides various degrees of thermal comfort and climatic condition through the spatial organization and degrees of the enclosure of the in-between spaces. Multiple envelopes, however, provide ranges of spatial conditions and qualities through layers of materials (with or without using different materials) at designated distances from one another. This approach creates a rich sequence of spatial adjacencies, degrees of transparency, and spatial qualities driven by material properties and organization. The projects' conceptual approaches in the interactive envelopes workshop were expected to frame and address concepts that corresponded to the envelope types selected. Therefore, before the workshop started, the conceptual mappings

[1] "An Introduction to Performance-Oriented Architecture" by Prof. Dr. Michael Hensel; "En Route to Informed Non-Standard Architecture" by Søren S. Sørensen; "Prelude: Whatever Happened to Program in Architecture?" by Prof. Dr. Michael Hensel; "Approaches to Data-Driven Design in Architecture" by Asst. Prof. Joakim Wiig Hoen; "Whatever Happened to Program in Architecture?" by Prof. Dr. Michael Hensel; "Envelopes in Architecture" – Lecture series 1 & 2 – by Sareh Saeidi; Snøhetta series of lectures including "Associative Modeling" by Jorunn Sannes, "The Façade for Le Monde" by Håvard Vasshaug, and "The Façade of the King Abdulaziz Center for World Culture" by Peter French.

[2] Energy Simulation and Analysis: Ladybug and Honeybee plug-ins Workshop, Conductor: Francesco de Luca. Arduino and Processing Workshop. Conductor: Asst. Prof. Joakim Wiig Hoen.

[3] For further reading see (Saeidi Derakhshi, 2017).

of the literature reviews of the PhD research project were presented and discussed extensively with the students in the studio's second lecture: Architectural Envelopes: Themes and Approaches. The discussions included a narrowed list of concepts selected (Saeidi Derakhshi, 2017, p. 18) and applied in each design project according to the specific aims of the project; these concepts were transparency (Rowe and Slutzky, 1982), particlization (Kuma, 2008), layering, and kinetic systems.

Students were asked to choose a room in their project that required programmatic or functional changes in relation to climatic conditions. This space was to be located within the outermost zone of the building and take into account how the interior and exterior met and were defined through the architectural envelope. The workshop brief also requested a detailed consideration of daylight and solar radiation as determining climatic factors for the interior thermal comfort, and of how these factors corresponded to the programmatic demands of the chosen space. The envelope design was to take into consideration the diurnal and seasonal cycles and the way space would be used in a related time-specific manner. The threshold design was expected to establish a strong relationship between the built form and its milieu via the climatic design considerations that directly affect atmospheres and programs of the interior spaces. The workshop results included scaled prototypes of part of the architectural envelope. The prototypes were used in conjunction with the custom-made Arduino measure stations to corroborate the anticipated climatic performance.

The designs address climatic conditions by creating a strong connecting between interior and exterior through environmental considerations. The latter includes not only the climatic conditioning of spaces but also certain desired atmospheric effects and moods. This also entailed the provision of heterogeneous conditions that enable choices for the inhabitant, besides sensor-based automated systems, for controlled interiors. This includes exploring the limits of dependency and independence within automated systems and ways by which the intentional physical interaction of the inhabitants (decision-making and operation) can be implemented in designing location-specific envelopes. This calls for a stronger correlation and interaction of interior and exterior environments.

Students started the workshop period by sketching design concepts and testing them immediately by iteratively developing and informing digital and physical models. This step included various digital and physical modes of analysis, such as structural logic and efficiency by way of the Grasshopper

plug-in Karamba[4], building scaled models of structural logics, sunlight and solar radiation analysis with Ladybug[5], and custom-made Arduino measure stations to take solar radiation measurements of the physical prototypes. The designs addressed and illustrated how envelopes can be articulated, scaled, and oriented to fulfill the performative criteria of each project. Therefore, the tests were actively engaged in measuring the degree of light penetration by exploring different materials with various degrees of transparency, translucency, surface color, and roughness. The students' design concepts were initially taken up in individual tutorials and desk discussions and subsequently developed further through an iterative design process and analysis. The workshop resulted in a series of prototypes that illustrate how specific architectural concepts and atmospheres can be approached within the performance focus of the research. The process also formed a guideline on how designing within an iterative design model can be evaluated, reflected on, and developed.

By utilizing associative computational modeling, the projects were able to address and develop the integration of programmatic, spatial, structural and environmental criteria. The iterative design process within this model made it possible for the investigations to conduct tailored analysis based on individual project objectives. The analyses included different studies on geometry definition, programmatic layout, sunlight and radiation analysis, and structural analysis. One of the aims with the projects was to integrate the adaptive program of the building in correspondence to daylight conditions and seasonal changes to the trees adjacent to the building. As a result, the project extensively mapped programs and activities around the project site – Slottsparken in Oslo – and proposed a program scheme for the building that juxtaposed the mapped information and the climatic and seasonal daylight conditions in the building. This led to a design that not only considered the thermal comfort, light modulation, and the degree of enclosure of the interior at once, but also addressed its programmatic needs in an urban context. The design consisted of two continuous surfaces, one

[4] Karamba is an interactive, parametric finite element plug-in for Grasshopper, which is a parametric design environment within Rhinoceros modeling software, for analyzing 3-dimensional beam and shell structures under arbitrary loads. This plug-in is being developed by Clemens Preisinger in cooperation with Bollinger-Grohmann-Schneider ZTGmbH Vienna.

[5] Ladybug is a Grasshopper plug-in that enables import and analysis of standard weather data by drawing diagrams such as sun-path, wind-rose, radiation-rose, while providing the flexibility for customizing the visualization of various analyses like radiation, shadow, and view in different ways. Grasshopper is a graphical algorithm editor tightly integrated with Rhinoceros 3D modeling tools. Rhinoceros is a commercial 3D-computer graphics and computer-aided design (CAD) application software developed by Robert McNeel & Associates. Unlike RhinoScript, Grasshopper requires no knowledge of programming or scripting, but still allows designers to build form generators from the simple to the complex.

of which formed the core of the building and the other the envelope layers. The envelope included three material systems that mainly correlated the programmatic needs to the degrees of enclosure.[6]

Another project in the studio utilized concepts of material transparency and layering in modulating light to provide thermal and atmospheric comfort in the chosen room of the project.[7] The design studies were inspired by Japanese traditional screens – shoji – that use rice paper and glass to provide ambient light and control visibility in space. The design consists of two layers of envelopes distanced to form an inhabitable in-between space. The outermost layer is shaped by several screens with various compositions of frosted and transparent glass. The design addresses the light requirements of the room by defining various zones that coordinate the spatial depth with daylight penetration. The composition of the glass pieces in the lattice panel is based on daylight analyses including specifications for glare, reflection, light penetration, and filtration. The analyses were conducted through computational simulations and parametric models of the design. The flexibility of the parametric model enabled quick feedback on design iterations, resulting in an effective model of transparent vs. opaque glass distribution for the panel. This also allowed the testing of various spatial effects and shadow pattern studies of the panels and their relative positions. The various layers of sliding panels with different transparent pieces brought a high level of human interaction to the design, allowing the space to be fully enclosed, semi-closed, or completely open. As such, the users of the spaces are able to change the light conditions in the room according to their needs and activities by adjusting and rearranging the panels. The second panel that formed the inner layer of the in-between space was a thickened light lattice that provided seating and shelves for the interior space.

The other two projects in the studio looked at an overall kinetic skin to modulate light and ventilation and to create an in-between space for the envelope. One of the projects proposed this building skin system for an existing façade of a building in Oslo that houses a rehabilitation center; as such, the system becomes a second layer to modulate light and provide natural ventilation.[8] The varying distances between the two layers of envelopes create spaces of different sizes and qualities, the largest of which generates a semi-outdoor room with a larger plantation. The middle size

[6] This student project was designed and developed by Matteo Lomaglio. For further reading on the project specifications, please refer to (Saeidi Derakhshi, 2017, pp. 28–33).
[7] This student project was designed and developed by Léa Guillot.
[8] This student project was designed and developed by Simon Heidenreich.

provides balcony-type spaces, and the narrowest distance becomes a space for climbing vegetation or small pots. Semi-closed spaces, balconies, and small pockets for vegetation all work as a whole to accommodate a green layer that modulates daylight according to the spatial needs and size of the room behind it. The façade units provide a vertical glass disk fixed to a rod at adjustable angles that correspond to light and ventilation conditions by providing different amounts of reflection and wind deflection.

The other project – a stadium in London – was the diploma project of the student in question, and she was in the early design stage when the workshop was held.[9] She chose to work on a kinetic skin as a second layer of the envelope to form a semi-closed in-between space for the outdoor area of the stadium's restaurant/café. The envelope pattern was inspired by considerable investigation of origami-inspired geometries that could be arranged in a kinetic array to form a sensor-based smart skin. As the café was located adjacent to the tennis courts of the stadium, its outdoor space had to provide a secure environment from which users could sit and watch the matches; this led the design to considerations of sensor-based skin that detects motion. The aim was to have a semi-open façade system that would react to a tennis ball by closing to protect the spectators sitting in the café area. Nevertheless, the complexity of motion detection and reaction speed of the façade – especially considering the sharp edges of the façade geometries – required extensive considerations of security issues. Eventually, these considerations pushed the decision-making on the envelope design to a closed façade with a mix of transparent and opaque materials to provide a secure view. The kinetic system was then coordinated with daylight detection and atmospheric considerations of light penetration and patterned light aesthetics. The issues surrounding the potential security risks of the sharp geometries in the design project could not be resolved within the designated time frame of the workshop.

The shortcomings of the physical tests conducted with Arduino-based sensors made it difficult to draw conclusions in a comparative and reflective model. These shortcomings can be identified as the low precision of the conducted radiation analysis due to the sensor's limitations, and the inaccuracy of material qualities of the physical models in meeting the material specifications of the designs. Another aspect encountered frequently with data collection concerns communication between the tools and the code; this has mostly been resolved on-site by adjusting the code, re-uploading the data, checking the wiring and connections of the sensors

[9] This student project was designed and developed by Karen Maria Eiken-Engelgård.

and tools, etc. Another common difficulty is the long analysis time needed if the surfaces of study are complex or too numerous. For instance, the analysis of the new façade system for the rehabilitation center crashed many times because there were too many input surfaces. In such instances, we chose a portion of the façade whose size corresponded to the space to which it was affiliated and used this for the studies. Based on that, we could draw the initial conclusions needed to then apply to the overall design for other extensive analyses.

Discussion and Conclusion

Although the task of designing inhabitant-based interactive operations in the envelopes was open to both automated and manual mechanisms, with the exception of one, all projects let to sensor-based or automated setups. The designed setups operated either through corporeal and incorporeal interactions of the inhabitants, or via automated setups responsive to climatic conditions. Arguably, the inclination of the designs towards mechanically operating installations is intimately linked to contemporary culture and today's high dependency on electro-mechanical equipment. One of the architectural operations is usually described through moveable mechanisms that either perform an action by having a range of motion as a response to a stimulus or an environmental change. These movements are controlled either by manual operations, mechanical, electrical, or digital mechanisms. The task of such operations is generally the mediation of environments, and the design of elements that accommodate these operations called the device paradigm (Leatherbarrow, 2009, p. 53).

Manual as well as mechanical architecture benefits from interactive systems to enhance the flexibility and adjustability of architecture to meet the requirements of interior spaces in relation to exterior conditions. The mechanical operations of building skins are commonly known as systems with higher energy efficiency with less or no representation of their excessive energy consumption rates. Rather than orchestrating efficiency, the interactive envelope design workshop aimed at examining the designs for fulfilling effective and adjustable systems that provide the flexibility required by the studio project brief in terms of the programmatic changes of the space. Effective systems within the scope of the research do not only include and focus on automatized systems with high efficiency focuses; instead, they provide systems that are open for modifications by latent inhabitation and adjustments in correspondence to climatic conditions and programmatic changes. The research and teachings in the workshop neither encouraged nor limited the application of different operational setups for

the designs, but urged students to have strong justifications for their choice of envelope interactive systems. The designed setup needed to firmly address the project's local conditions whilst strongly relating to the design concepts and the chosen typology of the envelope. The result was a complex, interrelated system that was hard to tackle with the methods used to test the designs.

Another shortcoming of the applied methods in the workshop on climatic tests concerned climatic analysis inputs. We had to analyze the designs with open-source data from Oslo's meteorological institution and pick data from the closest weather station based on the location of each individual project. Since the designs were tackling specific, detailed issues of the envelopes, there were questions of accuracy and validation of analyses. Investigations on local specificity and climatic design demand at least one annual cycle of climatic data that, collected specifically from the project site as input for the design process. Lacking wide range inputs for the design process tends to position the design in assumed and speculative design strategies.

Nevertheless, the examined design process of the workshop provided a framework through which I could reflect, realize, position, and examine the methods developed for my research and narrow down the mappings of conceptual approaches and taxonomy of the envelopes. The workshop thus functioned as a filter for the conceptual approaches, not only by identifying the concepts that generally needed to be addressed in the envelope design process, but also with regard to mapping the relations and dependencies between various concepts and their corresponding types of envelopes.

The research thus attempted to develop and elaborate further on the envelope's taxonomy along with the narrowed down list of conceptual approaches, and the author would then analyze and develop the two sets to present relations and interdependencies between them as a refined, applicable guideline for the design process of architectural envelopes.

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Productive Landscapes Workshop

October 17th – November 11th 2016

RCAT | ACDL Studio, Fall 2016
The Oslo School of Architecture and Design

Studio Tutors:

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Asst. Prof. Søren S. Sørensen
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Abstract

This report presents the activities of a focused design period in the Productive Landscapes studio project in the RCAT | ACDL (Research Centre for Architecture and Tectonics, Advanced Computational Design Laboratory) studio during the fall semester of 2016. As an integral part of my research project, I conducted four intensive design weeks at the studio, during which students were asked to closely focus on the progress of conceptual approaches and the inquiry into designing their projects' transitional spaces. In addition, I was engaged in weekly tutoring throughout the semester to undertake further investigations in relation to my PhD research, aiming to assess and develop the iterative research-by-design component model of my research project. The evaluation and analysis process focused on the performative aspects of the designs. This report presents an outline of the design process and the challenges encountered by students in applying different procedures and methods in the focused design period. The research thus aims to identify the shortcomings of the approaches and methodology for further development in connection to my PhD research project: Inhabiting the Architectural Envelope – A Design-based Research on Redefining the Climatic and Atmospheric Performances of Architectural Envelope. The research seeks to redefine the current notion of the building envelope through its spatial organization, climatic, and atmospheric performances. The studies are framed within the context of location-specificity of built forms and examine the envelopes' performance in creating in-between inhabitable spaces with considerations of climatic designs and atmospheric effects.

Introduction

Landscapes are an essential component of both urban and rural areas. Although they are approached differently within these two contexts, they are a platform for the co-existence of various species and organisms and shape a diverse environment of a complex cultural mosaic. Currently, a significant portion of government funding and national budgets are allocated to urban domains of construction and rehabilitation. As a result, the scope and efforts of many architects, city planners, and landscape architects also tends to remain mostly at the city scale. Within this domain, the significance of rural areas is diminishing, and the cultural identity, national character, and knowledge that has been passed and refined through generations and ages of experience are being lost.

Arguably, historical land use patterns in rural landscapes were mainly focused on cultivation and food production; the dependencies and relations between human beings and their natural environment are strong. These patterns indicate how the complex interrelations that began as survival methods have resulted in the development of cultures and agricultural knowledge over generations and throughout communities. Apart from their agronomical and economic value, production efficiencies, and collective structures, landscapes are a platform for cultural identity and long-rooted traditions. Rural landscapes are consciously and systematically constructed structures on which humans, in the course of their productive agricultural activity, impose natural landscapes (Sereni, 1961). In cultural landscapes, then, culture is the agent, the natural area is the medium, and the cultural landscape is the result (Sauer, 1926). Although some of the productive landscapes are currently regarded as cultural heritage, many others are abandoned, leading to dense forestation and the loss of diversity in existing landscapes (Agnoletti & Emanueli, 2016). Cultural landscapes promote the survival of cultural biodiversity, preserve local identities, and support tourism as well as sustainable and rural development. As such, a greater level of interdisciplinary engagement and collaborative research seems essential to underline the potentials and contributions these landscapes can offer their local contexts. These investigations should attempt to establish a model of integration that contains rich biodiversity.

Tuscany, Italy is known for a long history of wine production and traditions in developing productive cultural landscapes. Vineyards have traditionally, been constructed as terraced landscapes as a way to contend with steep slopes and prevent soil erosion and landslides whilst improving the microclimate for agricultural production. Today, many of these landscapes have once again become sloped landscapes, as terraces have been removed in favor of economic benefits on maintenance and production and to facilitate the use of large machines in agricultural production. In productive landscapes, the divisions, layouts, and management methods are affected fundamentally by industrialization and the use of machines. In the vineyards, this industrialization is driven by how the vintner wishes to grow the grapes. Traditionally, the terraced landscapes included soil and water management, and as mentioned above, the resulting microclimate has seemed to improve the quality of the produced wine. Influential factors for the quality of the produced wine include the vineyard's altitude, orientation and thermal conditions. Ongoing studies confirms the significant impact of dry stonewalls by "[…] heat-storing function that gives back thermic energy accumulated during the day, creating a particularly favorable microclimate […] " (Contessa, 2013, p. 30). Vintners believe that dry stonewalls extend

the effective temperature (20-30 degrees centigrade) necessary for the photosynthesis of the plants and are thus important for the quality and taste of the matured grapes.

The RCAT | ACDL studio at The Oslo School of Architecture and Design (AHO) engaged with this problematic through research-by-design and architectural projects that address their local landscape and are embedded in it as one of the main design criteria. The site of the studio design project site in the fall semester of 2016 was the vineyard Grospoli in the village of Lamole in the Chianti region of Tuscany. The designs examined ways of embedding and integrating with this productive landscape through material and spatial organizations, and they sought to address conditions of the landscape such as the microclimatic ranges necessary to promote viticulture.

The studio brief asked for the design of a visitor center with research facilities and accommodation for six staff members that could be converted into a holiday residence for up to six family members. The design encompasses 200 sqm, one-third of which was to be designed as transitional spaces between the exterior (as the most exposed) and the interior (as the most enclosed); the brief focused on transitional spaces to examine passive design solutions for negotiating interior and exterior climatic requirements. The task demanded built forms that transcended the object orientation of architecture by emerging from a magnitude of interactions between architecture, climate, and agriculture. Consequently, the brief asked for active engagement of designs with the surrounding exterior by incorporating at least 10m around the transitional spaces. In September 2016, the studio staff installed a network of measure stations to collect microclimatic data from two selected terraces of the Grospoli site for research purposes, but also to provide the students with a short cycle of site-specific weather data. The site-specific data included three months of measurements collected by weather stations mounted on the site that collected data on solar radiation, air, and soil temperature and humidity, wind direction and speed, and precipitation. This data was cross-referenced with climatic data from the local meteorological station, located approximately one kilometer from Grospoli.

The designs were to address ways of providing ranges of microclimatic conditions without interrupting the production of Grospoli's high-quality wine, but stimulating, integrating, and operating with it. The projects thus aim to lift the discussion towards the identification of methods of architectural synthesis by which the built form can relate and connect to its broader context. The design process required various characteristics and

interdisciplinary knowledge to establish an understanding of the range of built forms' effects, both on their immediate and more further removed surroundings. By studying this traditional terraced vineyard and its microclimates, students worked to understand and propose new ways of constructing architecture in such historically developed contexts. The collected data sets facilitated an understanding of the specificities of various terraces for cultivating grapes at an altitude of 600 meters.

During the intensive design weeks, students were asked to develop project designs with a focus on the transitional spaces. The studies attempted to underline the role of this threshold as the area in which the mutual effects between the built and existing landscape operate and can be defined. These objectives are directly related to my research questions on defining ranges and the types of effects that the building envelope subjects and is subjected to from its adjacent exterior and interior spaces by becoming an in-between threshold.

Methods, Process, and Outcomes

The intensive design weeks commenced with a series of lectures,[1] the themes of which were intended to strengthen students' understanding of transitional spaces and threshold conditions, as well as of how to build a systematic approach for mapping interrelated existing factors in design. These were expounded on using built examples of both contemporary and historical projects from around the world. Along with the studio lectures, students also attended lectures held by interdisciplinary scholars and experts in productive and historical landscapes at the University of Florence during their study trip to Lamole. These lectures provided an overview of current issues and challenges faced by cultural landscapes in Tuscany, and in Lamole in particular. The lectures provided the preliminary knowledge about a vineyard's specific requirements and demands, e.g. vine spacing, training, trellising, row direction, pruning practices, soil and drywall management, and accessibility regulations.

The discussions facilitated the progress of the intensive design weeks with a text assignment in which the groups were asked to deliver a thorough description of the concepts and aims of their design project. The description

1 Lectures series included: "Correlating Spatial, Sectional and Programmatic Strategies" by Prof. Dr. Michael U. Hensel, "Enacting Effects in Architectural Envelopes," and "Transitional Spaces - What? Why? How?" by Sareh Saeidi, "Computational Ontologies" by Hon. Prof. Dr. Julian Vincent, and "Material Ontologies" by Defne Sunguroglu Hensel.

was intended to expound on the primary design elements and approaches with which each group was aiming to achieve their concepts. This was to position the leading conceptual approaches of transitional spaces in accord with the overall design aims of each group. By doing this, the groups started to identify the elements of the terraces with which they wanted to engage and how they wished to do this. The orientation and positioning of different projects thus varied from direct association with the main structure of the built landscape to careful positioning on its outer borders. The conceptual approaches of each group demonstrate how the built form accommodates a dynamic relationship between landscape, human, and climate. Different groups attempted to utilize concepts that emphasized and intensified this dynamic interaction. The concepts varied from employing terraced structural elements such as water basins and dry stone walls to the movement of the human body within the landscape, the proximity and views in defining horizons of the built and the natural, utilizing the body's senses to accent human perception of productive landscapes, and climatic conditioning in correspondence to human comfort. The groups' tailored design approaches and processes enabled them to tackle specific challenges of their designs and related analyses. To address these varying approaches within groups, one of the initial discussions in the first week concerned the identification of data types and toolsets required for the intended concepts and aims of the projects. The iterations in the design process provided the flexibility necessary for alternating between different toolsets, if needed, to fulfill the design goals of each group.

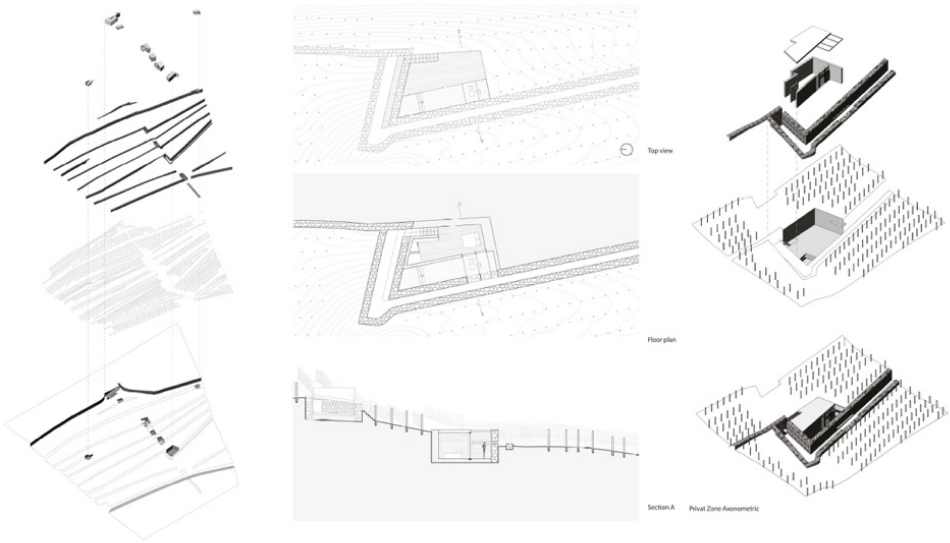
The overall aim of almost all of the groups was to create a theme for the built space that would amplify the experience and understanding of productive landscapes. Two of the groups chose to emphasize the theme of a journey to achieve this, nevertheless, their approaches and tools of analysis were different. Group One[2] used hand sketches and photographic studies to engage with the visitors' movement in the terraces and to emphasize various adjacencies and tactile elements along with the captured views of the surrounding landscapes. The photographic studies assisted in indicating specific locations on the site, and the story-telling method of hand sketches helped in illustrating the degree of the design's interference, thus enabling the group to successfully communicate and develop the qualities they were aiming to achieve. The notion of transition was thus unfolded as changing states in the visitor's journey along the designed path, corresponding to specific purposes. This designed journey is rather a landscape design experience that eventually ends in a building facility. The building is a

2 Students: Ignacio Madinagoitia & Gunnar Sørås.

composition of semi-open and enclosed quarters that accommodate different programs. The design flexibility of the semi-open rooms shapes transitional spaces that consolidate the continuity of the exterior in the interior space through spatial openness and varying degrees of climatic shelter.

Group Two[3] activated the concept of a journey through existing site patterns focusing on stonewall edges, vine rows, and water cavities. The dry stonewalls act as wind barriers against the prevailing west wind whilst also shaping the designed walkways. Vine rows provide alternative access points to the main designed path, and the attributed functions of water cavities differ depending on their adjacent program. The main aim was to emphasize how to build semi-sheltered spaces through which the body meets the dry stonewalls at various levels and horizons by building above, beneath, and alongside these walls. Different tools of analysis were employed in the design process to encompass the concepts of utilizing stonewalls and water cavities as the primary constructs of the transitional spaces. Therefore, the studies actively engaged in the progressive use of serial sections and analytical diagrams as tools for developing the spatial organization and its interrelations to the existing landscape. These also included iterative solar radiation and shading analysis throughout the process as part of the analytical toolset for developing the design.

3 Students: Andra Nicolescu & Kristian Taaksalu.



Group Three[4] sought to engage the basic human senses to intensify learning through experience of the landscape. To do this, they closely mapped the wine production process, the involved figures and representatives, and the factors that affect the quality of the produced wine. The resulting mind map consisted of the interrelation and dependencies between various components that led to grouping activities and functions in relation to specific senses and locations on site. The locations were spread across the entire terrace landscape to provide the primary elements necessary for intensifying particular human senses in each location. The choices of locations also involved extensive studies of the existing site patterns and structure of the landscape, including water runoff, vine rows, stonewalls, water basins, and machine paths.

Group Four[5] worked intensely with the concept of microclimates in relation to human comfort. The group benefitted from the concept of free-running buildings and adaptive thermal comfort to define various impact factors in buildings that accommodate climatically conditioned and inhabitable spaces throughout different seasons. Free-running buildings (de Dear & Brager, 1998) is an integrated design approach that addresses issues of thermal comfort and climatic tolerance through spatial and material organization. These inhabitable microclimates aim to provide zones with varying levels of comfort and characteristics that correspond to their use and program. The required gradient of microclimates was strategically designed through the

4 Students: Peder Pili Strand, Laura Traub, Xianwen Zheng.
5 Students: Joar Tjetland & Maria Lagging.

architectural modifiers of the project: walls, flooring, screen walls and roof, and the specifications for attributes of inhabitation. Factors such as heat storage, shading, natural ventilation, and precipitation were applied as design drivers to enable flexible use of the transitional spaces. The design took advantage of the thermal capacities of soil by embedding the visitor center in its surrounding terrace landscape, allowing for a low-tech solution with an efficient microclimate for the enclosed spaces of the project, which actively engaged with their architectural modifiers to lend flexibility to the design. The tests and analyses were conducted through associative modeling, the framework of which was formed by interconnected factors of materiality, program and inhabitants' activities and clothing. The iterative design process included an extensive mind map of the project's architectural modifiers through which the experiment arrived at a clear focus on the atmospheric and climatic intents of the group. The subsequent analyses of the thermal conditions were conducted mostly through Ladybug and Honeybee plug-ins.[6] Nevertheless, modeling and analysis of distinct thermal zones within the rooms was a challenge for the design group due to the difficulty of simulating various temperature zones and patterns that corresponded to the close interconnections of influencing thermal factors. The difficulty was most apparent in utilizing concepts of adaptive thermal comfort in transitional spaces due to their spatial openness. However, other analyses resulted in the identification of necessary interrelations and critical reflections that facilitated the development of the design. The simulation outlined interdependent factors in the organization and materiality of architectural modifiers that corresponded to other aspects such as solar radiation as one of the ambient climatic factors, as well as the programs and locations of the rooms, and inhabitants' clothing and activities.

6 Ladybug and Honeybee are two open-source plug-ins for Grasshopper and Rhinoceros that help explore and evaluate environmental performance. Ladybug imports standard EnergyPlus Weather files (.EPW) into Grasshopper and provides a variety of 3D interactive graphics to support the decision-making process during the initial design stages. Honeybee connects the visual programming environment of Grasshopper to four validated simulation engines – specifically, EnergyPlus, Radiance, Daysim, and OpenStudio – which evaluate building energy consumption, comfort, and daylighting (Sadeghipour Roudsari M., Pak M., 2013). These plug-ins enable a dynamic coupling between the flexible, component-based, visual programming interface of Grasshopper and validated environmental data sets and simulation engines. Grasshopper is a graphical algorithm editor tightly integrated with Rhinoceros 3D modeling tools. Rhinoceros is a commercial 3D computer graphics and computer-aided design (CAD) application software developed by Robert McNeel & Associates. Unlike RhinoScript, Grasshopper does not require programming or scripting knowledge, but still allows designers to build form generators from the simple to the complex. Ladybug is a Grasshopper plug-in that enables import and analysis of standard weather data by drawing diagrams such as sun-path, wind-rose, radiation-rose, while providing the flexibility to customize the visualization of various analyses like radiation, shadow, and view in different ways. Honeybee is an energy simulation tool for building energy, comfort, daylight, and artificial lighting analysis. This plug-in connects Grasshopper3D models to simulation engines such as EnergyPlus, Radiance, Daysim, and OpenStudio.

Outcomes, Conclusion and Discussion

In the process of information-based research, learning by action and responding to data through design is compulsory for the researcher in order to develop the research further. To guide the design process towards an informed yet controlled procedure, the researcher must understand the importance of how to respond to the collected data sets, and to what one should respond. This includes how closely the data sets might inform or change the design process and concepts, and how the built knowledge from the analyzed data must be visualized and communicated to correspond to the design objectives. Collecting data sets and information facilitates building the understanding and knowledge of the existing structures by the identification of the problems and strengths within the existing systems, extracting successful models, shaping maintenance strategies by forming value arguments, and building multi-scalar action models for interdisciplinary collaborations. Furthermore, the established knowledge benefits the design process by allowing individuals to determine how to parse the data based on their design intents to test the validity of their pre-imposed scenarios and conceptual approaches.

The productive landscape theme opened interdisciplinary discussions on an enhanced ecology. The intensive design weeks in the studio contributed to establishing the framework of the process and information towards working with and in productive landscapes. The studio project demanded a thorough understanding of the ways in which these landscapes operate and the patterns from which they emerge. The initial stage of shaping this understanding was identification of the type of site-specific data required in relation to the questions and themes of the project brief. Subsequently, and upon characterization of the collected data, we could interpret the data and find its relevance and interrelations. Doing this and building the knowledge needed for design enabled the students to determine how they wanted to intervene and how to convert the collected information into meaningful and applicable information. The intensive design weeks were scheduled at almost the middle of the semester, which benefited the designs with further design iterations and development. Nevertheless, the short cycle of site-specific collected data limited the scope of climatic studies to sensible speculations that were based on the provided data from the open-access climatic records for Tuscany.

The investigations enabled further research on how to develop design methods and analysis toolsets that facilitate the understanding of planned biodiversity in relation to built forms. The developed approach facilitated

the identification of the constructs of a tailored design process and its demand for an interdisciplinary mode of research. As such, the ACDL studio teaching team sought to pursue this initial stage further by developing the examined methods in the studio's design project of the fall semester of 2017. The project brief followed a similar theme and program and sought to explore the designs within the annually collected data that were available for further research and analysis. The workshop's design projects exemplify well-tempered architecture as an inhabitable space attuned to its site specifications while providing climatic shelter and atmospheric qualities for the built space.

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R4

Inverted House Study Trip

April 04th – 07th 2017
Mêmu Meadows, Taiki, Hokkaido, Japan

Abstract

This report describes a case study conducted during the author's visit to Mêmu Meadows in Taiki, Hokkaido, Japan. The visit – from 4th to 7th April 2017 –was made possible by a travel grant awarded by the Scandinavia – Japan Sasakawa Foundation. The purpose was to undertake a study of the Inverted House for the author's PhD research project. The PhD thesis, entitled Inhabiting the Architectural Envelope – A Design-based Research on Redefining the Climatic and Atmospheric Performances of Architectural Envelope, aims to redefine the architectural envelope as a threshold that can be spatially inhabited and experienced. This report gives an outline of the conducted studies and discusses the findings and observations from the visit for further development of the case study in a forthcoming article on the research. The studies focused particularly on the thermal performance and spatial experience of the house; in contrast to the fully closed traditional houses in Japan, the radical design approach for Inverted House included semi- and fully-exposed rooms in Hokkaido's harsh winter climate.

Two parallel data collection methods were applied to conduct the investigations and to understand the climatic performance of the design: the making of a personal record of the perceived thermal comfort, and the collection of weather data from measure stations. The analysis is thus conducted as a mixed method mode of research and includes both qualitative and quantitative data. The two sets of collected data help the research build its qualitative reflections in a comparative model to base its arguments not on hypothesis, but measured data. The data sets are therefore complementary when addressing the research's inquiry. Furthermore, through this approach, the research aims to correct data and the ways in which the data sets can be utilized as principles for envelope's design process.

Introduction

Contemporary architectural practices attempt to design sustainable architectures using strategies like zero-energy buildings, green architectures, or highly efficient and controlled interiors. These approaches tend to treat the building envelopes as a layer of control and insulation against climate and the exterior environment, and thus, independently of their local surroundings; doing this partially or completely ignores one of the effective ways of relating the built form to its surrounding environment through this threshold. Therefore, the author's PhD research project redefines the architectural envelope not as a material boundary to isolate the built form

from its milieu,[1] but as a spatial zone, a threshold, engaged in and affected by the interactions between the built form's outside and inside environments. But is there a start or an end to this threshold? How is the envelope shaped by other architectural elements rather than exterior walls? This specific project is interesting in the context of the research for its radical approach to pushing the limits and patterns of inhabitation in correspondence to thermal comfort and questioning the notion of the enclosure in Hokkaido's extreme climate. The case project challenges the notion of enclosure not by the boundary definition approach to envelopes, but by defining the envelope as in-between spaces shaped by both interiority and exteriority of the built form. The case study, more specifically, exemplifies how the envelope – as a mediator between these two environments – can facilitate inhabitable spaces by providing various degrees of sheltered and comfort. This includes discussions on the definition of comfort and thermal adaptation within the envelope's threshold in terms of inhabitants' expectations, cultural backgrounds and the level of acceptance.

Research Questions and Objectives

The research attempts to identify the thermal conditions of different rooms by collecting climatic data and examining the extents of validity through comparative studies of various data sets. The data collected on Inverted House facilitates a better understanding of the project's microclimate, as well as providing the possibility to create an applicable method for the use of climatic information in the design process. The analysis aims to open discussions on the role of site-specific collected data sets and on the degree to which these affect and inform the considerations and criteria of the design process; this includes questions on how various interrelated data can be correlated, assessed and visualized effectively to become applicable for an informed design process. In addition, it addresses questions on how inhabitants' expectations of a certain level of indoor comfort can affect the perceived temperature and determine acceptance and tolerance of extreme thermal conditions. Through these studies and analyses, the research seeks to develop an operative design approach rather than proposing modification and developments for the case project.

The Case Project's Design Concepts

[1] See Footnote 1.

Inverted House won the 5th LIXIL International University Architectural Competition 2015, sponsored by the LIXIL JS Foundation. Designed by a team of students at The Oslo School of Architecture and Design (AHO) with the supervision of AHO professors, it opened in June of 2016.[2] The competition called for the design of a "House for Enjoying the Harsh Cold" in Hokkaido. The house consists of open, partially and fully sheltered spaces that offer different experiences of the exterior environment. Almost all activities in this house – including cooking, dining, bathing and sleeping – take place outdoors, although there is one fully enclosed room for the event of the very worst unexpected weather conditions. The variation in the house's roof slopes and floor levels accommodates different climatically sheltered conditions that correspond to each room's activity, leading to inhabitable spaces between the enclosed room and its exterior environment. The conceptual design approach of the outdoor rooms and the ways in which they function both as main living spaces as well as interstitial ones gives the house its unique identity. The house's organization of rooms and elements, such as roofs and floors, designates the envelope's threshold as the curator of a desired character and effect. This atmospheric quality only emerges from the integration of the milieu, the inhabitant and the structural systems, including both the material and spatial realms. Thus, the threshold determines the degrees of comfort and shelter of the inhabitant. By addressing the potential of human adaptation for pushing definitions associated with comfort, the house's climatic force and exposure reinvent the primitive relationship of the human body to its climatic environment and dwelling. In these architectures, the adaptation and interaction patterns of inhabitants with their living spaces also open larger discussions on the active engagement of inhabitants with their local environments. These include topics such as perception of daily cycles and seasons, cultural impact on behavioral patterns towards indoor comfort, and flexibility of spatial use based on degrees of shelter and climatic conditions.

When motivating and describing the openness of the project, the design team stated that a house that wants to embrace the cold needs to open itself to the world and control its architectonic environment more subtly; the house would therefore need to bring the outside within. Two intersecting walls form the main structure, creating four inhabitable zones in the house: the garden room, the outside living room, a room for cooking, and the inside room. All zones are exposed to the outdoor environment with the exception of the inside room, which is the only fully enclosed space. The

[2] Student design team: Laura Cristea, Mari Hellum, Stefan Hurrel, and Niklas Lenander. Advising professors: Neven Fuchs-Mikac, Thomas McQuillan, and Raphael Zuber.

house is oriented on a northeast-southwest axis, so the inside-outside character of spaces inverts with the changing of the seasons. As such, the inside room, which is the warmest room in the house in the winter, becomes the coolest shaded room during the summer. Furthermore, the exposed rooms that challenge the inhabitants' comfort during harsh cold winters become pleasant, shaded, open spaces from which in enjoy summer breezes. The roof angles and heights are designed to either stop the wind and create sheltered areas, or to capture and redirect it to collect snow in the garden room (Illustration 1). Except for the few hours in the mornings, the garden is shaded throughout the day; as a result, the snow collected there will remain there until late spring, intensifying the atmospheric mood of coldness in the inside room (Illustration 2).

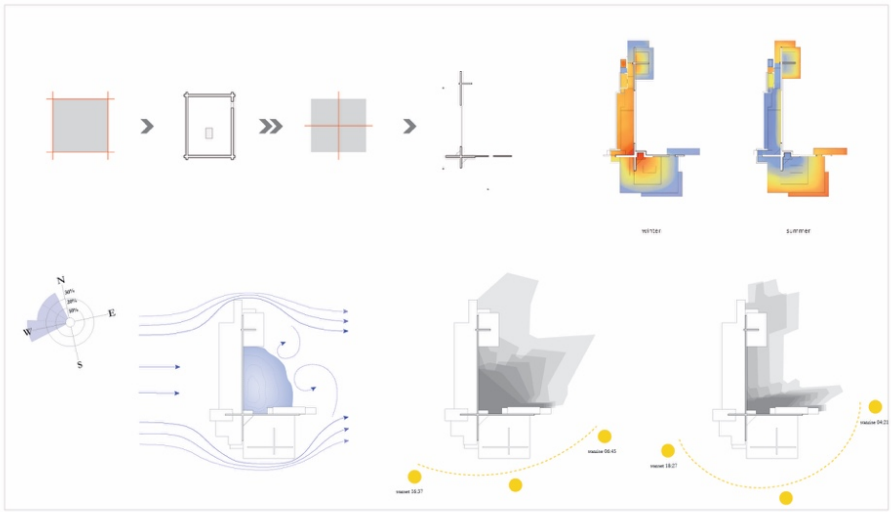

Illustration 1: Diagram representations of Inverted House:
Top right: The design concept of the house, illustrating the conversion of the traditional Japanese introverted plan to an open extroverted organization; Top left: Thermal condition of the house during winter and summer; Bottom: the spatial arrangement, wind, and shading analysis for snow collection in the Inverted House in Hokkaido, Japan. Diagrams produced by the AHO team in 2015.

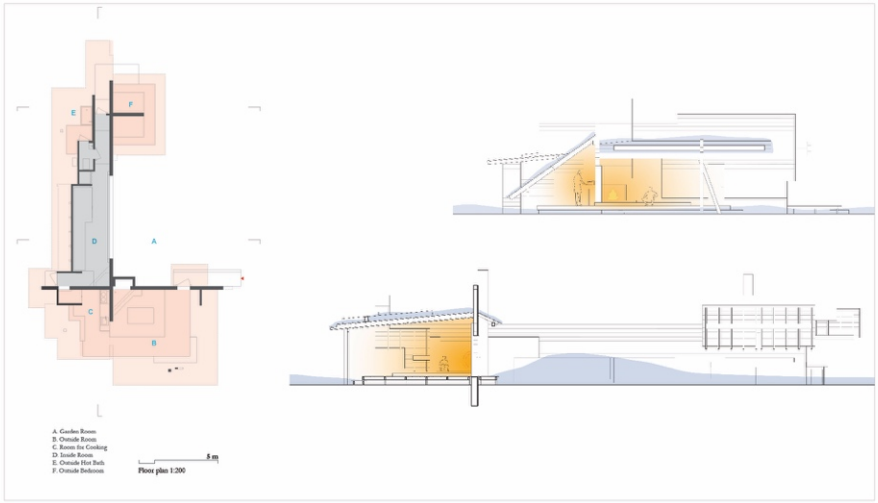

Illustration 2: Plan drawing and sections of the Inverted House produced by the AHO team in 2015.

The view from the low-height longitude window of this room allows appreciation of the room's peaceful atmosphere and the joy of watching the calm, beautiful cold behind the window. It is thus upon inhabitation that the house finds its breath of life, perhaps as all architectures do, and it is then that the house is heated enough to accommodate a comfortable stay. In the initial design concept, the two fireplaces heat a small water container, the content of which is then circulated through pipes to the inside room and outside sleeping area by floor heating (Illustration 3); unfortunately, this floor heating system had to be abandoned due to the project's restrictive construction budget. The stereotomic elements of the house, including concrete walls and indoor wood block floor, provide the thermal mass and inertia necessary for both cold and warm seasons. Furthermore, the project's tectonics consisting of roofs and the exterior floor slabs modulate the degrees of shelter and atmospheric effects of the rooms.[3]

[3] The descriptions of the project's concepts and aims are based on the author's readings of the booklet of the design project published at AHO as part of the design team's competition entry in April 2015.

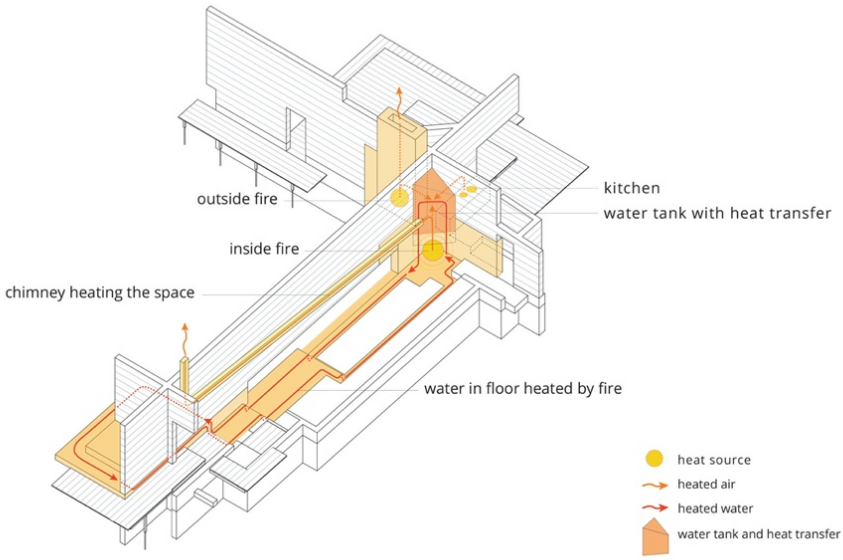

Illustration 3: Representative drawing of heating system of the Inverted House produced by the AHO team in 2015.

Methods and Tools

Designing within the theme of architectural performance and local specificity requires the collection and analysis of various sets of regional and local information. Today's means of collecting contextual data and retrieving information from online open resources facilitate access to the essential information for the design. Technological resources make it possible to build or customize data collection tools and measurements in the event that the necessary local data is unavailable or difficult to access; such might be the case for e.g. locations with high specificity or difficult accessibility, or when detailed information and high precision of data is required. Various information-based design methods and assessment models facilitate improved understanding of the complex environmental and contextual conditions of built forms and their interrelated networks within the framework of local specificity in architectural design. The utilization of information-based mechanisms and analysis offers a framework for observing and examining the complex interrelations, dependencies, and interactions between architectures and their surrounding

context, leading to non-discrete architectures.[4] These architectures perform by implementing and utilizing factors from their local environment to build their design features, attributes, and atmospheres. They seek to create spatial meaning and harmony through their eminent awareness of occupying a location, their tectonics and material presence, their internal forces, relations, and spatial orders.

Studying the house's eminent spatial organization and its complex dependencies of thermal comfort and understanding the constructs of the project's spatial realm would not have been possible without living in the project. Although the trip was short, the visit made it possible to identify the elements that addressed the initial concepts of the project most effectively, as well as to collect measured data on the thermal and climatic conditions of different rooms of the house. A mixed method mode of inquiry consisting of both quantitative and qualitative studies was applied and included installation and use of measure stations to collect climatic data on the house's microclimate and the recording of the subjective experience of the house's perceived thermal comfort and atmosphere. The short duration of the visit allowed for only two days of data collection and one day for assembling and disassembling the setups on site. The collected data and written observations address the questions on the relation of the body and the exterior wall and how thermal comfort affects this relationship. The data sets act as references for the perceived temperatures during the stay, in addition to verifying the thermal design concepts and presumptions of the house. The exploration therefore studies the case example's ways of crafting the experience of the architectural envelope through its inhabitable climatic environment. The focused areas of the studies include the identification of the elements that define enclosure and shelter, the atmospheric effects of various rooms, and the role of spatial and material adjacencies in intensifying or decreasing these atmospheric qualities – especially with regard to the inhabitants' thermal comfort.

The equipment chosen for data collection included both custom- and commercial setups for economical and practical reasons. The short visit and the project's location were the main reasons for purchasing commercial weather stations rather than setting all the stations by custom-made Arduino setups – the project site, Mêmu Meadows, is a 30-minute drive from the closest village in which materials and electronics for fixing measurement

[4] Non-discrete architecture is a term borrowed from Michael Hensel. The author uses the term in her dissertation and research to refer to built forms that integrate with and correspond to their local conditions and surrounding environments through their design strategies and considerations. For further readings on Hensel's definition of the term, please refer to (Hensel, 2013, pp. 31–43).

setups could be purchased in the event of practical issues. There is one mounted weather station located in the garden room of the house, and a control station in an open field relatively nearby, on the west side of the house. The station in the garden included nine thermo-hydrometers for temperature and humidity data collection of nine various locations in different rooms, and two wind sensors located on house's north and south sides recording wind speed, wind direction, gust, and chill. The main station was mounted on a wooden stick 70 cm distance from the ground. The positioning of various sensors corresponded with the research's questions on envelope's tectonics and material organization, degrees of enclosure, and the direct effect on thermal conditions of the rooms. As a result, the thermometers were all located on wooden surfaces and a minimum of 30 cm from the closest walls, and at least 40 cm from the floor. The control station was mounted in the fields to collect reliable ambient climatic data and included one thermo-hydrometer and wind sensor. It was mounted 130 meters from the house and 70 cm above the ground, and there were no adjacent obstructing constructions or vegetation. The data collected by the control station covers the climatic data of 48 hours that provides the necessary context data for the house's 24-hour data collection. A map showing the location of weather stations is included in the appendices of this report, as a visualization of the collected data.

The data collected in this short cycle is used as a model to illustrate how the approach can be applied to larger data sets of a similar type. Moreover, it deepens the understanding of the climatically conditioned rooms by serving as a reference for the perceived temperature and thermal comfort. Three factors – humidity, wind condition and temperature – were pinpointed as data sets for the analysis of the house's thermal comfort and its corresponding inhabitation patterns. A comparative study of various data sets collected from the sensors located in different rooms of the house indicated only several degrees deviation between measurements; this confirms the validity of the analysis model and mapping method of the house's thermal conditions. Nevertheless, overlaying and analyzing the variables on a collective body of data, these mapped deviations open for interesting discussions on free-running buildings (Nicol & Pagliano, 2007) and data processing of location- dependent designs. Location-dependent designs, in the view of this research, include built forms that function in specific ways that are directly dependent on their local context, and within a particular time cycle. Complementary to this, free-running building argues for design provisions that address a variety of indoor climates through the joint necessity of non-discrete architectures with the inhabitants' adaptation abilities. The approach includes design strategies that implement concepts

such as inhabitants' acceptance, adaptive capacities, and expectations from the built (indoor) environment by modifying clothing, activity, and spatial arrangements (2007).

The collected data sets from the control station, the house station, and the region's weather forecast database were compared and analyzed to correlate the data for a more extensive analysis. In Japan's meteorological archive, a factor of "feels like" is also forecasted as "human thermal comfort". This factor is considered in comparison with the personal record of Inverted House's perceived thermal conditions. The collected data sets of the research consist of groups of measured data with specific variables. These climatic data sets enable the research to form a comparative analysis between the data sets of varying intervals. The intervals indicate differences and distances between the measurements in various data collections. These intervals, especially regarding sets such as perceived temperature and thermal comfort, may prompt significant disagreements due to their greater inaccuracy, dependent on subjective preference. Nevertheless, analyses of correlational data sets help the research project to clarify patterns of relationships between various quantitative and qualitative collections of data with common variables.

Outcomes, Discussions and Further Analysis

The conducted studies and record of the spatial experience are presented as outcomes of the case study visit in this report, as well as in an additional report written as a descriptive narrative during the visit. Both are included in the Appendices of the PhD dissertation. The extensive analyses and reflections on this project is presented in Article 3 of the research as part of the case studies analyses. Through the further investigation, the author aims to utilize the collected data to generate mappings of rooms' patterns of use concerning the thermal comfort. This mapping includes identifying the project's significant architectonic elements concerning the human body by analyzing factors of proximity, materiality, shelter, and heat distribution in leading to inhabitation or reluctance to inhabit different spaces. The author thus hopes to characterize the investigation's divergent data (quantitative and qualitative) to examine the possibility of developing a systematic map. The map intends to distinguish the attributes of different inhabitation patterns by identifying possible relations between architectural elements (Being-in-the-world) and inhabitants (Being) (Merleau-Ponty, 1968, pp. 130–155).

The abovementioned article sought to characterize these divergent data sets to establish ways of generating relational models that identify methods and patterns of data utilization during the design process. The outcome of the analysis thus leads to a design guideline in which the iterative information-based design process includes different stages of identification, utilization, and analysis of the data. These stages include operations such as identification of types of the data needed before the start of the design process, limitations and strengths of such data sets, data collection methods and tools of specific data sets, methods of data processing, and analysis for and during the design process.

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Appendices

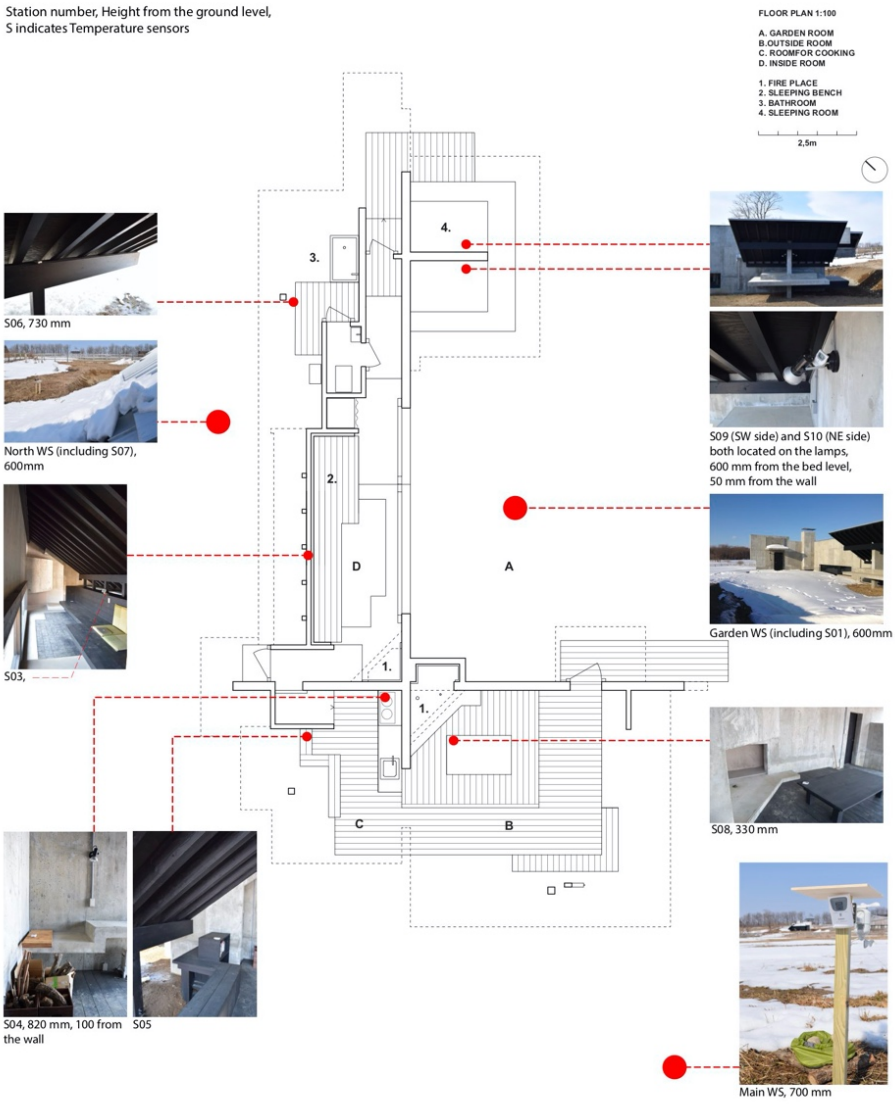


Figure 1. Position of weather stations placed inside and outside Inverted House, Sareh Saeidi, 2017

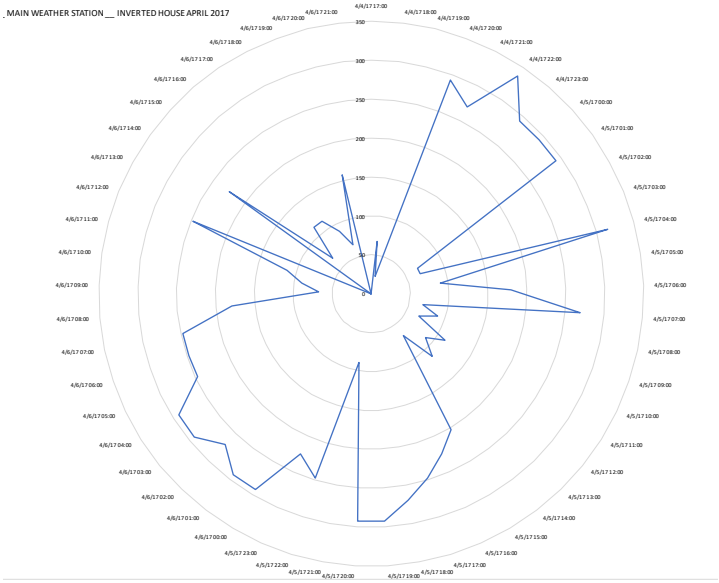


Figure 1. Gust direction (degrees), Main weather station, Inverted House, April 2017

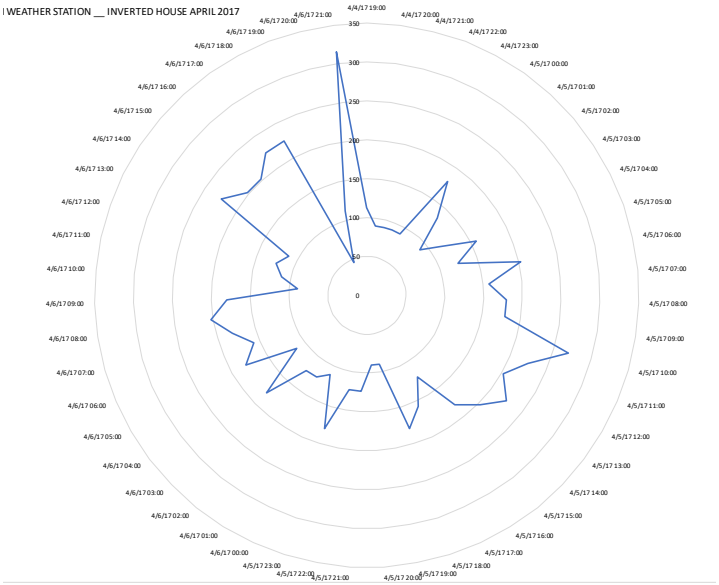


Figure 2. Gust direction (degrees), Garden weather station, Inverted House, April 2017

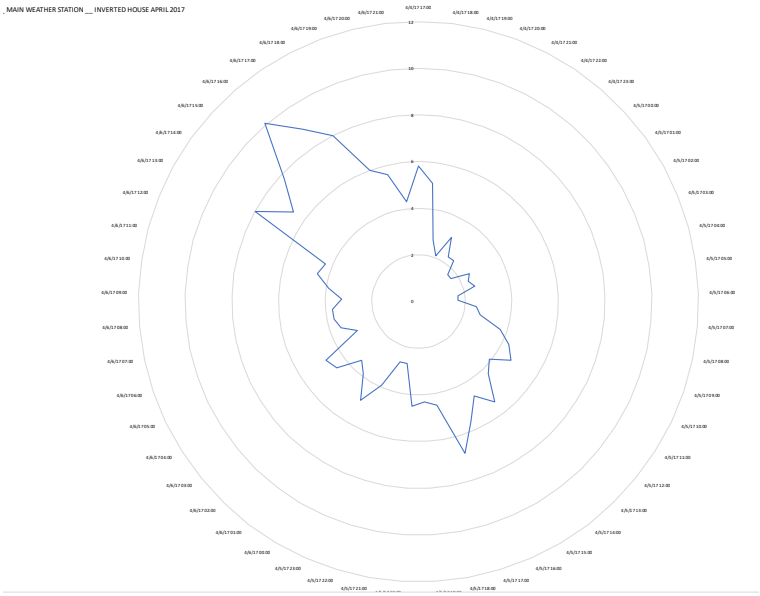


Figure 3. Gust speed (knots), Main weather station, Inverted House, April 2017

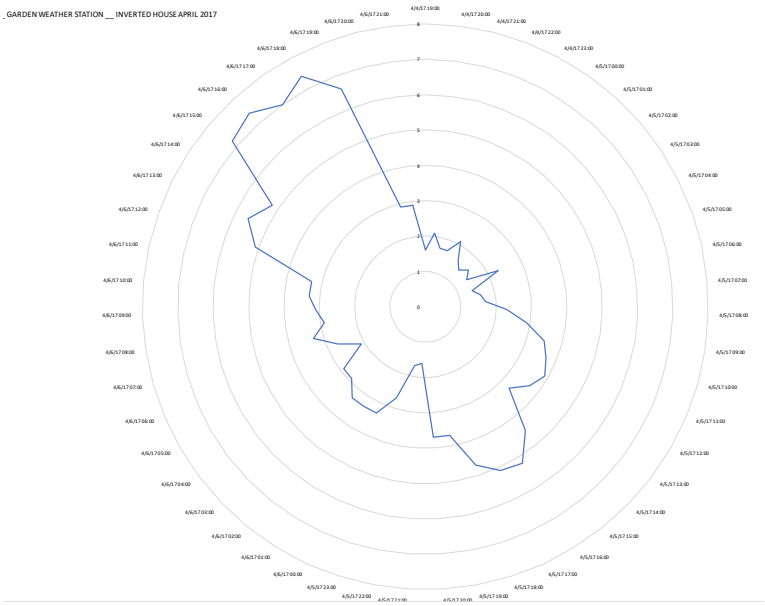


Figure 4. Gust speed (knots), Garden weather station, Inverted House, April 2017

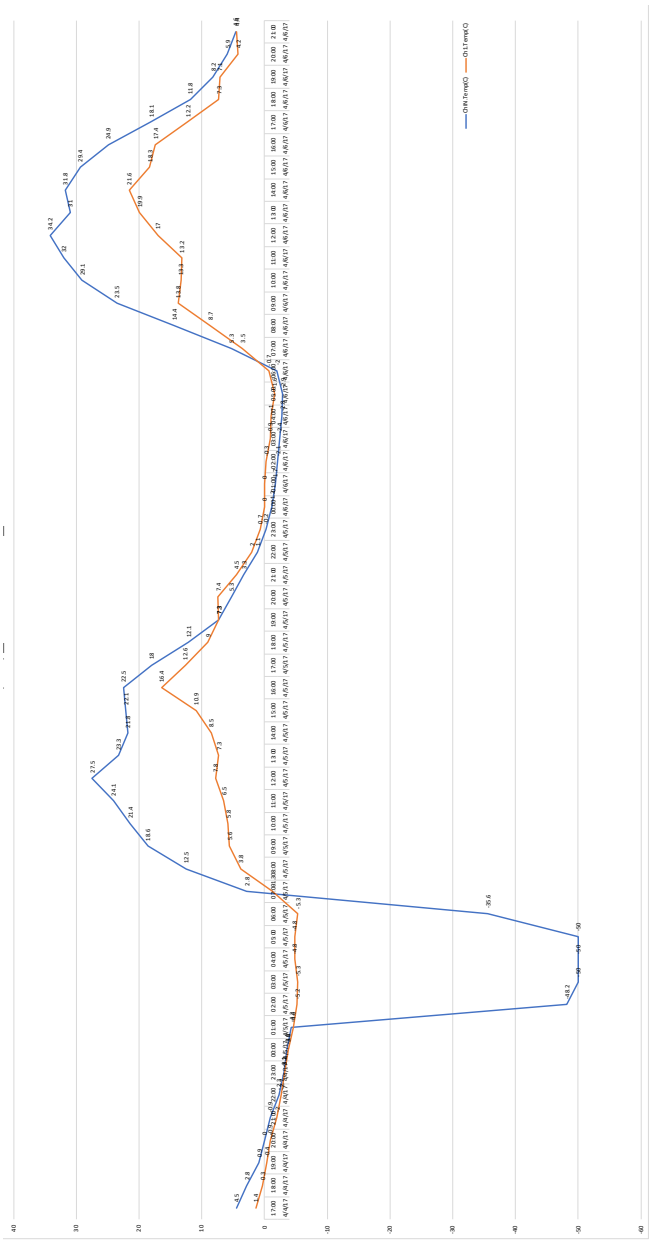


Figure 5. Temperature Values (Celsius), Main weather station, Inverted House, April 2017

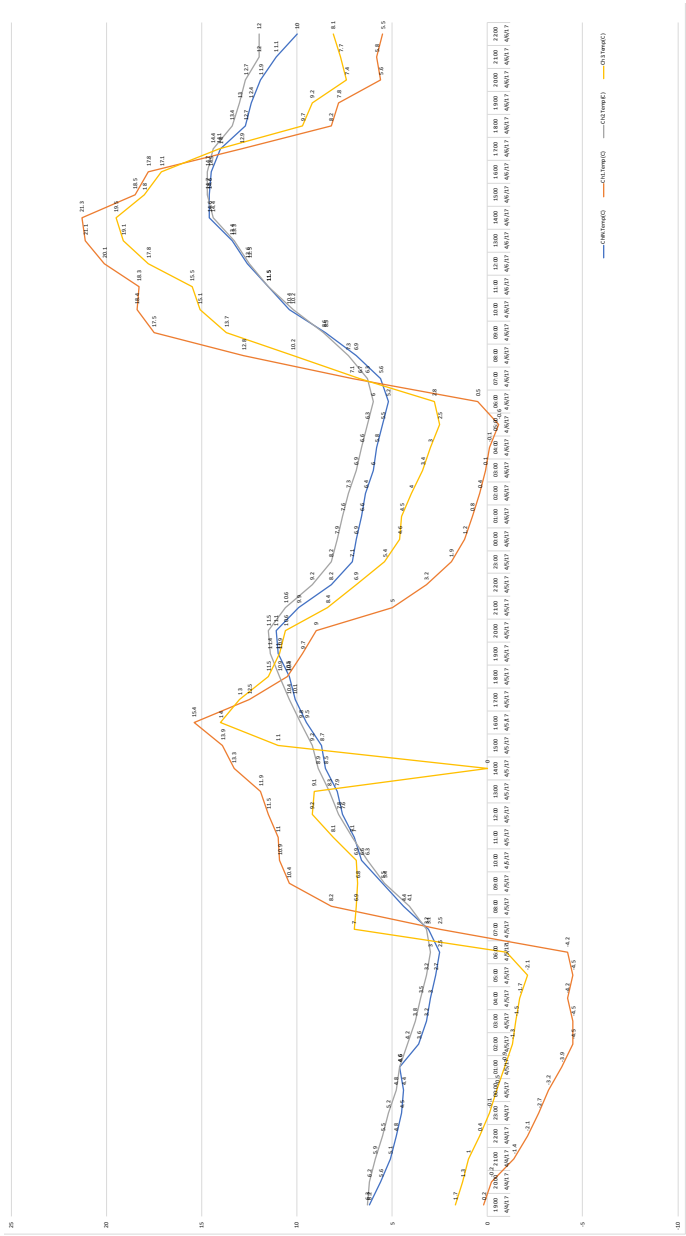


Figure 5. Temperature Values (Celsius), Garden weather station, Inverted House, April 2017

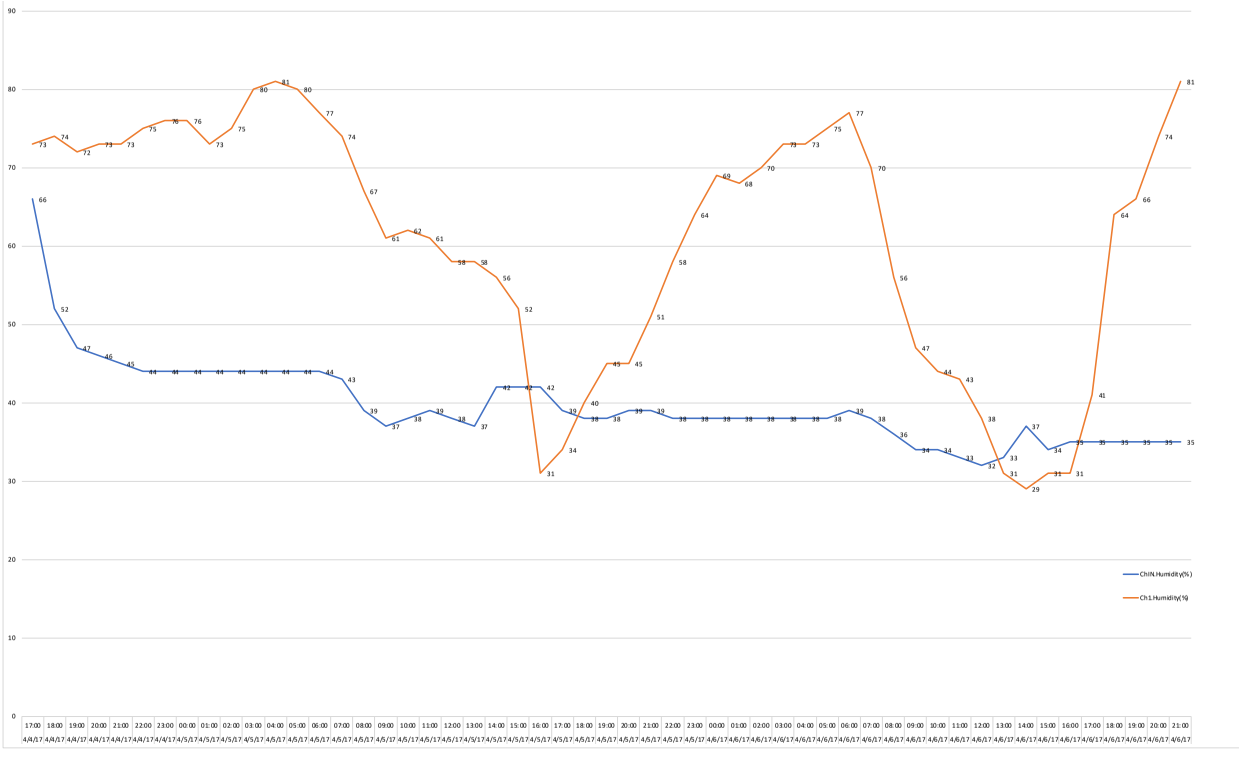


Figure 5. Humidity Values (%), Main weather station, Inverted House, April 2017

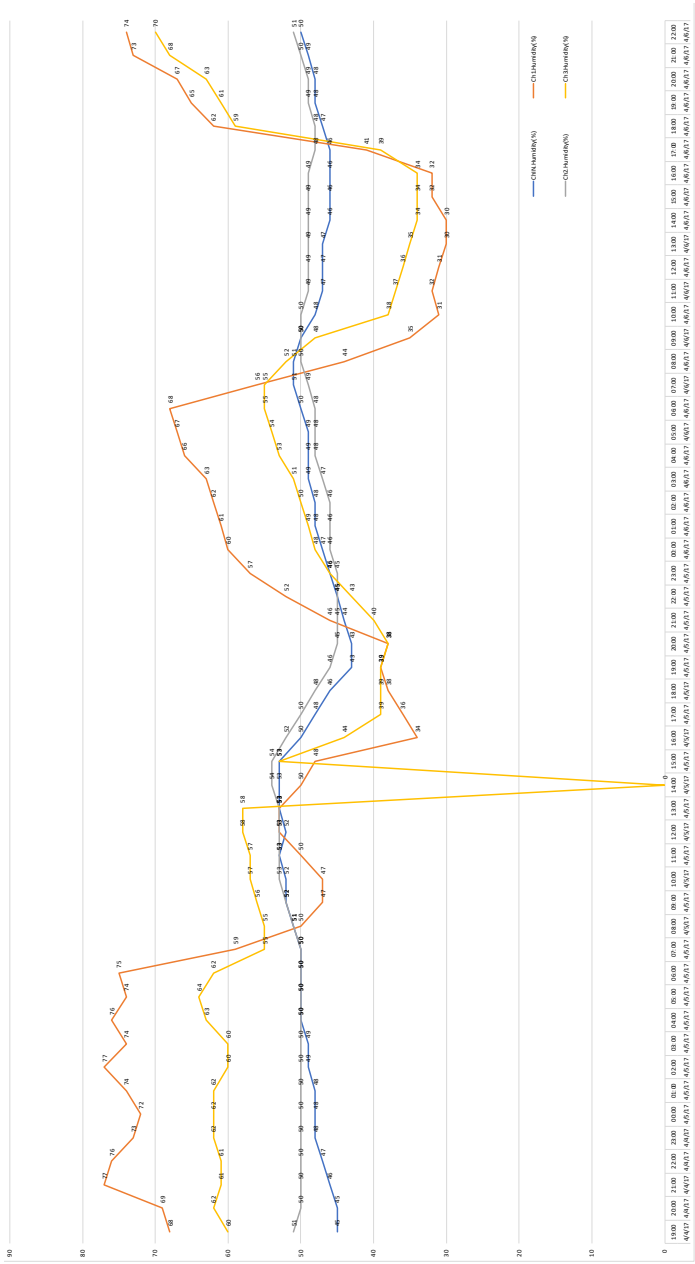


Figure 5. Humidity Values (%), Garden weather station, Inverted House, April 2017

Figures

Figure 1. Research Structure of the PhD, Sareh Saeidi, 2019

Figure 2. Development of Research's Definition of the Building Envelopes, Sareh Saeidi, 2019

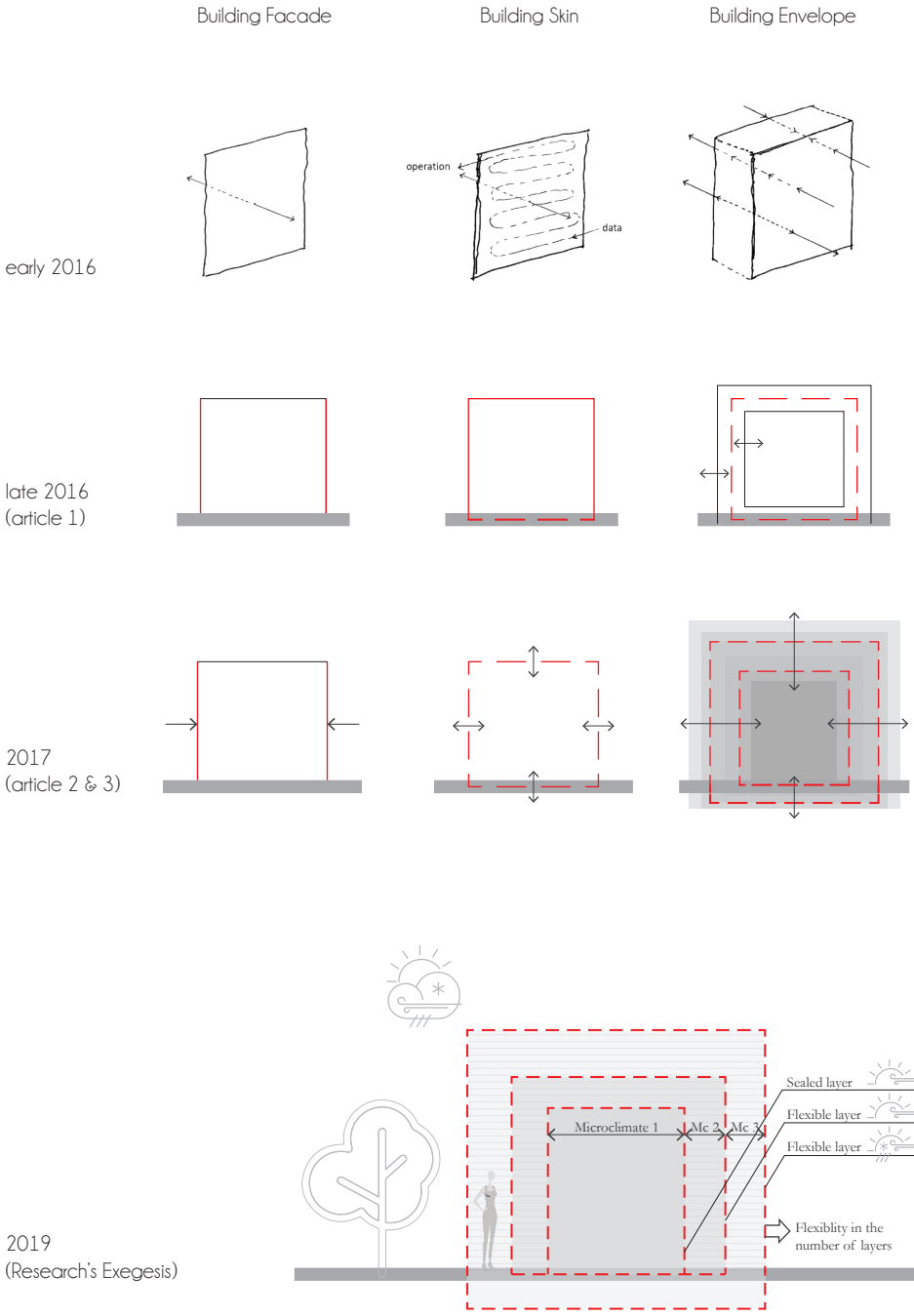


Figure 3. Phylogenic Tree of the Research's Taxonomy of Envelopes, Sareh Saeidi, spring 2015 – 2019

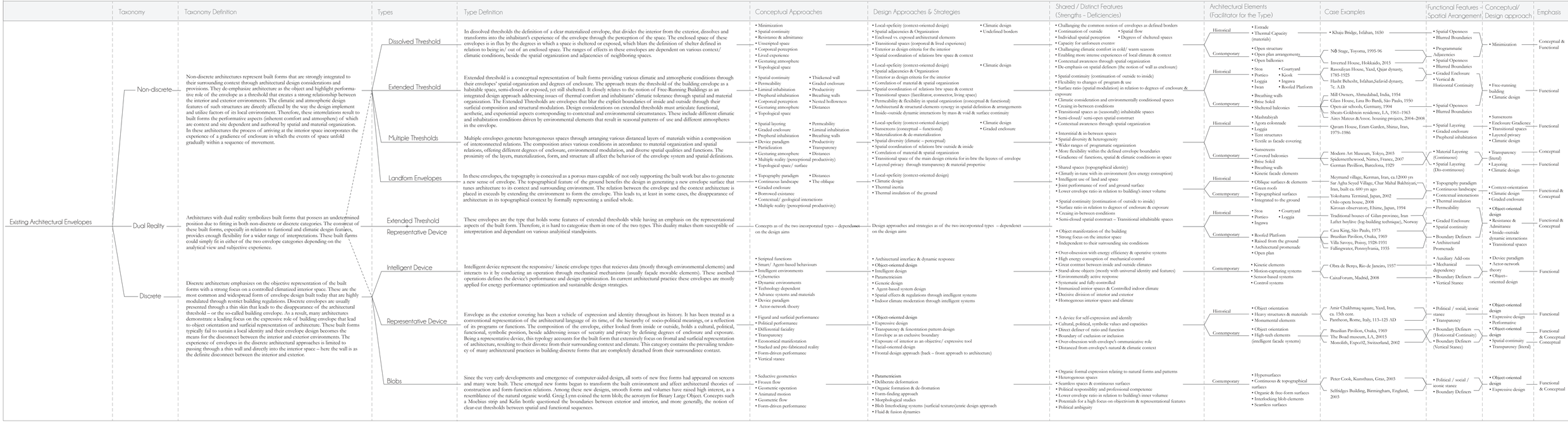


Figure 4. Envelopes' Concepts and Design Approaches, Sareh Saeidi, 2015 – 2019

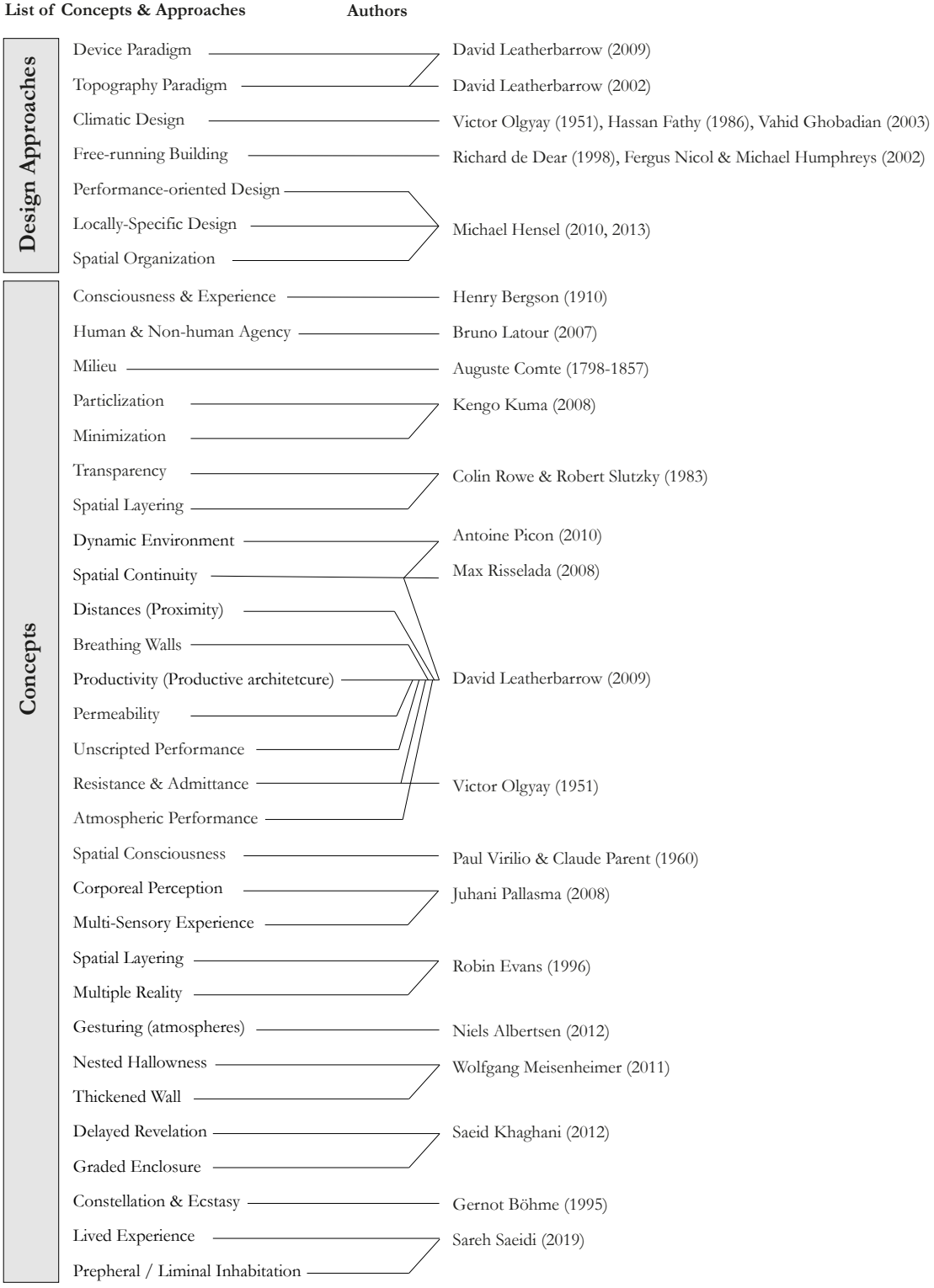
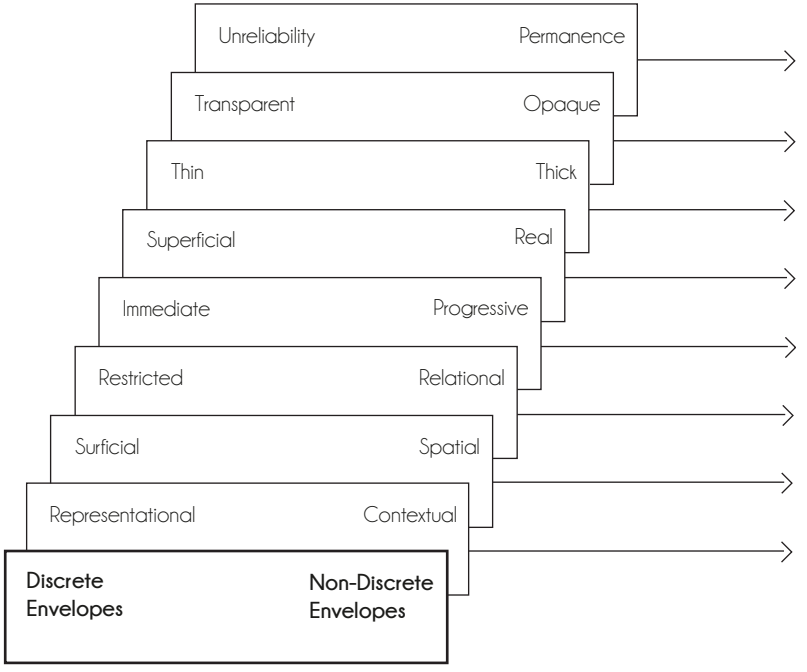


Figure 5. Effective Themes in Designing Performative Envelopes, Sareh Saeidi, 2019

The themes are defined through envelope's relation to interior and exterior; inspired from Farshid Moussavi's defined categories (2005) for the potentials of structural ornaments as effective means for designing envelopes.



Technological failure and questions of life span of intelligent systems in comparison to tectonic considerations

Performativity of materials in terms of optical depth and visibility – Interplay of hiding and revealing in comparison to exhibited interior

The functional and programmatic use of the thickness of the masonary wall in comparison to a thin glass surface

Surficial treatment independent to the core functions and programs (of the building) in comparison to their dependent extension and integration to aspects of local context and climate

Spatial organizations, dependencies, and interrelations in creating effective relationships between interior and exterior or different interior spaces

Boundary defining and separating in comparison to conditioning and building spatial conditions that corresponds to the contextual changes

Flattened boundary in comparison to volumetric and spatial presence

Appearance and facial representation in comparison to strong local integration

Figure 6. Non-discrete Design Principles Extracted from Case Studies, Sareh Saeidi, 2018

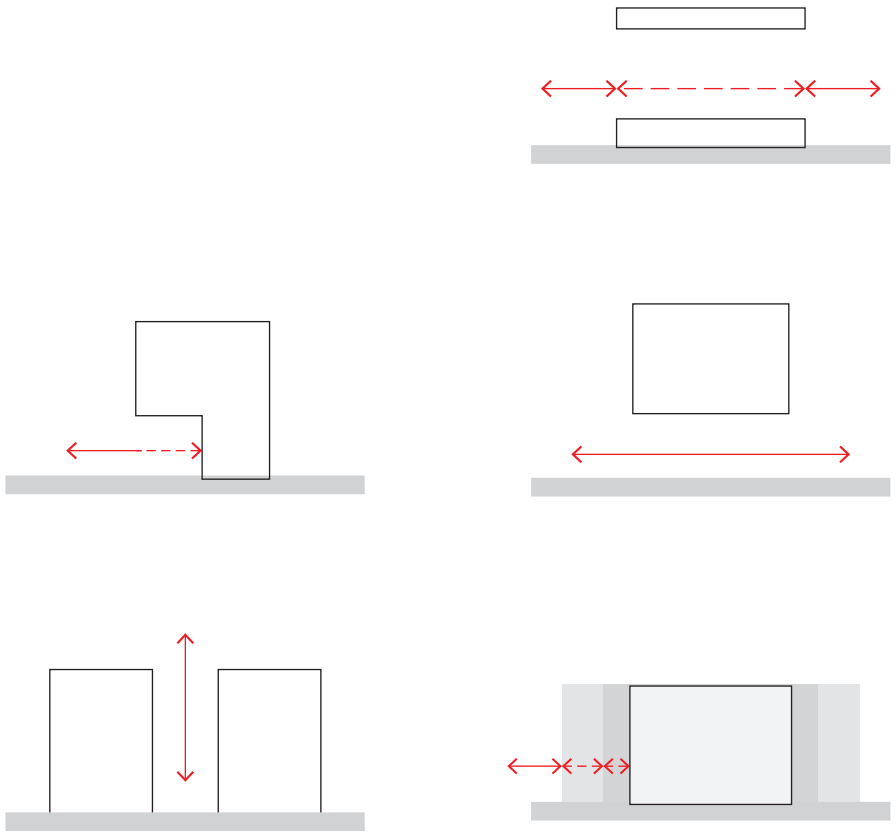


Figure 7. Shared Concepts Between Non-discrete Envelope Typologies , Sareh Saeidi, 2019

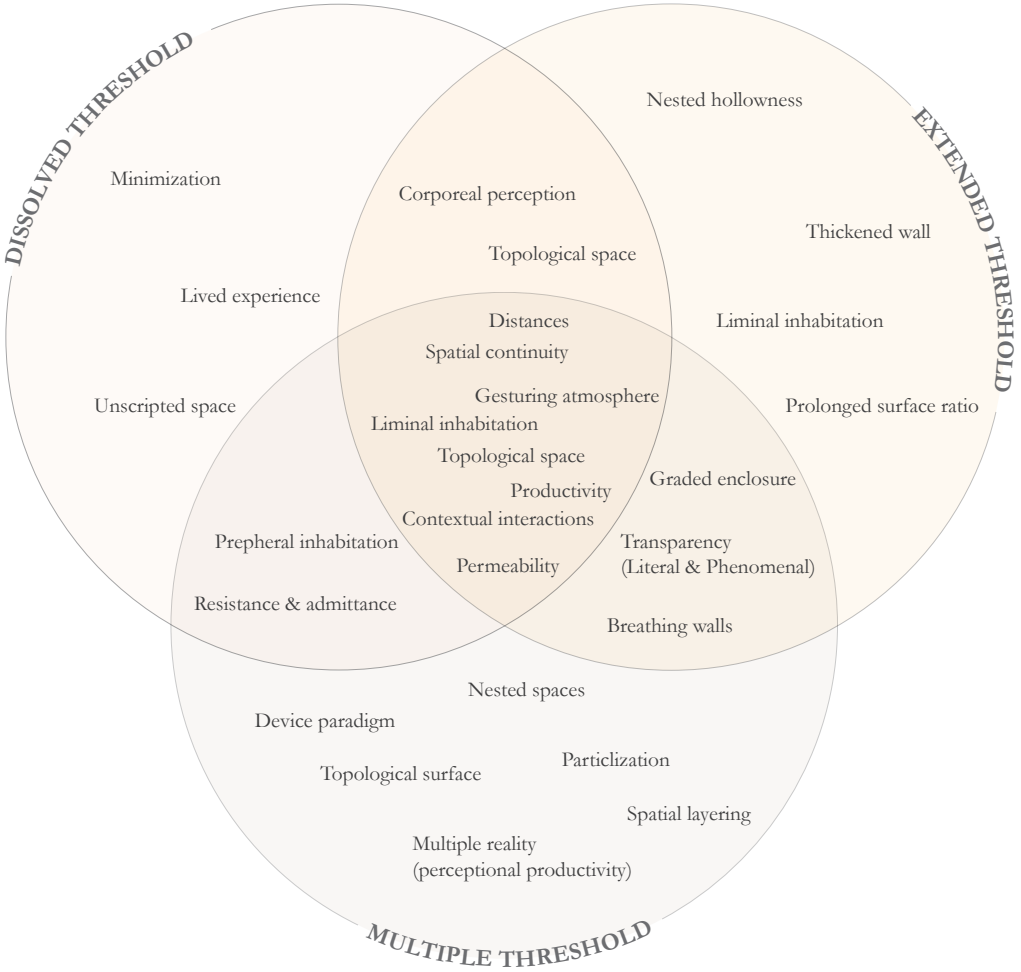
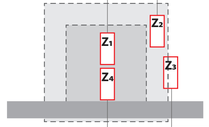
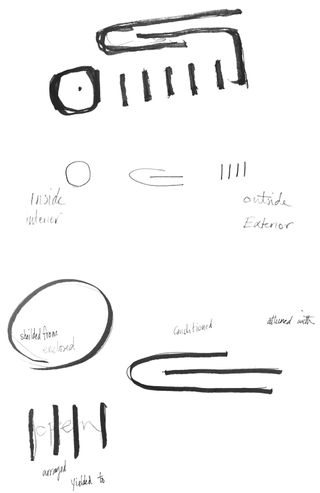


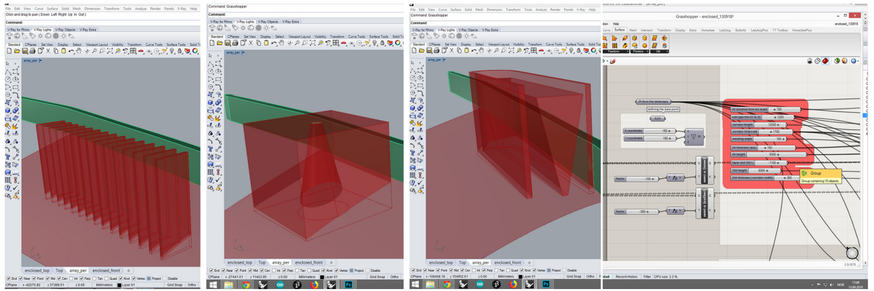
Figure 8. Mind-map of the Research's Design Experiment

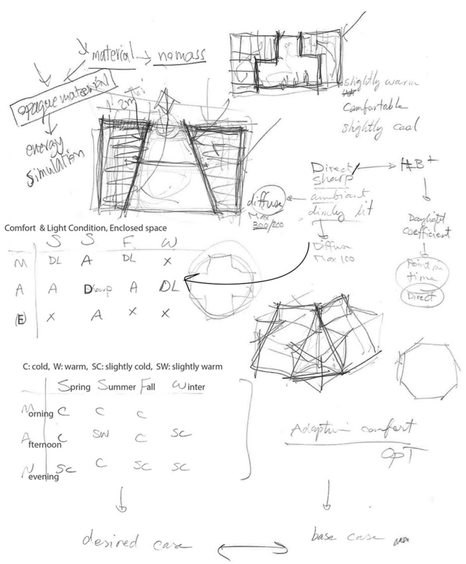


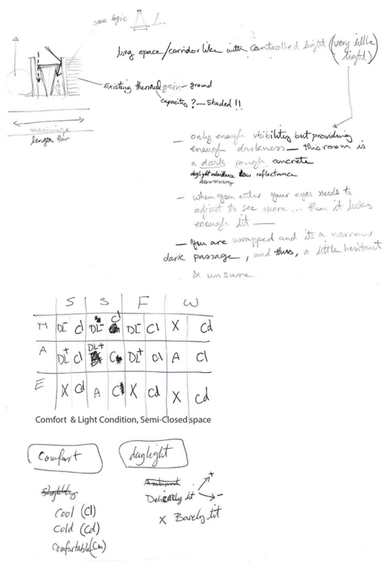
BASIC PRINCIPLE	ZONES	SPECIFIC PRINCIPLE	EXTENDED SETTING APPROACH	ENCLOSURE APPROACH	DESIGN AIMS (in relation to light & heat)	CONCEPTUAL APPROACH/ PERFORMATIVE ASPECT	ATMOSPHERE	PERCEPTIVE DISTANCES/ PROXIMITY	LOCAL SPECIFICATION FOCUS	POSITION ON SITE (MAIN AXIS)	POSITION ON THE CHOSEN TERRACES	MAIN ADJACENCY	PUBLIC/ PRIVATE	TIME OF USE	LEVEL OF COMFORT/ DISCOMFORT (TEMPERATURE)	ANALYSIS FACTOR	LIGHT INTENSITY	DEGREE OF SHADE	POSSIBILITY OF GLARE	LIGHT DIRECTION FOCUS	TEMPERATURE (°C)	VENTILATION	HUMIDITY (%)	ZONES' ENCLOSING MATERIL	FLOORING MATERIL
Contemplation		Extended Threshold	Shielded from		to stop and control	Transparency (Phenomenological) Ecstasy (Böhme)	Cloud-like, White, Lit	Immediate	Orientation & angles to daylight	Square	Leveled with the upper terrace	Vine trees	Privatized	7:00 – midnight	Comfortable & Uncomfortable	Sunlight hours Thermal comfort analysis	Ambient, Soft	Fully shaded/ Indirect light	No glare	All cardinal directions	23 – 28	Natural Ventilation	40 – 70	Wooden frame structure & Polyester fluorocarbon coating	Solid timber
Z1 + Immediate Exterior (Vine rows)					homogenizing daylight, daylight & vine trees shadow	Spatial layering, atmospheric filtered light, Minimized radiation impact		Immediate								Shading analysis Radiation analysis Radiance analysis									
Z1 + Z4					sound & temperature exchange	Cold radiation impact		(passive-hearing)								Heat transfer analysis									
Reading		Multiple Threshold	Attuned with		to partially allow, & stop	Thermal resistance & admittance Atmospheric filtered light Proximity & distances	Bright, Airy, Sunset effect	Local + Extended	Integration with vine trees	North-south	On the lower terrace incorporating 2 vine rows	Vine trees Main walking path	Public & Semi-public	7:00 – midnight	Comfortable	Radiation analysis Thermal comfort analysis	Filtered, Patterned	Partially shaded/ Filtered light	Glare: YES	South (West)	20 – 30	N.V.	40 – 70	Wooden plate or concrete roof & columns	Dry stone paving
Z2 + I. E. (Vine rows, main path)					patterned daylight & minimizing solar radiation			Local								Shading analysis									
Z2 + Z3					shared ambience, separate spatial character	Spatial continuity		Local								Airflow analysis									
Wine-Tasting		Dissolved Threshold	Yielded to		to allow & let in	Spatial continuity Constellation (Böhme)	Cozy, Patterned light, Lit	Local + Extended	Openness & minimal footprint	North-south	On the lower terrace incorporating dry stonewall	Dry stonepaving The sheltering roof	Public	17:00 - 1:00	Comfortable & Uncomfortable	Radiation analysis Thermal comfort analysis	Direct, Immerse	Partially shaded/ Filtered light	Minimized	West (North & South)	18 – 35	N.V.	40 – 70	Wooden plate or concrete roof & columns	Dry stone paving or gravel
Z3 + I. E.					to well-shade but compensate thermal loss for vine trees	Breathing walls		Local + Extended								Shading analysis Airflow analysis									
Z3 + Z4					shared thermal impact	Cold radiation impact		Local								Thermal comfort evaluation * Heat transfer analysis									
Storage & Bar		Extended Threshold	Partly shielded, partly attuned		to partially allow, & stop	Permeability Particlization Ecstasy	Dark, Narrow, Closed-off	Immediate	Thermal mass & storage	North-south	On the lower terrace incorporating dry stonewall	Dry stonewall	Public	17:00 - 1:00	Comfortable	Thermal comfort evaluation * Heat transfer analysis	Filtered, Minimized	Almost completely shaded	No glare	North	15 – 24	N.V.	50 – 80	Dry stone	Dry stone paving or gravel
Z4 + I. E. (Dry Stonewall)					controlled thermal condition	Stored cold radiation, unfavored thermal impact on dry stonewall solar radition harvest & latent release		Immediate								Heat transfer analysis									
																* Comfort Shade Benefit Evaluation									

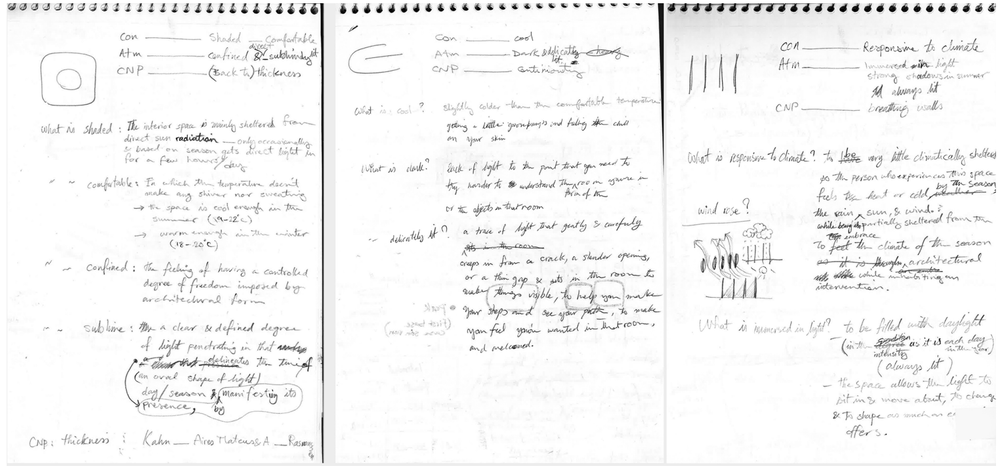
Figure 9. Design Process of Defining the Set of Comfort and Atmospheric Goals of the Research's Design Experiment.

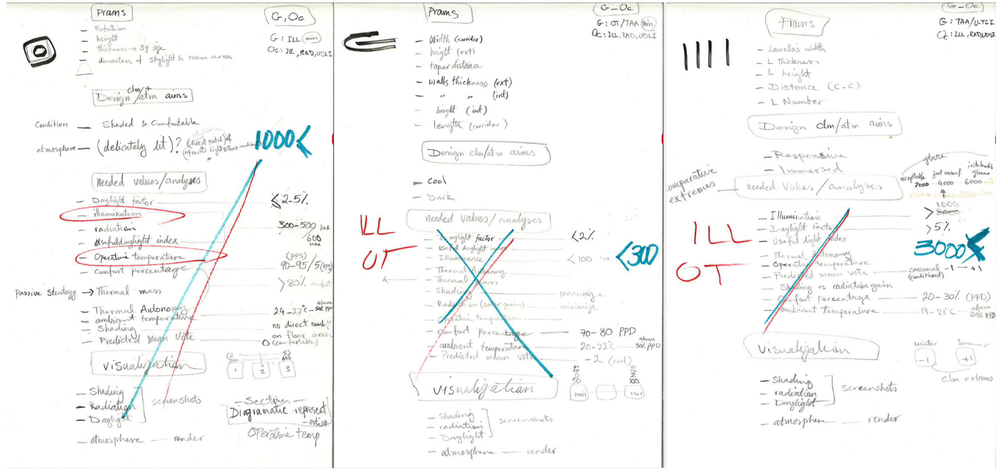






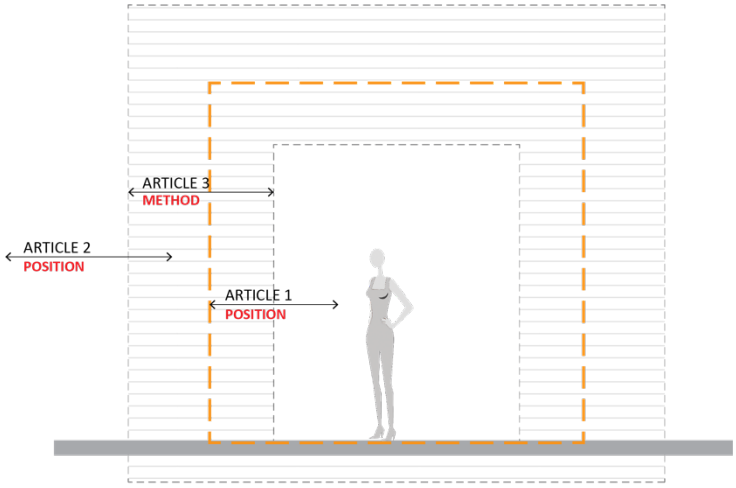






Articles

Focus Areas of the Research's Articles, Sareh Saeidi, 2019



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Rethinking The Performance of Envelopes in Architecture

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The paper's objective is to propose a redefinition of the notion of 'envelope' in architecture that goes beyond the common definitions of 'building skin' or 'façade.' The intention is to ground the notion of 'envelope', within the context of contemporary discourse on 'performance' in architecture, as an extended threshold that affects humans' experience of architectural space. This is done through four thematic sections: [a] discussion of selected conceptual approaches to the notion of envelopes based on literature study; [b] a proposed taxonomy of envelope types based on an analysis of built and unbuilt projects; [c] research-by-design inquiry by way of designing performative envelopes, and [d] formulation of a resulting position including a synthesized conceptual and methodological approach for the purpose of further development. The aim is to initiate a design approach that intensifies the interrelation between interior and exterior through specific performance foci.

Keywords: Architectural Envelopes, Performance-Oriented Design, Taxonomy of Envelopes, Architectural Envelopes' Inhabitation, In-Between Spaces

1 Introduction

Contemporary architectural discourse frequently focuses on the tension between globally uniform architectures and their lack of response to local conditions and circumstances, and the constraints that this places on approaches to sustainability. Many of today's attempts for creating sustainable architecture using strategies like zero-energy buildings, green architectures, or efficient and controlled interiors fall short when considering the capacities of envelopes. These approaches treat building envelopes as a layer of control and insulation against climate and exterior environment, and thus as independent of their local surroundings. By doing so, these approaches underestimate the capacities of envelopes as a threshold that provides the necessary sheltered space by attuning to its interior and exterior environments and creating modes of adaptation and change by its constructs. However, these constructs are the first architectural body that the inhabitant experiences when moving from the exterior environment to the enclosed interior. It is therefore of great value to revisit the notion of the building's outermost covering to explore and define guiding factors, within the envelope design process, that should be considered in the way an envelope meets its local context and affects its inhabitants' experience of interiority and exteriority.

Before proceeding to clarify the scope of performance in this research, it is useful to redefine the notion of 'envelope', in order to set it apart from other notions such as 'building skin' or 'façade,' that continue to assert the separation of architecture from its setting by rendering it discrete. This research defines these notions based on their spatial reality. Façades are the two-dimensional representation of architecture, defining a material boundary for the enclosed space, setting apart the interior from the exterior. Building skins are the three-dimensional representation of architecture, with higher complexity, that respond to

features of the surrounding environments by conducting specific operations. These operations are mostly orchestrated using today's technological advancements and intelligent systems. This research therefore proposes the following definition for the notion of architectural envelope: unlike the building skin, which is the operative or static material division of exterior and interior, an envelope is a spatial zone, engaged in and affected by the interactions between the outside and the inside of the built form (Figure 1).

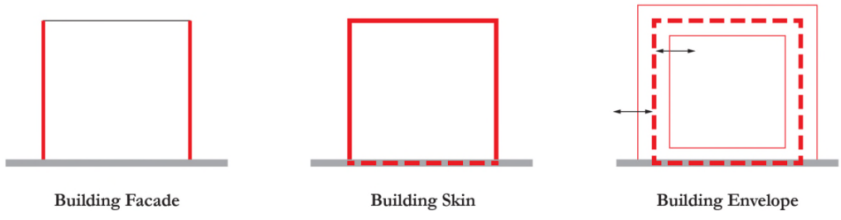

Figure 1 Diagrammatic Representation of Research Definition of Building Faces, Building Skins, and Building Envelopes, produced by Sareh Saeidi, spring 2016

Defining envelopes as spatial zones thus incorporates the traits and attributes of the notion of building skins and façades, as well as transcending them by including architectural performance and experience foci in their design. It is a threshold that can be experienced, and by creating a sensible relationship between its interior and exterior spaces, it also possesses a character. Through this, the envelope becomes unique and claims its distinct character not through its effects, but by its affective encounter with its inhabitants and surrounding environment: a dialectics in which matters and souls, substances and subjects, spaces and emotions sublimate.

To frame the aforementioned relationships, the research focuses on performance aspects that contain studies of climatic design, spatial experience, and the notion of agency in envelopes to establish ways of conditioning the interior by relating to the building's milieu. This investigation refers to these interactions, conditions, and their mutual correspondences as active agency,[1] including various actants[2] ranging from micro- to macro-scales, and from objects in an architectural space to climatic factors. The role of material and spatial organization in creating in-between spaces is a key factor by which these studies seek to clarify the position of architectural envelope as a space that affects its inhabitants through its atmospheres. The research presented in this article attempts to outline a design approach of the aforementioned focuses by examining the research's tailored methods within the design studies of a series of workshops conducted at master level studios.

2 Literature Review

According to Gottfried Semper, the building's covering is one of the oldest architectural elements. It is what defines the enclosures, the building's identity, and its spatial and climatic aspects. In "Four Elements of Architecture", Semper describes the enclosure through the wall, the role of which he divides

[1] The notion of agency and its passive and active role in envelope's performance will be discussed again later in this section.
[2] Bruno Latour defines actant as: "anything that does modify a state of affairs by making a difference is an actor –or, if it has no figuration yet, an actant" [12].

into two distinct parts: structural, i.e. primary and more permanent, and covering, i.e. secondary and more temporal [30]. Apart from clarifying the relationship of the human body and the built through this systematic division, he defines the boundary's role as symbolic as well as functional representations of human purposes. Semper's focus in this study is the temporal element of the wall; he refers to the nomadic tent structures as an exemplary argument that the primary need of humans was not essentially the solidity and permanence of the built form, but providing the enclosure and shelter created by a materialized boundary. Semper emphasized that the same temporal structure, when used as cladding or a secondary covering, is a way of self-expression and representation, or perhaps a sign of power [30]. Taking this discussion further, one may argue that the human desire for expression and beauty, by using the outer stance of architecture as a representative device, is one reason for the emergence of architectural styles. And as such, façades become operative tools for architectural styles, reflecting shared assumptions and expectations that result from the conventional face-to-face encounters and interpretations, through which the building gains identification and significance within its context [17]. The emphasis on architecture's representational features can lead to approaches with a focus on the object position of buildings that might result in fragmentation and the disaffiliation of the built form from its surrounding environment. These attempts lead to the emphasis on surface architecture that focus primarily on the representational features of buildings' stance, and thus, typically fail to sustain a local identity for the built space.

Technological advances, changes in values, attitudes and actions for standardization that started the international style in the 20th century led towards globalization in architectural design. The emphasis on rectilinear forms and use of glass and steel superseded the use of local materials for construction. Such tendencies foreground efficiency and insulation in designs and reinforce the emergence of sealed spaces that are incapable of integrating with their local environment. As a result, the exterior walls of the built form became a boundary to exclude and isolate the interior. These structures mostly focus on the object stance of architectural design that is governed by dominating mechanical and electrical setups, thus, blurring the possibilities that can unfold through the latent use of the space. The continuum of this approach towards standardization in today's culture and the prevalent technological advancements have resulted in the production of synthetic, identical environments with similar features and characteristics. By becoming independent of their local climate, culture, traditions, and regional building materials, these built forms are "reducing architecture to the provision of aesthetic skin" [4] and transforming it into fully controlled mechanisms and constructs. The outermost covering of a building is, as a result, defined as a boundary that excludes any direct or indirect interaction between architecture's outer and inner environments. In this way, buildings turn into either expressive devices that are politically charged [35]; or operative boundaries of insulation that become a spatial support for structural, mechanical, and electrical systems, thus leading to what Farshid Moussavi calls blank envelopes [19]. In this investigation, these types of architectures are regarded as discrete, due to their intentional focus on the object stance of architecture.

In contrast to approaches to creating highly immune environments and efficiency preoccupation, another discourse has emerged that places emphasis on questions of performance; in short, the locally specific interaction between architectures and their settings. This approach includes the inhabitants, environmental factors, and local conditions within its constitution and defines them equally as 'active agents' with

reference to Actor Network Theory [12]. The interaction between architectures and their settings opens up the possibility of redefining aspects of both – not by way of separation, but as a continuum, resulting in non-discrete architectures [10]. Non-discrete architecture represents built forms that integrate with, and correspond to, their local conditions and surrounding environments through their design strategies and considerations. These structures perform by implementing and utilizing factors from their local environment to build their design features and attributes. By doing so, architecture creates a character for the space that is enacted by an intricate network of human and non-human relations with and within the space. According to Hensel, the basis of performance-oriented design is to understand how architecture unfolds its performative capacity "by being embedded in nested orders of complexity and auxiliary to numerous conditions and processes" [10]. This view points towards a definition of architectural performance that would foreground architecture itself rather than its technical add-ons and which is in the scope of this investigation. The tendency to define performance through advances in electrical and mechanical systems and their efficiency optimization accentuates the object stance of the built form rather than attuning it to its local conditions. Criticizing the current emphasis on the object in contemporary practices of architecture, in his book "Anti-Object" Kengo Kuma uses examples of his projects to propose an alternative view that disperses the object in a wider spatial field of architectural design. He illustrates, instead, a substitute design approach that engages architecture with its milieu.[3] Kuma emphasizes relationships and involvements of architectures that create meaning, balance, and harmony through their eminent awareness of occupying a location, their tectonics and material presence, their inherent force/counterforce relations, and spatial orders [11]. The research presented in this paper focuses on one such aspect, namely the interrelation and interaction between exterior and interior across a threshold defined by architecture: the performative envelope.

As Antoine Picon stated, architecture today is expected to perform at various levels, similar to the performing arts, "from an ecological footprint to the realm of affects" [24]. Architecture thus requires an integrated approach, constructed from a variety of concepts and methods, to systematically enable it to address performance foci and experiential aspects. According to Hensel, "performance-oriented architecture requires an overarching and inclusive theoretical framework together with integrated and instrumental concepts, design strategies and methods" [10]. A clear thematic classification of performance is required to redefine the envelope as an essential element of conceiving non-discrete architecture constructed upon a synergy of complex relations. These thematic categories are addressed in three ways[4]: Environmental conditioning and climatic design consideration to position interiority and exteriority; Conscious and unconscious architectural experience; Co-authoring performance through design provisions and flexibility.

There is a large body of knowledge in recent discussions on addressing environmental, technological, and

[3] Marcellin Berthelot (1827-1907) referred to milieu as the "element surrounding a given body"; however, Auguste Comte (1798-1857) expanded it to "the total ensemble of exterior circumstances […] upon which the existence of a given organism depends" [32] including both the organism's surrounding physical world and the external conditions essential to its existence.

[4] These three categories are explicitly and individually discussed within the body of the article; in the following paragraph they are introduced as a whole as part of an overall description.

structural performances in architecture. One of these includes discussions of contemporary approaches in defining architectural performance through a series of case studies, collected in the book "Performalism" by Yasha J. Grobman and Eran Neuman [8]. In this book, approaches to the notion of performance within architecture and today's architectural digital interface are discussed. Emphasis is placed on professional practice and how various aspects of performance can be developed within a synergetic design process. Other potent references on the performance foci, especially regarding environmental studies, are local traditions in architecture that provide a significant body of knowledge on climatic design of different climatic zones. In vernacular architecture, the outermost wall of an enclosed space was not regarded as the divorcing boundary that isolated the human body from the exteriority of the building, but as the mediating element that attuned the needs of the human body to its local climate and environment. Architectural elements such as windcatchers, Mashrabiya, also called Islamic sunscreens, or design strategies in spatial planning like Persian courtyard arrangements and Iwans, are mediators of an inclusive approach in which architecture derives its character and identity through an active integration with its context. In addition to this, such built forms operate effectively by attuning to climate and utilizing the climatic restraints in favour of creating additive and novel qualities provided for interiors' climatic comfort. Hassan Fathy's studies of vernacular architecture and climatic considerations in arid regions illustrate how climatic designs strategies can result in architectures that respect and attune to both their surrounding environment and inhabitants by ways of adaptation [2,3]. He argues that a climatic element like heat, as a force, creates different formal expressions than cold, and highlights how climatic design considerations exhibit designs that are formally and spatially specific to their local context [27]. Vahid Ghobadian's analysis of local design traditions and material specifications in different climatic zones of Iran is another explicit reference. Within his systemized studies, Ghobadian organizes knowledge about traditions and regional elements of Persian architecture, spatial arrangements, and choices of materials, as well as elaborating on cultural expressions in different regions [6]. This investigation attempts to build an understanding of local climatic designs that are focused on developing spatial strategies and principles to interrelate the interior and exterior of a built form.

Traditional buildings emerge and grow spontaneously from the interaction of landscape, soil, climate, and type of culture, and in doing so create a synergy of physical conditions and psychological needs that form the ultimate balance within a built form [22]. Aligned with approaching the climatic design by extracting knowledge from traditions of architecture, this research looks into an approach that addresses interior thermal comfort through human adaptation and programmatic considerations. Free-running buildings is a method that provides a variety of indoor climates through the joint necessity of non-discrete architectures with the inhabitants' adaptation abilities. It includes design strategies that implement concepts such as inhabitants' acceptance, adaptive capacities, and expectations within architectural designs by attuning clothing, activity, and spatial arrangements [20]. Addressing the potentials of envelope design for providing flexible systems and provisions of adaptation, these studies also aim to define the role of inhabitants in modifying designated qualities of space. This systematic flexibility and adaptation determines the envelope design's capacity for interacting and responding to various foreseen and unforeseen needs of its inhabitants and programmes. The objective of this investigation is to open discussions regarding the repositioning of inhabitants' subjectivity in the co-authoring of spatial characteristics along with the design's provisions. The built form creates certain spatial qualities with its

elements' organization, and an integrated network of correlations and correspondences between these architectural components and inhabitants of the space can affect and change the space's conditions, resulting in the co-authoring of the spatial characteristics. As David Leatherbarrow says, the task of architecture will be lacking and has been misunderstood if the building's requirements are only associated to the physicality of architecture and discard human praxis [13]. Human praxis includes the inhabitants' efforts, interactions, and living in architecture that has been actuated according to their preference and deliberate choice rather than on purely technical and functional operations and labours [5]. This Investigation thereby positions the potential actions of human in the building envelopes.

Apart from discussions on environmental and technological performance, there are other discourses that concentrate on phenomenological aspects of architectural envelopes in creating distinct atmospheric features beyond their design considerations. These include phenomenological debates on spatial and material experience [26]; spatial design provisions and effects [13]; and the role of multi-sensory experience and the body's memory in human perception [22,23]. The underlined importance of envelopes in creating distinct spatial qualities is how architecture affects the memory and experience of space and moves[5] its inhabitant. By defining functions of architectural forms and elements, Leatherbarrow attempts to highlight the role of the latent design provisions in creating additive effects and qualities to the bare necessities of the architectural spaces. These provisions create a disposition or mood in the space and develop a character for the built form, and by doing so, make the architectural experience lasting in one's memory [13]. The character of architectural space is produced by, and can perhaps be identified as, the embodiment of human interactions. This character is not a thing-in-itself, but rather emerges from the intersection of an intricate network of human relations with, and within, the space. It includes both corporeal and incorporeal interactions of the inhabitants, besides their perceptional intakes of these relations within the space. The character of architecture is what Rasmussen calls poise, representing the way through which the built form is directly experienced; i.e. seen, heard, or felt [26].

In his architectural essays on Sensing, Pallasmaa uses the metaphor of the body to expand on how the interrelations and correspondences between elements of architecture form a unified whole to foster the sensations of their spectator's experience [22]. In regards to human corporeal experience, in his book "Experiencing Architecture" Rasmussen also attempts to elaborate on the notion of architectural experience through perceptional accounts of various architectural elements and expressions. These include concepts such as the contrasting effects of solids and cavities that create an active observation in the spectator of architectural forms. Additionally, he elaborates on how various characteristics of materials of architecture such as surface's finish, materials' thickness or organization affect the process of spatial perception. He amplifies these features by exemplifying built works that represent design considerations on scale and proportion, materials' finish, textual expressions, and how concepts per se empower or forbid certain sensations in the space. Through detailed analysis of rhythmic compositions of elements like windows, vaults, or columns, he discusses their affecting sensation of stability or motion, and how they define the architectural presence of a built form. His studies open up for discussions on how

[5] Zumthor defines architectural quality as the ability of architecture to move its spectator. He lists three points to define this moment: [1] when architecture becomes part of people's lives, [2] when it creates a coherent whole by interrelations of its individual parts, and [3] when beside these it also creates a beautiful form [36].

architectural designs can be heard, seen, and felt through interacting with an inhabitant or spectator [26].

Architecture then turns into a synthesizing system in and through which the envelope becomes the curator of a desired character and identity, created by its milieu and inhabitants. This is the domain of envelope's performance within which this research positions itself. As such, the envelope develops an integrated network in which the way the building works is dependent on complex interrelations and correlations of design provisions. How the building works includes both the operative and functional aspects of architecture, in addition to its atmospheric characteristics and effects.

This research seeks to redefine the notion of envelopes in architecture through the chosen methodological approach. This attempt is closely related to both passive and active agencies of envelope design to present an integrated system within which various actors and actants work as a unified whole to expound the built form. Actor Network Theory defines actors as participants that modify a state within a system by performing an action, while actants are the participants in a course of action that are waiting to be given a figuration [12]. Therefore, both actors and actants need to be integrated within a system for the action to occur. To put this in the context of architectural character and experience, one could say that experiencing architecture not only requires the human being, i.e. the one through whom we define it, but also the non-human constructs that actively participate in shaping the process of perception and experience. Non-human constructs include architectural elements and their tectonics, as well as the surrounding natural environment. Active agents, in this investigation, are defined as actors who directly affect and modify a state through physical operations, while passive agents are defined by material properties and design strategies, such as the thermal capacity of materials, or spatial organization.

The investigation does not strive to explore optimization and efficiency in the envelope design process. Instead, it aims to pursue an approach, leading to an effective design model that function as a guideline for approaching envelope designs. Optimization either limits the design to the manipulation of elements predetermined by the imperatives of production, or results in superficial masking and compensatory façades [4]. Revisiting envelope designs with effectiveness, however, directs the design process into an exploratory mode, in which provisions of use can be utilized for unplanned conditions. Unplanned conditions curate spatial flexibilities that are unveiled through inhabitation and latent use of space. In the scope of this research, effectiveness, includes design considerations and strategies that address both functional and atmospheric conditions by enabling ranges of adjustments and adaptation patterns. Flexible patterns of use and climatic conditions as such enable the design with latent possibilities that emerge in the course of the building's life. The investigation's developed approach pursues envelope concepts, taxonomy, and design experiments within a mixed method mode of inquiry consisting of quantitative and qualitative studies. Design experiments follow an iterative logic and include digital simulation, evaluation, and data collection that support an informed mode of exploration and feedback. The simulation and analysis benefit from the implementation of the informed non-standard approach through which context-specific and real-time datasets are integrated to inform the computational design process [31]. An example of these datasets is climatic measurements, collected through sensor-based electronic setups that directly stream the data to digital models and provide real-time feedbacks. The application of this method equips the design process with an informed mode of reflective thinking, decision-making, and real-time design modifications.

3 Research Objectives

The design process for envelopes can be presented as a systematic approach, addressing inhabitation patterns, atmospheric effects, climatic and spatial context, and material elements of architecture within an integrated system. This research seeks to find ways on how the envelopes' design process can be approached to result in nuanced architecture and environmental interactions through the envelope's overall scheme, by which the performative aspects of the built form can also be defined. This includes questions on how to design envelopes as inhabitable spaces with a flexible construct that provide heterogeneous spaces for adapting the use of space to individual preferences. It is therefore relevant to pursue the design of envelopes as an early step in an integrated design process that includes a strong focus on environmental and experiential aspects of envelopes.

The investigation aims to initiate a design approach, both conceptually and methodologically, in which the synchronization of specific environmental inputs and ranges of flexibility within the envelope design creates and defines the extents of spatial experience and performance. The approach investigates various concepts, design strategies, and scenarios to find the most effective patterns (regarding the design's intended performance) within a flexible design through close interrelations of both human and non-human agencies. The investigation aims to provide a guideline for the envelope design process by which envelopes' various performance and design aspects can be adequately addressed, assessed, measured, and actuated. The research thus bases its objective on existing knowledge while developing its distinct approach to envelope design to pursue it further by redefining this notion through a systematic evaluation and analysis.

4 Methodology and Design Studies

The investigation is organized into four thematic sections: [a] discussion of selected conceptual approaches to the notion of envelopes based on a literature study; [b] a proposed taxonomy of envelope types based on an analysis of built and unbuilt projects by various architects; [c] research-by-design inquiry by way of designing performative envelopes, addressing both qualitative and quantitative aspects within the performance foci; and [d] formulation of a resulting position, including a synthesized conceptual and methodological approach for the purpose of further inquiry and development.

The first two themes initiate the theoretical basis of the investigation by creating operative tools within which the research-by-design inquiry explores and evaluates the actualization of various design scenarios for performative envelopes. Assessing and operating the experiments within this approach allows for an iterative process that can both meet the aims and challenge the hypotheses of each design research. The cross-connections and overlaps between various themes and concepts provide the possibilities of choosing, juxtaposing, or integrating them with one another. This in turn empowers the design process to achieve the targeted performance foci. These progressive tools substantiate the experimental projects' framework by providing validated, operating concepts as initiatives of the design. Therefore, the method equips the research by generating a precise definition of the approaches to the project, as well as by building its arguments on a grounded premise. Another advantage of the method is that it enables the examination of different approaches that can potentially create an ingrained mode of practice in which the

synergy of various approaches form the initial design parameters. Criticism of operating through and within the mentioned approach is the subjective observation and reflection, which is derived from a specific point of view and unchallenged by alternative possibilities. While this argument is valid and concerns a relevant deficiency of the method, the advantage of research-by-design mode of practice enables the "reflecting on and in action" [29] that allows for effective development and exploration of the investigation in other aspects. The design process can start from sets of principles or established disciplines that can be altered or revised upon further elaboration of the design in an iterative process to meet the aims of the project and its contextual demands of locality. According to Schön, the process of reflection-in-action is an effective design process in which the designer chooses strategies for action or models of phenomena implicitly, through reflection-in-action on the construction of the problem. He elaborates on how the designer's domains of language are affected by the decisions within the process, or how reflecting on and in action during the design process provides systems of implications that constitute a discipline or break an initially established one. This stimulates shifts in the designer's stance and, therefore, the whole design process makes the thought-experiment manageable [29].

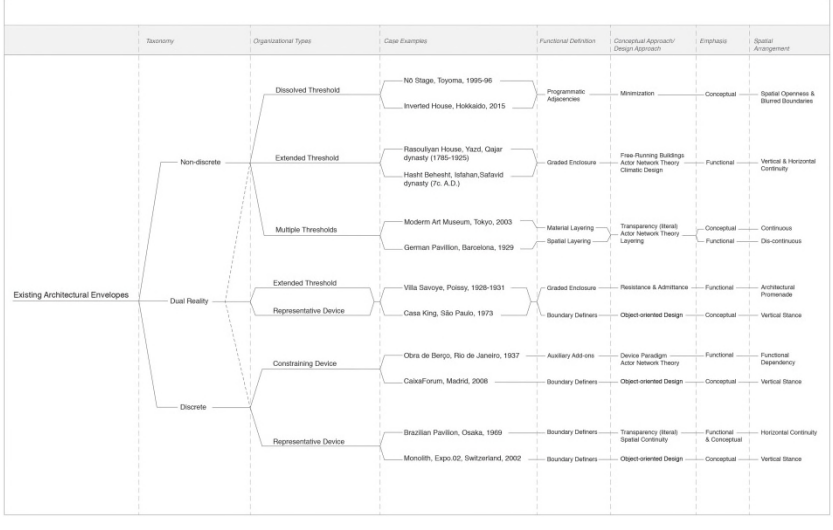

Figure 2 Phylogenic tree of the existing envelopes' taxonomy, produced by Sareh Saeidi, spring 2016 (progressive document)

The research's envelope taxonomy functions not only as a reflective map of the prevailing approaches to envelopes within architecture, but also as a guide to envelope types that are used by design investigations for facilitating the re-examination of design scenarios. This progressive document, while providing a good understanding of the current shortcomings and strengths of the envelope designs, constitutes one of the main tools that will be developed further during the author's research. Figure 2 represents the envelope's taxonomy, produced by the author as part of this investigation.

This document, based on how the built form relates to its exterior surrounding, classifies three types of envelopes: discrete; non-discrete; and envelopes with a dual reality. Discrete envelopes refer to the object-focus of the built form, as explained earlier in the text, and the iconic stance of architecture. Non-

discrete envelopes identifies built forms that are embedded in their surrounding contexts in such a way that the separation from their surroundings disrupts their architectural means and functions. Envelopes with a dual reality represent built forms that are more open to subjective interpretations and possess characteristics of both mentioned types, with different magnitudes. This taxonomy uses built case examples for each type to clarify each category by the author's reflections on properties, architectonics, and conceptual emphasis of these buildings.

An iterative research-by-design inquiry provides a framework in which the investigation can develop its theoretical basis through a design-based experiment, benefiting from causality [33] within both digitally and physically simulated environments. As such, the researcher can establish a cause-effect relationship throughout the experimental research design process by various features such as outcome measures, unit of assignment, and control or comparison groups [7]. This ascertains the relevance of the designs' hypotheses by examining the experiments in two ways: by testing designs through digital simulation and data analysis of parametric models, in which the iterative process of design provides immediate, real-time feedbacks, and by qualitative analysis of physically collected data and measurements that can be used either as data streams for the digital simulations, or as observational feedback to reflect upon. The application of this methodology benefits the design process by enabling iterations to extract the working ideas and actuate design hypotheses through systematic experiments and database analyses. The approach illustrates how theory and practice can be systematically integrated to form an active, informed design process.

Within this framework, two workshops were conducted as an integral part of the research of the author, which is entitled: 'Inhabiting the Architectural Envelopes: A Design-based Approach for Performative Envelopes', to assess the methodological approach of the investigation. The workshops were organized at the Advanced Computational Design Laboratory (ACDL) studio at the Oslo School of Architecture and Design (AHO). Within both workshops, the designs aim at establishing a strong relation between the built form and its milieu by integrating various performance foci and defining active and passive agencies within the design concepts. The objective of the first workshop, entitled "Performative Envelopes", was to design envelope systems that approach the notion of performance for creating heterogeneous spaces through multiple building envelopes in which the outermost layer was supposed to be a membrane structure. The envelope design was expected to offer ranges of the enclosure and environmental modulation for different kinds of activities related to the building programmes. The second workshop, entitled "Interactive Envelopes", aimed at emphasizing the position of the envelope as a spatial zone ascribed with human or non-human agency. The envelope system was expected to utilize light in accordance with the programmes in the building, and include provisions for ranges of adaptation in relation to the programme.

In both workshops, a few conceptual approaches were addressed by all projects. These shared concepts establish a common ground, and a framework for the performance foci, including the themes milieu, climatic considerations, and agency.[6] The topics have been approached in various ways within the workshops by each envelope design specifications. In the workshops, students were asked to initially

[6] The concepts will be discussed further in the following pages.

approach their envelope designs by choosing Multiple Envelopes as their envelope typology. Multiple envelopes represent layers of envelopes that are arranged and positioned concerning one another to fulfil different demands of the built environment, from providing enclosure and achieving spatial effects to acting as insulation. This approach provides a convenient flexibility for designing and examining different materials and spatial compositions by creating in-between spaces. The interstitial spaces can inherently equip the designs with distinct spatial qualities and programme distribution. Therefore, the choice of multiple envelopes initially provides the design with enough flexibility for testing different design concepts, while allowing the design to switch between other alternative taxonomies upon further design requirements. These interstitial spaces also addressed the climatic design and free-running building approaches in individual projects.

To establish a strong connection between the interior and exterior, the building must respond to and address its milieu through various design concepts and approaches. These include focuses on different performative aspects of architectural experience and consciousness, human and non-human agencies, and climatic design considerations. The chosen literature studies of this investigation were therefore directly derived from these performance foci to demonstrate possible approaches to developing the abovementioned relationship through the envelope's threshold. These themes resulted in a list of conceptual and design approaches. This list was then narrowed down into shorter divergent or collective lists to correspond to the workshops' frameworks and individual projects' aims. Each workshop's selected conceptual approaches are implemented through projects' aims, and are then evaluated and assessed throughout the process. The mapped conceptual approaches are applied in design experiments along with the research classification on taxonomy and types of envelopes to create the necessary coherence for the design studies and experiments. Figure 3 illustrates the workshops' design methodology and the interrelations and dependencies of its various components.

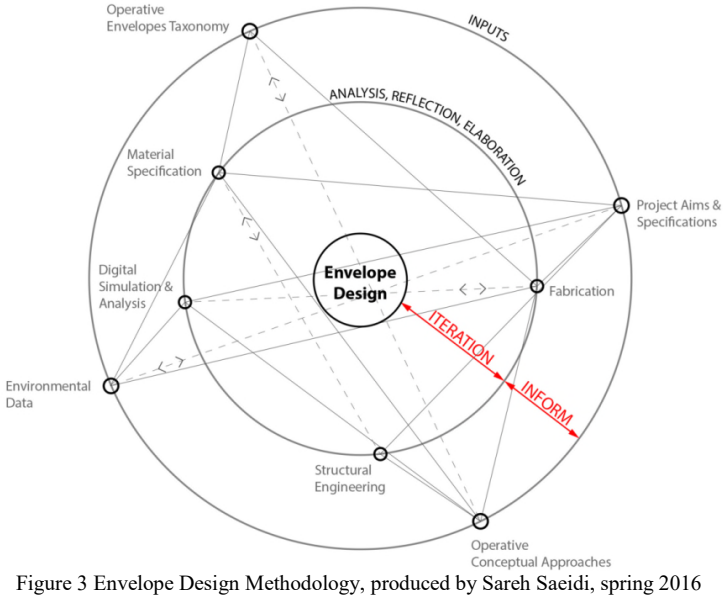

Figure 3 Envelope Design Methodology, produced by Sareh Saeidi, spring 2016

The primary focus of the investigation within the framework of the workshops was to distinguish key conceptual approaches according to each workshop's focus. Therefore, apart from the main design criteria in the workshops, several concepts were chosen to test how consistent ideas and themes can be implemented and addressed as different designs' strategies. The selected concepts were: spatial organization, permeability, spatial continuity, proximity, dynamic environments, particlization, and transparency.[7] Figure 4 illustrates the chosen concepts and design approaches of the literature studies, and how they have been approached by the workshops' design projects.

The selected concepts are focused on the three themes agency, climatic design, and architectural experience that define the research's notion of performance. These concepts were approached in various ways by different projects within the workshops. Some concepts were addressed in almost all projects; others were shared in some but approached at different levels; and other concepts were considered and applied only in individual projects. The choice of application was highly dependent on each envelope design system's aims and specific configurations to intensify the relationship between the project and its local conditions.

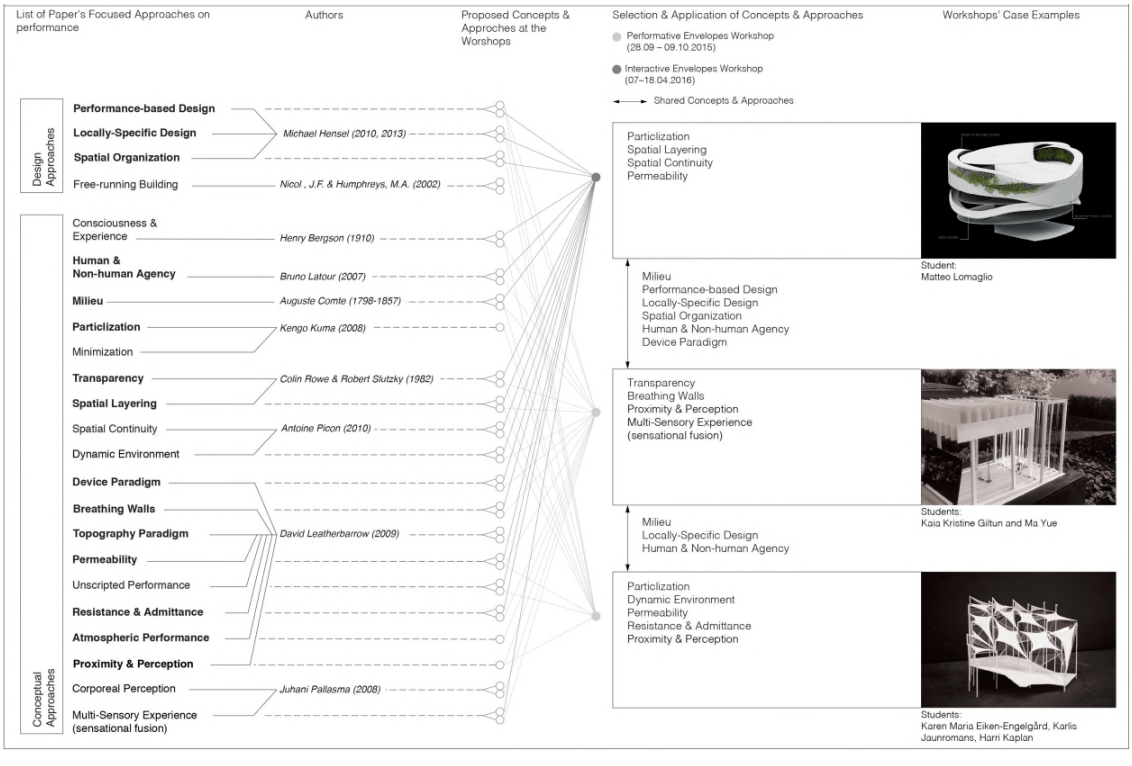

Figure 4 List of Envelopes Conceptual Approaches, collected through the research's literature studies, and applied in the workshops conducted by Sareh Saeidi at Advanced Computational Design Laboratory (ACDL). The Oslo School of Architecture and Design (AHO) respectively in fall 2015 and spring 2016. The illustration is produced by Sareh Saeidi, fall 2015

[7] These concepts will be discussed further later in this article.

Nevertheless, in both workshops, the most significant conceptual focus in creating a strong relationship between the interior and exterior was designing with daylight through the permeability of envelopes. This discussion led to concepts such as breathing walls [13] and particlization [11] that utilize strategies of surface treatment to determine degrees of air and light penetration along with desired spatial qualities. All projects within the workshops address structure, scaling, spacing and proximity as design considerations and input for coordinating the relationship between the interior and exterior. Nevertheless, the main leading concepts addressed were milieu and topography paradigm.

One of the main objectives of a built work is to generate a new identity, not only for the site at which it is located, but also for its surrounding context. In creating this character, the built form must relate to, and establish a strong relationship with its surrounding environment or milieu. The French term milieu was extended by Auguste Comte (1798-1857) to address not only the physical environment that surrounds an organism, but also the external conditions required for its existence [32]. It should be noted that in this paper, the notion of milieu does not refer to the sole causality through which an organism is shaped and affected by its milieu, but rather, the "relationship and coexistence between the two" [34]. Through design, the built form allows its milieu to exist not only outside, but also within it. Thus, the building discovers and adds to the existing conditions through its design configurations, and in doing so creates productive architecture [13]. In the Breathing Walls chapter of his book "Architecture Oriented Otherwise", David Leatherbarrow defines productivity as the performances through which the building operates in a more particular way. He refers to productivity as the alteration and adjustment of the phenomena, which milieu provides the built form with, and which is not necessarily sufficient. Or as Leatherbarrow said; it is the adjunctive or adjectival modification of what the built form inherits from its surrounding environment [13]. A tangible example of a productive façade element is Mashrabiya, or Islamic sunscreens, that in addition to equipping the built forms with means to minimize the effects of the intense sunlight and reduce heat through radiation, they also provide fresh air and privacy.

Another aspect that was part of these common design strategies is the notion of orientation and topography.[8] David Leatherbarrow refers to the milieu in which architectural performance unfolds as topography, indicating both the built and the unbuilt. He elaborates this notion by how performance-oriented design approach should exclude strategies that are built on device paradigm, and rather include strategies that entail a topography paradigm. The topography paradigm is what he defines as the capacity of architecture in responding to ambient conditions through its force-counterforce relationships that result in ranges of alteration in the building's physical body [13]. Device paradigm includes designs that are dependent on either manual, electrical, or mechanical systems to perform an action initiated by human or environmental prompts. In these designs, the ranges of positions and movements of the movable mechanisms script the device performance [14]. In the workshops, although students were exposed to both approaches, the design experiments results relate closely to the device paradigm approach.

[8] For further reading on Topography, refer to references on Leatherbarrow's 2000, 2010, and 2015, cited in this article's bibliography.

4.1 Performative Envelopes Workshop

The workshop was conducted from 5th to 15th October 2015 and aimed at formulating a coherent definition of the performative aspects of envelopes in each team's projects. The design process started by developing concepts and approaches that address spatial performance of the research's mappings with the focus of establishing a strong relationship between the interior and exterior. This stage included considerations on the context, project, and material specifications. The development of design concepts consisted of various stages – such as explorations of material properties, fabrication process findings, structural engineering, and digital simulation and analysis – that are tightly interwoven and form a synergetic system. The results and outputs within each stage and their interrelations informed the further modifications and adjustments during the design processes to achieve a specific performance within envelope systems. In the Performative Envelopes workshop, the joint necessity and integration of different conceptual approaches within the context of a design project seemed crucial for forming an effective system.

The designs were examined in an iterative process by working with multiple design criteria tightly framed by specific performance foci and feedbacks from physical and digital models. The teams formulated their conceptual approaches, such as proximity and distancing, as operative criteria to develop performative aspects of light; either atmospheric or functional. The achieved qualities, and their modifications during the process were addressed differently by moving between and testing various concepts attuned with spatial and material organizations. The designs used a systematic organization of envelopes' architectural elements in relation to the surrounding environmental factors that were directly affecting and supervising the design. The concepts of envelope organization were examined within an iterative design process of evaluation and reflection in and on action. The benefits of this design approach are: the design parameters are easily controlled and adjusted to test various conditions and inquiries, each test's variables are inert during the test process and therefore remain consistent and allow accurate measurements, the outcomes are explicit and therefore enable the research for further possible iterations, precise demonstration, and documentation.

The theme of the RCAT/ACDL studio in the fall semester 2015 was "Performative Envelopes - Rethinking Architecture from its Boundaries", and comprised the task of designing a pavilion with two different uses and locations. In the first location, the project was to serve as a pavilion for the Oslo Architectural Triennial 2016 in a central location in Oslo. Subsequently, the project was to be relocated to an island in the Oslo Fjord with a large waste landfill area, where it would serve as a small environmental research laboratory. The project consisted of approximately 100 m^2 of fully enclosed spaces and 50-100 m^2 of transitional spaces. The different zones of the pavilion, including enclosed and open spaces and dark and light areas were to be articulated by the building envelopes that organize the space. Environmental modulation was supposed to be following the specific activities housed by the project, which was fully aligned with a free-running building design approach. The inhabitants' relation to the park as the pavilion's surrounding environment revealed interesting perspectives on drawing new relationships between the built form and its surrounding environment both conceptually and climatically. These had been considered in the process – not only from the initial design configurations, but also as an emerging quality enriched by the design process itself. The students were asked to choose either the

overall envelope system, or a selected room of the pavilion to develop further during the weeklong workshop. The following paragraphs present and reflect on two selected projects from this workshop to expand on how each design team applied and developed their chosen design concepts methodologically through their design process.

Team one[9] chose one room of their pavilion design for which to develop a performative envelope system. The pavilion itself followed a programmatic layout, designed as a journey through the project. It emphasized the way in which the visitor moves in sequence through different rooms and encounters various degrees of enclosure and spatial qualities that correlate with each room's intended programme. The portion selected for the design project is a workshop and reading space area, intended to provide the brightest zone within the project, that includes reading screens, workshop tables, and sitting areas. The envelope layers are positioned in such a manner that they correspond to the programmatic needs of different zones of the room. For instance, the screened reading zone is surrounded by translucent glass to prevent glare and the reflection of light. The distance between the arrays of glass louvers results in a multiple envelope system as a layered space in which the aesthetic and functional properties of the in-between spaces are varied. The relation between static and kinetic louvers generates these varied conditions and specifies different functional zones in the space. The configuration of the louvers' position, mobility, and degree of transparency creates a vivid, atmospheric effect in which the designed daylight is the driver of the mood in the space.

The pavilion provides nuanced and changing light modulation and embraces an existing tree as part of its multiple envelopes. The primary structure defines the roof of the room, while the secondary structure forms the enclosing walls. The combination of the diffracted softened light that penetrates from the ceiling and the transparent glass louvers of the multi-layered walls gives the room a sense of layered, regulated visibility that is affected by the seasonal change and degrees of enclosure. The arrangement, distancing, and depth of the roof's louvers provide direct ventilation and an ambient light condition in the room. The students chose David Leatherbarrow's notion of breathing walls to define the performative aspects of their envelope design. Breathing walls as a concept articulates how architectural elements can simultaneously operate in three different ways: technically, practically, and symbolically [13]. The louvers abstractly represent Oslo Triennial 2016's theme, "After Belonging", by challenging the inhabitants' presence through a spatial boundary between inside and outside that results from the layered louvers' transparency variations. On an abstract level, this is a metaphoric interpretation of participation in society. The pavilion thus attempts to create a space in which the condition of space adjusts to the presence and needs of its inhabitants. The composition practically structures the events and arrangements in the room through modulating light and wind by the louvers' interactions. This aspect includes in itself technical needs of the emerging space in which the notion of device Paradigm [13] is actuated by what the louvers do. This includes movable elements and scripted operational behaviours of architectural elements. On the operative basis, the concept of the device paradigm provides active engagement of the inhabitant by the labour of sensors and mechanical apparatuses. This envelope setup creates the means for the conceptual approach of the project while emphasizing the role of envelope's permeability in creating spatial relations and climatic variations.

[9] The students in team one were Kaia Kristine Giltun and Ma Yue.

The first array of sensor-based louvers, which constitutes the outermost layer of the envelope, is made of single-sided mirrored glass plates that provide different light exposures within the pavilion in conjunction with the second layer of louvers. They are therefore scripted to adjust mechanically according to the direction of the sunlight during the day within the rooms. The inner louvers enclosing the room are constructed in smart glass with various degrees of transparency. They interact with the presence of the visitors, according to their proximity, by changing their levels of transparency. The spatial qualities experienced by the visitors through the changes of visibility and the light's intensity create a unique character for the room. The spacing between the louvers is sufficient for the visitors to cross the thresholds when they are fully open – a state in which the border between inside and outside is dissolved. The spacing of the arrayed louver layers provides the design with interstitial spaces and in-between climatic conditions dependent on their distance and orientation. The spacing and degrees of translucency of the louvers were determined experimentally throughout the iterative process of data-driven design and physical data analysis (Figure 5).

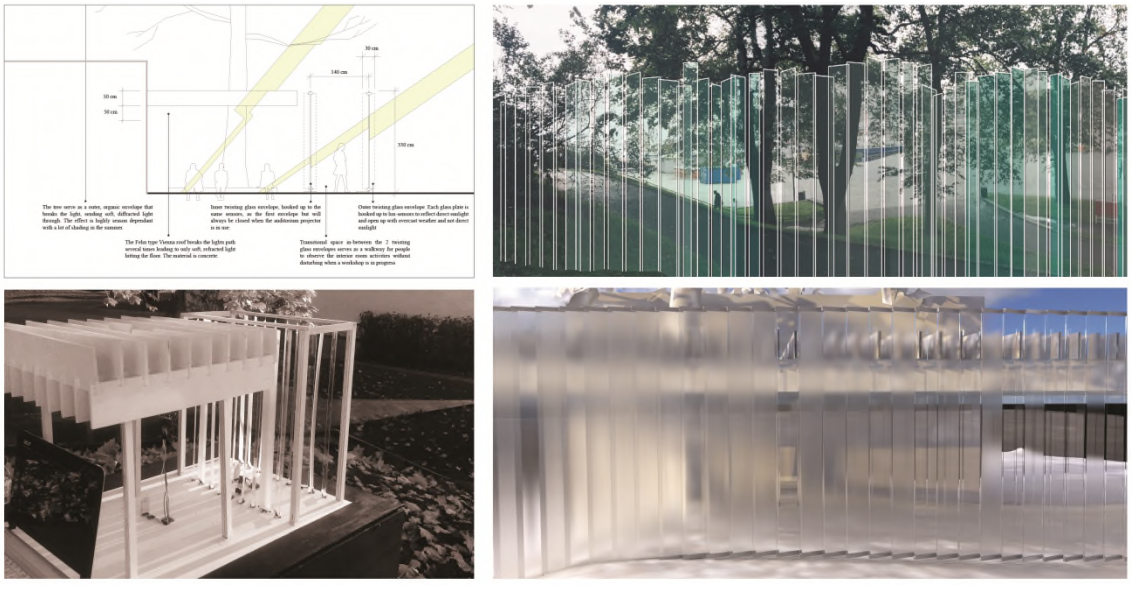

Figure 5 Team One's Envelope Design Documentations. Performative Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL) studio, The Oslo School of Architecture and Design (AHO), fall 2015. The students in team one: Kaia Kristine Giltun and Ma Yue

As flexible design elements, louvers could easily be rearranged and modified. They have the potential to be explored further through their formal arrangement and orientation to fine-tune the design intentions and local specifications of the project. For instance, the formal expression of the project could be further elaborated and assessed by a geometrical expression that could potentially provide pockets of distinguishable climatic zones for the project. Aspects such as these seem to be an area where the project falls short of addressing and developing further. Figure 6 illustrates the findings of physical and digital analysis of the conducted tests on the envelope's design system.

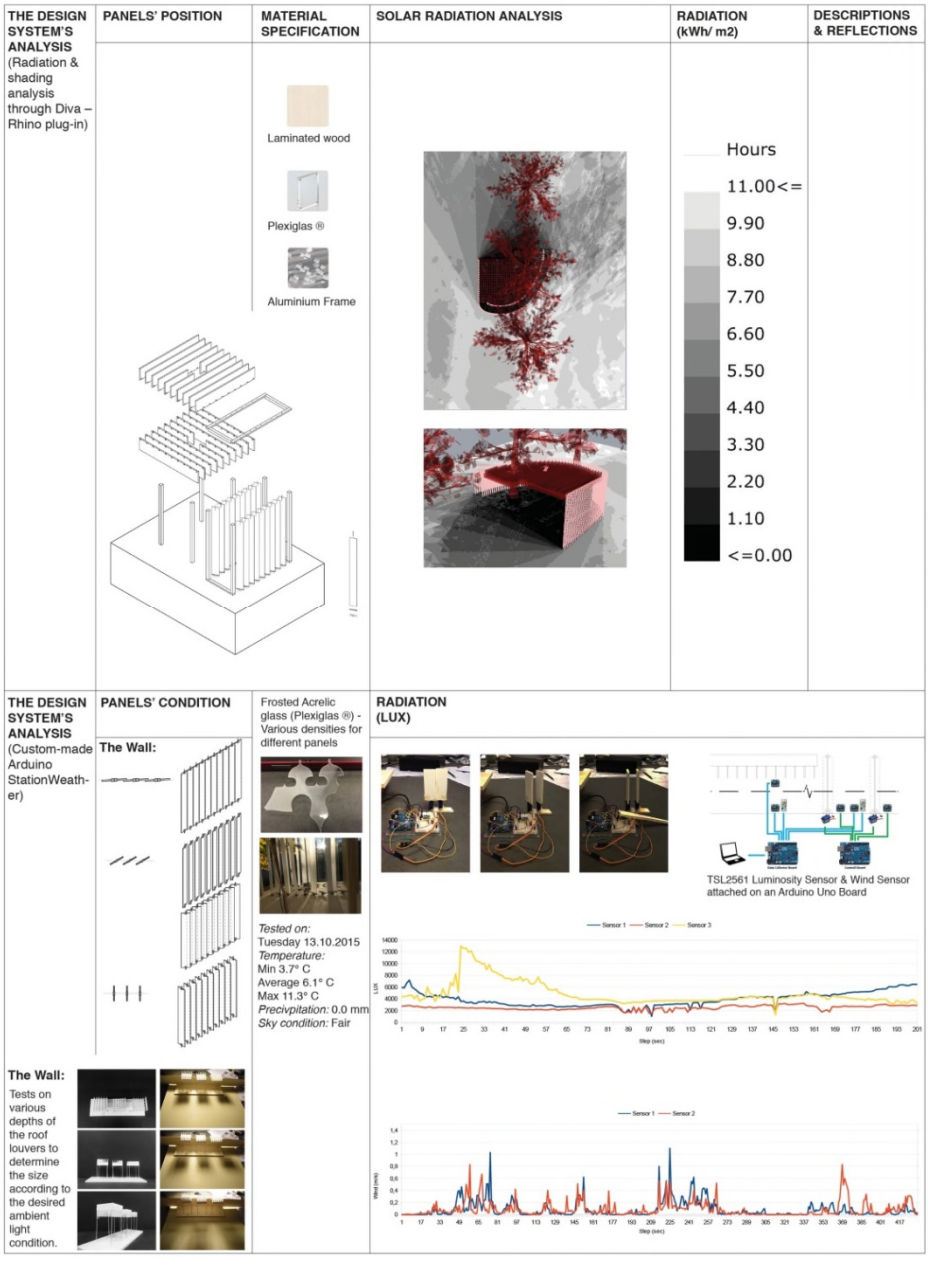

Figure 6 Team One's Envelope's Design System Simulation and Light Analysis. Performative Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL) studio, The Oslo School of Architecture and Design (AHO), fall 2015. The students in team one: Kaia Kristine Giltun and Ma Yue

On a conceptual level, the project addresses transparency as its main design characteristic. The ambient presence of the pavilion, its formal expression through the mirrored glass, and reflections of light in defining levels of transparency are characteristics that define the pavilion's presence. Transparency as a conceptual design approach was also considered in other design projects of the workshop. However, the approach of this project to transparency in comparison to the other projects in the workshop is significant and different due to the design's considerations of the participation and presence of the inhabitants experiencing the envelope. The setup defines a boundary of change that not only reacts to its surrounding environment, but also to its inhabitants. By creating various layers of envelope, transparency turns into a phenomenon of gradual literacy of space. Once one is outside, in-between, or inside the envelope setup, depending on the light conditions and distance, the perception of the space and layers of envelopes differ. Transparency as a conceptual approach has therefore been used to define various degrees of privacy, light regulation, and spatial mood. It affects, and to some extent controls, the inhabitant's spatial perception and experience, in addition to its environmental regulations for providing a semi-sheltered space.

Team two[10] approached the pavilion design as a continuous space and therefore developed an overall design for its multiple envelopes system. The design of this pavilion was developed through an experiment-based, reflective thinking process of testing ideas substantiated early in the process by immediate feedback through digital and physical scaled model studies. The pavilion design is shaped through two elevated membrane systems with a series of columns as the supporting structure. The pavilion standing on the site resembles a dense forest covered in snow, like an early morning fog that lingers among the trees before it is dissipated by the heat of the sun.

The membrane systems articulate the floor of the pavilion, which is formed by a reinforced membrane system, and the roof structure consists of a grid of both adjustable and static membrane patches. The organization of these membrane systems and the structure's elevated floor provide it with various degrees of spatial privacy. The ground level space is a sheltered, yet public area that is open to passersby. The room above is a semi-public, semi-closed space for the exhibitions with a grid-based roof structure that provides it with ambient light throughout the day.

At the ground level, the passersby experience walking among the series of thin columns within a continuous landscape at the horizon, and in the distance, seeing the city's active life framed by the columns and experienced by the limits of the pavilion's scales. Besides providing a preliminary space for the exhibition entrance, this level also serves as a public passage. Nevertheless, it potentially engages and arouses the curiosity of passersby due to the membrane's properties and effects that enable them to see the shades and hear the ongoing events in the exhibition level above. The entrance to the exhibition is almost at the centre of the pavilion at this level. Conceptually, the pavilion tries to create a structural impression that resembles a continuum of the trees of the park. The columns are laid out as a base grid to support and define different layers of envelopes and interstitial spaces. This grid also provides the possibility of creating new enclosed spaces by wrapping series of columns with additional layers of textile. The white steel columns, the PTFE-coated glass fibre fabric, and frosted Plexiglas® shadings and enclosures give the pavilion an integrated unity.

[10] The students in team two were Karen Maria Eiken-Engelgård, Karlis Jaunromans, Harri Kaplan.

By elevating the pavilion, the design activates the terrain of the project as an inhabitable space, and also has a minimal footprint. The considerations of distancing and proximity of the multiple envelope layers enable the design, establishing relations between the project's membranes and the terrain. These fluctuations, especially concerning raumplan structure of the pavilion, result in an intriguing spatial flow and disparity. One can discern raumplan as the established relationship of the main living areas (entrance hall, living hall, dining room, study) in a fixed scheme, in which, rooms are not primarily separated by walls, but by their situations at (slightly) different levels [18]. The openings in the membranes help the visitors to orient themselves continuously throughout their walk. The adjustable membrane roof modules enable ranges of enclosure, thus allowing for modifications of the intensity and airflow. Through this, the design provides time-based conditions that adjust to the various spatial and programmatic needs of the room. Nevertheless, this setup provides a semi-closed space and therefore opens up discussions on degrees of climatic control and insulation for various exhibition conditions. The designed system also provides potentials for the application of sensor-based mechanical systems that define degrees of enclosure and light penetration (Figure 7).

The team realized and tested arrays of a single patch logic within an assemblage and explored how scaling and distancing affect both collective and individual behaviours in its overall system. The tested physical and digital models and the light analysis informed the final choice of materials and degrees of roof patches' enclosure in correspondence to the zone and programme distribution of the pavilion. Figure 8 illustrates the analysis and results of the digital and physical studies of the project's envelope design system.

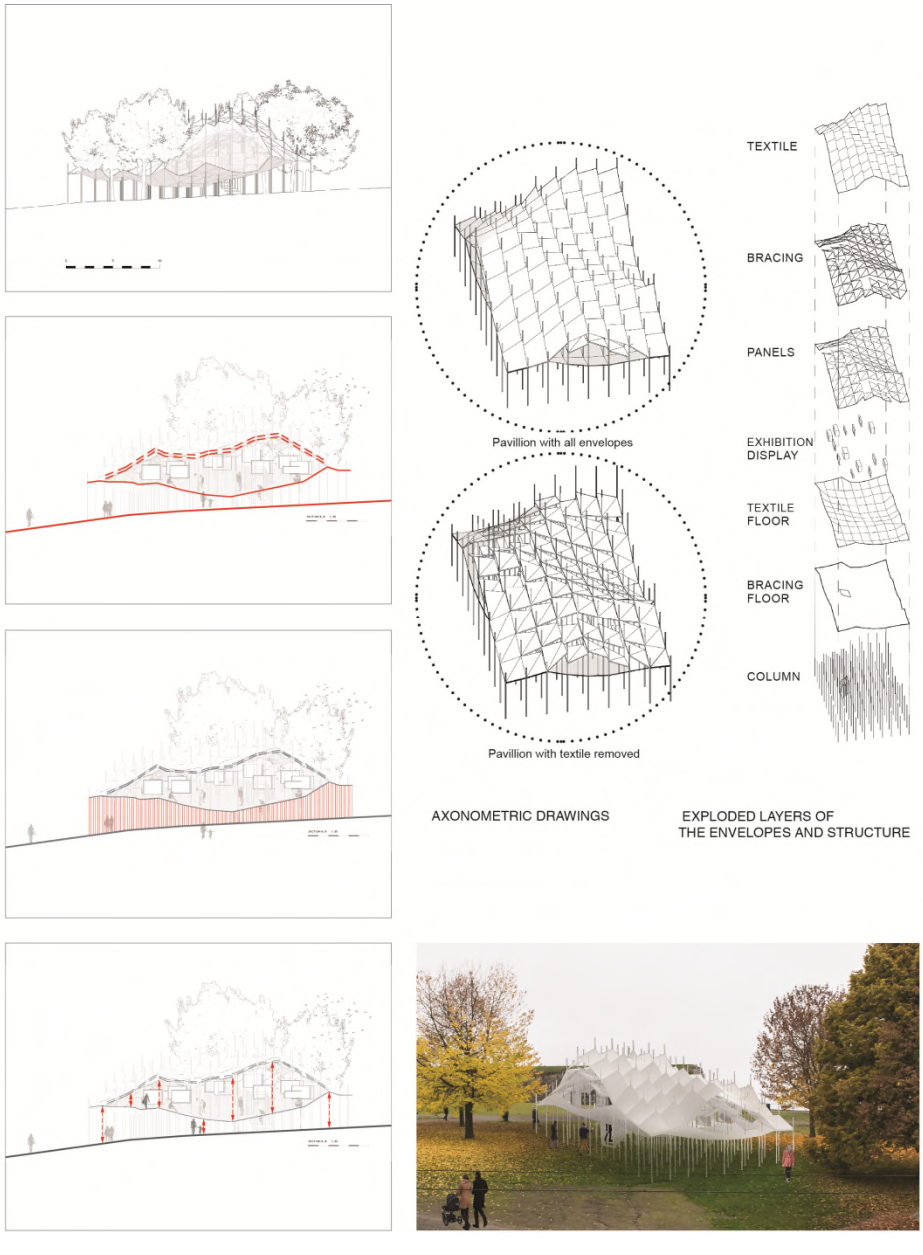

Figure 7 Team Two's Envelope Design Documentations. Performative Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL) studio, The Oslo School of Architecture and Design (AHO), fall 2015. The students in team two: Karen Maria Eiken-Engelgård, Karlis Jaunromans and Harri Kaplan

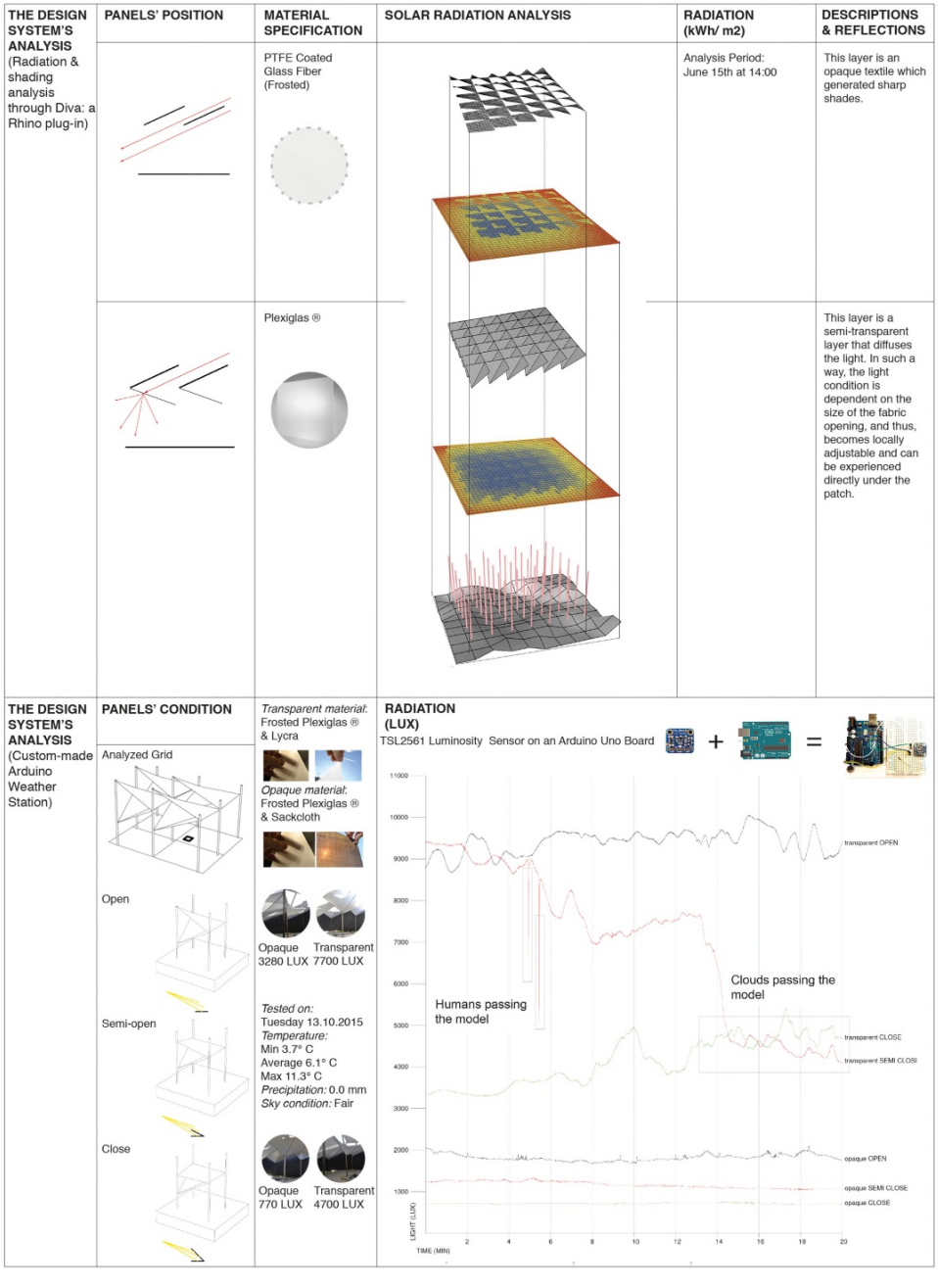

Figure 8 Team Two's Envelope's Design System Simulation and Light Analysis. Performative Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL) studio, The Oslo School of Architecture and Design (AHO), fall 2015. The students in team one: Karen Maria Eiken-Engelgård, Karlis Jaunromans and Harri Kaplan

4.2 Interactive Envelopes Workshop

The 24-hour Oslo studio brief asked for a multiple-use, 24-hour building of circa 400 m^2 that addresses the demographic changes of the population of Oslo. The project was to take into account and respond to adjacent actors, activities, and programmes, as well as those that are further afield but linked to the site. The Interactive Envelopes workshop aimed at developing the envelope designs of studio projects. The workshop proceeded with a week of design, parametric modelling, digital simulation and analysis, and building scaled models followed by two days of climatic data collection and analysis with custom-made Arduino weather stations. On a conceptual level, the workshop dealt with societal and cultural themes in relation to the visitors of the space and related issues of envelope design and its adaptation to changing programmatic requirements. On the technical level, focus was placed on how to reflect on and inform the design with the collected digital and analogue data.

All projects sought to address spatial and programmatic needs by emphasizing conceptual and environmental mediation to create productive buildings [13] and atmospheres through the envelope's design by way of providing an extended threshold between the interior and the exterior. In order to address non-discrete architecture, the students framed their designs within the concepts of: transparency [28], particlization [11], layering, and kinetic systems. The designs were expected to address the role of envelopes in creating heterogeneous spaces while providing the visitors authorship through modifying conditions of daylight in accordance to their spatial needs. The envelope systems thus provided interactive mechanisms with integrated sensor-based operations or physical interaction.

Defining interactivity through agency requires theories around the subject in which the correlations of various elements and concepts of architecture are engaged. For this reason, the conceptual approaches to the notion of envelopes within the workshop included environmental, programmatic, and material considerations. The selected design project[11] presented here focuses on creating an adaptive building programme that corresponds to the envelopes' reactions to light conditions and seasonal change, while defining the notion of public and private realms through its envelope's organization and enclosure. The project in question is located at Slottsparken, a public park surrounding the Royal Palace in the centre of Oslo. As the initial stage of the design process, the programmes and activities in the area were mapped to inform the approach to the 24-hour programming of the building. The site analysis included the site's accessibility, sports activities, modes of transportation, neighbouring touristic attractions, adjacent buildings' programmes and functions, and distances between the public hubs in the area. The juxtaposition of mapped data informed the choice of location for positioning the building and decision-making related to the programme's distribution. Through its organizational strategies, the project decisively arranges a graded transition both in terms of its degrees of enclosure and climatic control, and transitions from public to private realms. In this project, the common practice for – or rather, traditional way of – addressing private and public realms through the defined border of envelope is revisited and redefined. The envelope systems not only affect the interior space conditions in terms of climatic comfort, light modulation, and degree of privacy, but also its urban surroundings.

[11] This project was designed and developed by Matteo Lomaglio during the spring semester 2016 at ACDL studio, the Oslo School of Architecture and Design.

The design consists of two continuous surfaces that form a spherical building. One of these continuous surfaces constitutes the core of the building and is surrounded by the other surface that supports the three envelope systems. The envelope systems consist of a metal mesh, a kinetic louver façade, and an open structure that surround the building's innermost, fully enclosed glass core. Each of these envelope systems provides different degrees of enclosure and various climatic, daylight conditions. The metal mesh creates a zone that houses vegetation, providing spaces with seasonal features and changing degrees of climatic conditions. The opening in the envelope creates a semi-sheltered space that is exposed to its surrounding environment, and mostly accommodates the public areas of the building. The kinetic louver system equips the spaces with adjustable degrees of enclosure and exposure. The degree of enclosure of these systems and their orientation were determined upon climatic analysis and environmental assessments of the project's analytical mappings. The envelope surface's porosity defines the daylight penetration and sunlight exposure of the enclosed spaces, along with the climatic conditioning of the in-between spaces they create. The inner and outer layers provide various spatial depths of interstitial spaces corresponding to the programme and spatial needs. Together, the building systems fulfil the varying needs of the 24-hour programme of the schemes in correspondence with the changes in its diurnal and season-specific conditions and milieu. The spherical envelope types often contain gradients of publicness within themselves, and as such, they go beyond defining only a border between private and public through the surface treatment. Being open to the public at its ground floor and oriented at this cross-connection, the project therefore engages the passersby by providing an opportunity for social interactions and coffee pauses, while fulfilling its 24-hour building programmes (Figure 9).

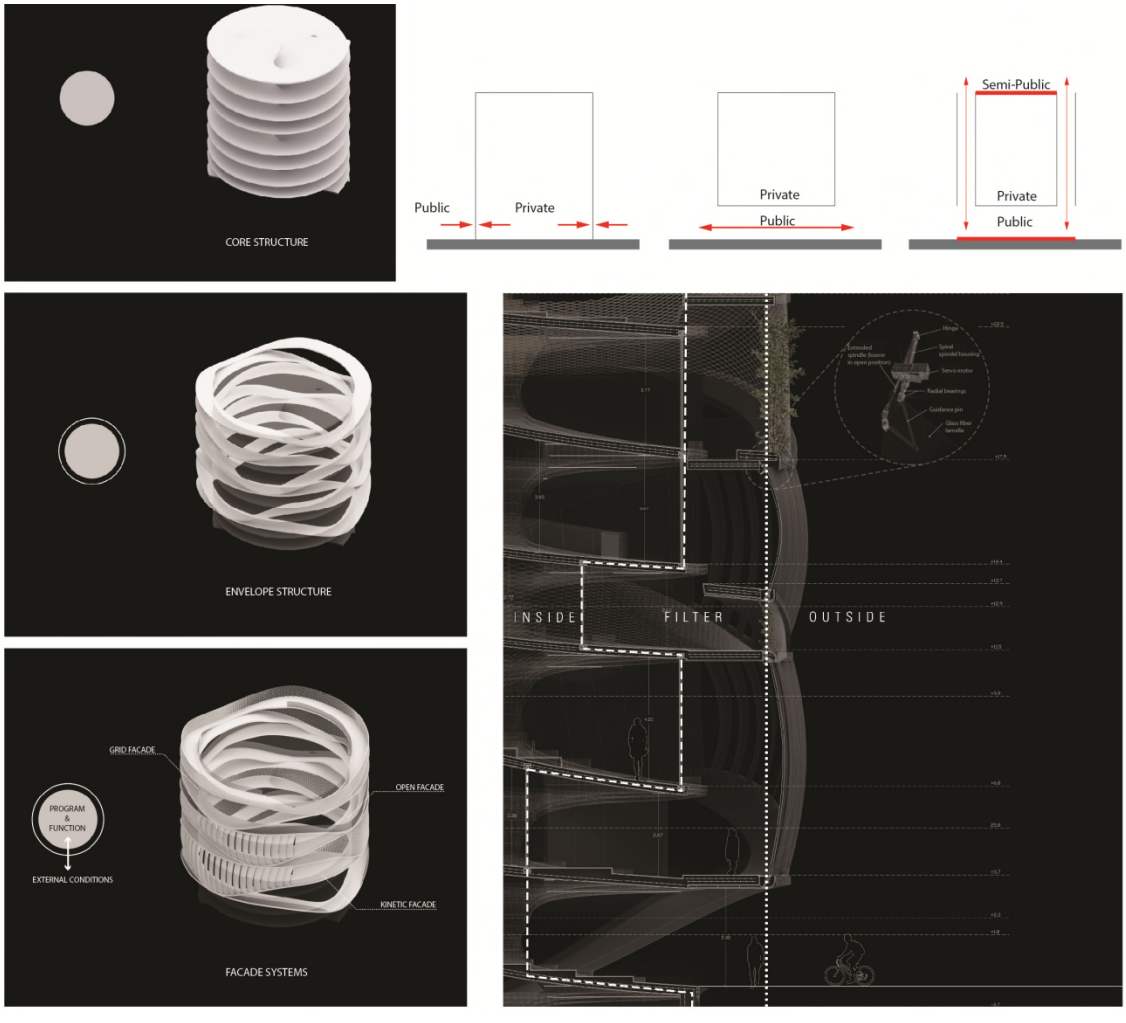

Figure 9 The Selected Envelope's Design Documentation of Interactive Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL), The Oslo School of Architecture and Design (AHO), spring 2016. This project was designed and developed by Matteo Lomaglio

The continuous ramp of the building, which is located at the outer ring of the project, provides an in-between space that allows public access to the roof garden through which the visitors can catch a glimpse of what's happening in the interior spaces as they pass by. The project thus consists of transitions between public and private spaces by addressing the ground floor as the public space, the roof garden as the semi-public space, connected by the continuous ramp that accommodates the envelope systems, and the private rooms in the core of the building. By defining a different degree of privacy through movement, the project creates a flexible zone, a new topography [13] that moves between the public and private zones by distancing from the innermost layer with full enclosure, or penetrating it and constituting new access points to the semi-private zones (Figure 10).

Figure 10 Rendered View of The Selected Project designed at Interactive Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL), The Oslo School of Architecture and Design (AHO), spring 2016. This project was designed and developed by Matteo Lomaglio

In his book "Anti-Object" Kengo Kuma exemplifies different conceptual approaches that he had developed for various projects. One of these approaches is particlization, which he describes as attempts to create similar effects as fine particles of reflected light on a water surface by breaking up the surfaces of the projects. Doing so, he believes, creates a distinct spatial effect, while maintaining the surface's overall identity [11]. The mesh surfaces of the project create a constant spatial quality throughout different seasons while changing the density of the patterned light that penetrates through the plants during summer, or the exposed mesh surfaces during the cold seasons when there is no foliage. The kinetic envelope system uses a sensor-based setup that is mechanically controlled to provide modifiable ranges of openness in response to time-specific programmatic requirements. The setup allows the inhabitant to control light penetration and the degrees of spatial enclosure, in addition to its potentials of being mechanically programmed for a responsive sensor-based system. All three of the project's envelope systems define conditions of interactivity within the interior by creating an active relationship between the inhabitant and the exterior conditions. The overall building design, therefore, creates heterogeneous spaces that are continuously varied in terms of their functional and atmospheric conditions. Figure 11 illustrates the digital structural and climatic analysis of the model, and physical model's measurements on degrees of light penetration at various intervals and ranges of openness in the kinetic panel.

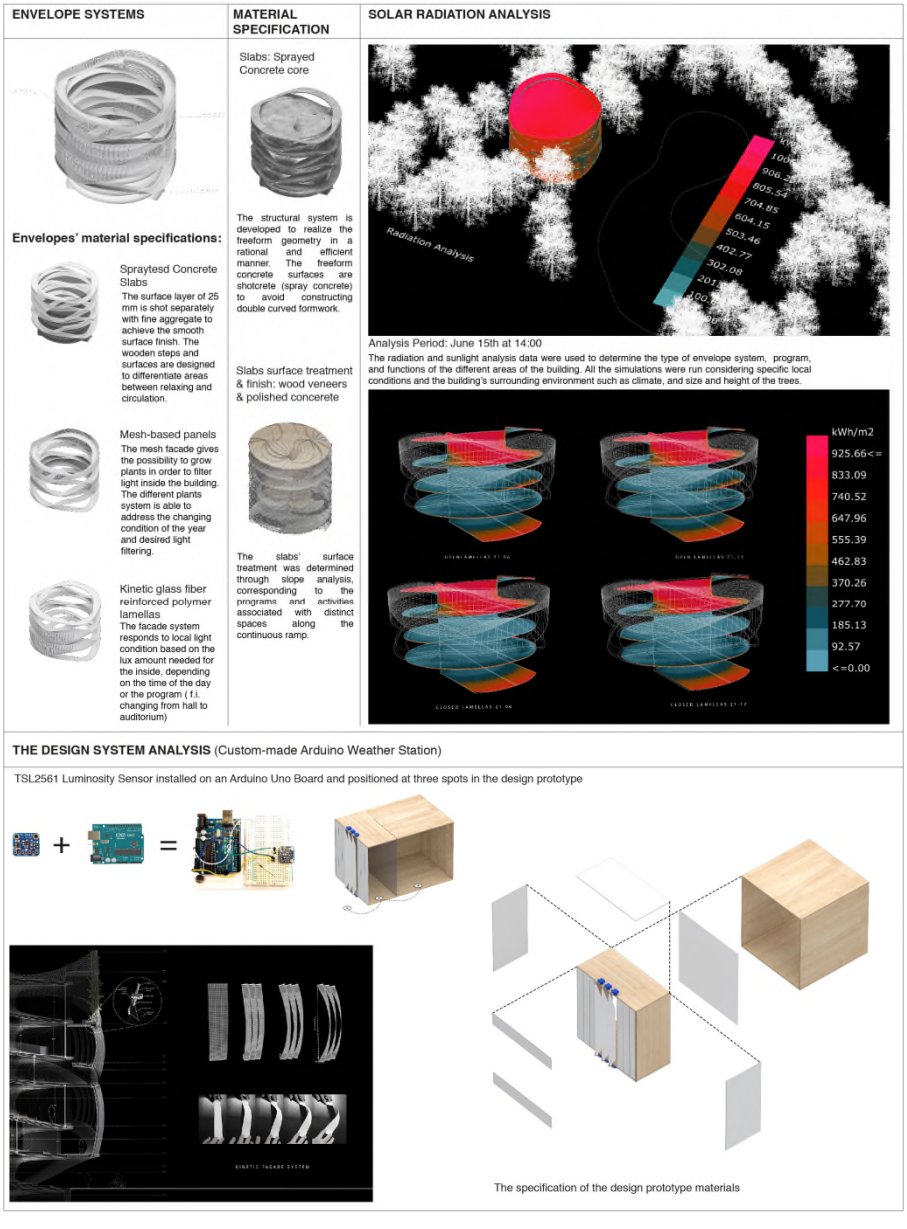

Figure 11 The Selected Envelope's Design System Simulation and Light Analysis, Interactive Envelopes Workshop conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL), The Oslo School of Architecture and Design (AHO), spring 2016. This project was designed and developed by Matteo Lomaglio

The physical model of the design was evaluated by a custom-made Arduino measure station.

The design was based on an iterative process. The various design parameters and related analyses that were considered as criteria in this process included: [a] slope analysis and surface treatment of the slabs;

[b] height differentiation; [c] structural analysis; [d] bracing structure and its stress and displacement analysis; and [e] material definitions and programmatic layout in relation to these analyses. Figure 12 illustrates the correlation between the design parameters.

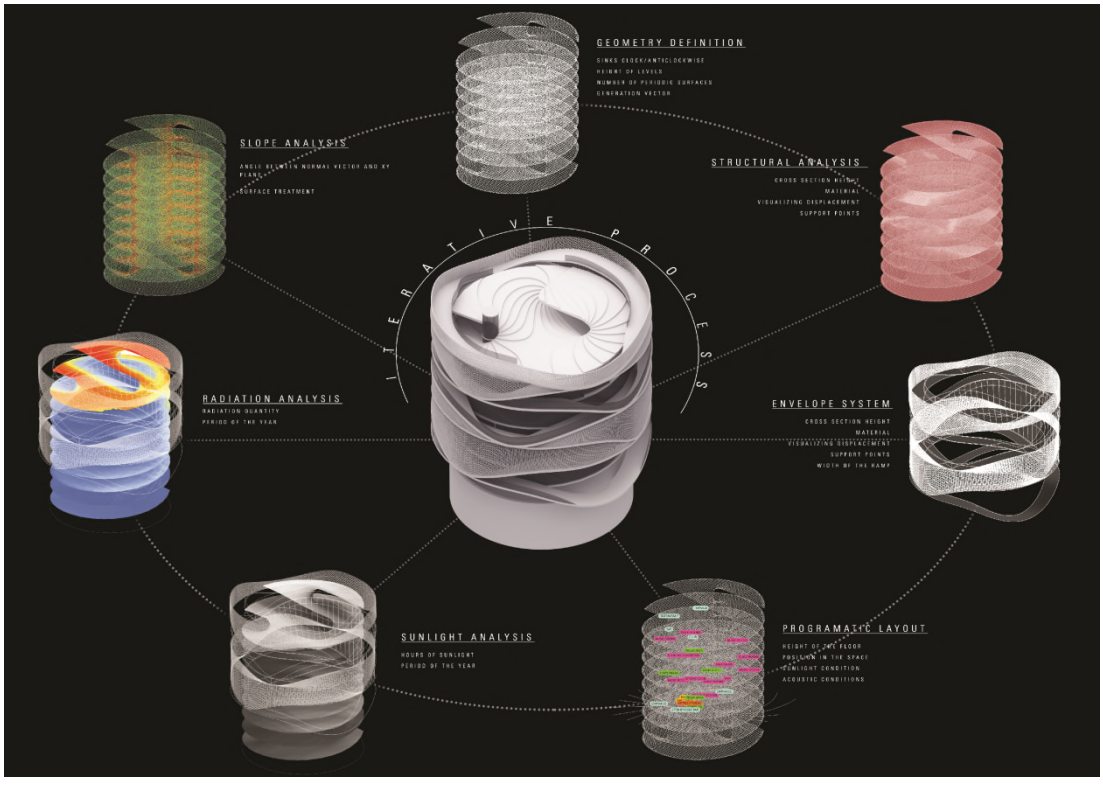

Figure 12 The Iterative Design Process and Analysis Diagram of The Selected Project designed at Interactive Envelopes Workshop, conducted by Sareh Saeidi, Advanced Computational Design Laboratory (ACDL), The Oslo School of Architecture and Design (AHO), spring 2016. This project was designed and developed by Matteo Lomaglio

The process included digital and analogue analyses to assess the design iteratively through direct feedback and modification.

5 Discussion and conclusion

The envelope of a building defines and conditions a given space. Interiority is created by a material boundary that defines the enclosure, either by abstracted and minimized constructs or by massive structures. The importance of the role of façades has been the focus of various discussions within the architectural discourse. These arguments can be classified into four thematic approaches: structural and static; expressive and representational; socio-political and economical; and environmental discussions and issues of sustainability. This investigation focuses on the lattermost theme to approach a redefinition of envelopes with the focus on local specificity in architectural design through specific performances and design concepts. The research tries to find ways through which envelopes are the author, or governing

threshold, of the strong relationship between built forms and their milieus. It therefore reveals the problem of today's architectural envelopes by elaborating on how the dominant approaches in current practices lead to objectification of architectures that are independent of their surrounding environments. It also shows how within this approach, the building's outermost layer is treated mostly as a materialized boundary. The aim of the investigation is to redefine the notion of the envelope as a spatial zone that creates heterogeneous in-between spaces. Heterogeneous spaces include and enable various types of inhabitation, climatic adjustability, and programmatic flexibility within a sheltered zone. The investigation therefore selectively utilizes some of the current focuses on performance in the architectural discipline to establish an operative approach to envelope designs. The performance's emphasis is constructed through the notions of agency, architectural atmospheres, and environmental conditioning.

The outcomes of two workshops conducted at the Advanced Computational Design Laboratory (ACDL) studio at the Oslo School of Architecture and Design (AHO) in the fall 2015 and the spring 2016 semesters helped the investigation to reflect, realize, and position its arguments on the applied methods and conceptual approaches. They included questions on how and what should be addressed and examined during the design process to arrive at a result that fulfils its objectives and can be described by its design approach and process. The workshops' design experiments highlighted the necessity of narrowing down the mappings of the research to work through a few conceptual approaches leading to non-discrete architecture by their envelope design. The experiments made it evident that approaching non-discrete architecture requires an acute emphasis on designing transitional spaces. They manifested that the constructs of an envelope, as a spatial zone, are dependent on the gradient and articulation of spaces in correspondence to its exterior and interior demands. The New Oxford American Dictionary defines 'transition' as: [a] the process or a period of changing from one state or condition to another, and [b] a passage in a piece of writing that smoothly connects two topics or sections to each other. It defines 'transitional' as: relating to or characteristic of a process or period of transition. Similar to the definition of transition in the literary works, a transitional space is one that connects two different spaces through a smooth gradient of change. This specific change is embedded in both atmospheric and climatic conditions that affect the architectural experience.

To correspond to the emphasis on transitional spaces, the research's selected concepts need to be focused according to their conceptual importance in facilitating concepts around designing transitional spaces. The conceptual approaches listed previously in this article include: spatial organization, permeability, spatial continuity, proximity, agency, dynamic environments, particlization, and transparency as the main concepts within the design experiments. Therefore, the concepts can be grouped into three categories. One of these consists of approaches that build the spatial notion of envelopes, and the second consists of concepts on its surface treatment and material organization. The third group includes post-inhabitation readings and provisions of design, taking into account notions of active agency mentioned earlier in this article. The first group incorporates spatial organization, layering, adjacency, and continuity, as design approaches that can be worked through at the initial stage of the design process to constitute the necessary spatial gradient and articulation of the envelope. The second group includes concepts such as particlization, transparency, and permeability. These concepts address design provisions for envelopes in creating heterogeneous interstitial spaces that, through locally specific design, affect the inhabitants' experience and perception of envelopes.

The research's methodology helped the delimitation of conceptual mapping towards framed concepts that could be easily applied and evaluated within the design process. In the experiments conducted, a need became evident for greater elaboration of defining ways to approaching flexibility and provisions of change in envelope designs. This includes questions and considerations on change and how it affects the experience of envelopes. Change, in the scope of this research, is the ability of the envelope design to meet and include the effects of its both interior and exterior surroundings in time and space. Time and seasons had a greater presence in historical traditions of architecture; one of the reasons for this is their close relation to climatic design considerations. The organization of materials and space can be utilized to engage closely, and demonstrate, the factor of time, seasons and climate to create specific spatial character and modes of inhabitation. It can provide possibilities for creating ranges of enclosure and shelter, resulting in different degrees of public-ness, climatic comfort, and programmatic flexibility. In addition, material and spatial organization of the envelopes can provide the design with post-inhabitation-provisions. Two examples of this can be named as spatial considerations that are mindful of vegetative growth or programmatic adaptation of the envelope's interior and exterior environments.

The paper seeks to introduce the research's approach to facilitating a discussion regarding the validity of the design approach, and to position the investigation within contemporary envelope design research in architectural practice. The application of analytical and iterative approaches based on design studies and the systemization of the existing knowledge provide the design with the instant feedback necessary for the reflective thinking and modification within an iterative process. Through the conducted experiments and methods, and upon their further development, the research seeks to establish an operative design approach that can be utilized within both architectural practice and academy. The mapped conceptual approaches initiate a guideline for envelope design that, along with the envelope taxonomy, establishes the notion of performative envelopes and their inhabitation capacities by designing in-between spaces. These semi-sheltered and in-between spaces provide greater chances of interaction between interior and exterior or private and public environments. On that account, the inhabitable building envelopes elevate the common design tendencies of surface treatments in architecture to a higher level that also engages discussions on social interactions and climatic designs. The research's guideline on how to provide spaces with various microclimates and multiple patterns of use through building envelopes' articulation, benefits the academy and practice by providing an adaptable systematic approach that can be evaluated upon application and modified based on various designs' specific inquiries.

The developed approach will be examined and investigated further through design experiments that are sharply focused around contemplations on ranges of inhabitants' experience and the process of change within the constructs of performative envelopes. It would therefore appear necessary for the studies to specify the effects of envelope's design on its adjacent environments through demonstrating various ways of inhabiting the envelope and experiencing it. This includes phenomenological aspects such as human consciousness, intentionality, and sensory fusions, in addition to defining the role of non-human agencies in affecting inhabitants' spatial perception and moods within a space.

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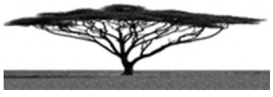

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Envelopes and exteriority

Local specificity and extended exterior as design criteria for architectural

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Sareh Saeidi

Envelopes and exteriority

Local specificity and extended exterior as design criteria for architectural envelopes

Abstract
This article discusses the relationship of architecture to its surrounding environment. The objective of the article is i) to reposition the relationship of architecture and its surrounding exterior by expanding the understanding of architectural envelopes, and ii) to systematically define exterior space as design input. The notion of the envelope encompasses a spatial recognition defined by interactions between interior and exterior environments that affects an inhabitant's experience of architectural space. This research is organised in three sections: a) a literature review to systematically examine the terminologies of this research, b) selected case studies that consider exteriority as a design criterion, and c) research through design inquiry to combine a systematic approach with design thinking. The study applies both conceptual and method-oriented approaches to develop an integrated design approach focused on the climatic and atmospheric performances of architectural envelopes.

Keywords*:* Architectural envelopes, performance-oriented design, extended setting, extended threshold, in-between spaces

Introduction

This article examines the relationship between built forms and their surrounding environment with the aim of developing an integrative design approach to locally specific architectural envelopes through an extended threshold between the interior and the exterior. This is systematically approached using a number of case and design studies. Conceptual approaches are extracted from the case study diagrams that can act as a design guideline. The diagrammatic guideline constitutes generalised principles from locally specific designs. However, the intention is not to derive universal design principles that can be applied at any location. Instead, the goal is to derive principles that need to be re-contextualised and adapted to the specific settings they are positioned at. Therefore, these principles cannot be applied irrespective of the specific exterior environment of architecture.

A significant driver today in the disconnect between architecture and its settings in the industrialised parts of the world results from an exclusive focus on energy efficiency and modulated interior climates, which

> …tend to create an overall drive towards optimization, that is, towards the reduction of building to the maximizing of economic criteria and to the adoption of normative plans and construction methods reducing architecture to the provision of an aesthetic skin – the packaging, in fact, of nothing more than a large commodity in order to facilitate its marketing.
>
> (Frampton, 2007, p. 376).

In contemporary architectural practices there exist a great variety of approaches to designing the relationship between architecture and its setting. These include, among others, a continuation of vernacular architecture in various parts of the world that continue building structures such as courtyard houses; various forms of regionalist approaches that are – to a

lesser or greater extent – informed by vernacular examples; as well as contemporary designs that propose the addition of new technologies and solutions. In parallel, there exists a common trend that emphasises a separation of architecture from its setting by way of increasingly generic architecture and lack of consideration of local specificity. The architecture of the latter mainly results in a singularity of the architectural form that is ignorant of its context. Although varied in intentions and approaches, the resulting architecture of this type is designed to separate and be separated, resulting in "provisions of an aesthetic skin" (2007, p. 376). or operative boundaries of insulation that lead to blank envelopes (Moussavi, 2005). Rem Koolhaas's essay on *Bigness* (Koolhaas & Mau, 1995, pp. 494–517) is a primary example of affirmation of what might be termed the object-orientation of architecture. Koolhaas does so by positioning architecture as an object independent and often wilfully ignorant of its surrounding urban context, and as a creator of an emerging context through size and individuality. Contemporary urban fabrics increasingly adhere to Koolhaas's concept of Bigness with a distinct idiosyncratic diversity of unrelated architectural objects and their deliberate disconnect from context. The provocation of "fuck context" posits that Bigness, through its very independence of context, survives by "not [taking] inspiration from givens too often squeezed for the last drop of meaning". Instead, it finds its independence by "its own raison d'être" (1995, p. 515).

This article is a continuation of an ongoing research that is focused on developing an alternative notion of the architectural envelope (Saeidi Derakhshi, 2017) as a critique of the common practice of building skins or façades that represent a strict boundary condition. One cannot sensibly deny that the built form impacts its surroundings and interacts with them, thus "presenting itself as though [they] were coextensive" (Leatherbarrow, 2009, p. 39). This investigation aims to reposition the performance of architectural envelopes within the scope of local specificity and architectural experience. This is to examine the role of surrounding local conditions as an integrated criterion in designing envelopes with the purpose of creating atmospheric experiences. The investigation redefines the notion of architectural envelopes, focusing on spatial organisation as the factor for creating an extended threshold that is habitable, and with features of the exterior environment as its key design criteria (Figure 1).

The question that arises is how to define a performance-oriented approach in which the material and spatial constituents of the architectural envelope condition and are conditioned by the exterior environment. The notion of *performative envelopes* refers to envelopes that accommodate experiential effects through their constructs, allowing for interactions between architecture and its surroundings. To meet this objective, the investigations are pursued through two types of studies: case studies that focus on how specific aspects of exteriority have been designed or addressed in selected architectural projects and design experiments in a workshop conducted by the author in the context of an architectural master-level studio. The workshop aimed to explore methods that enabled assessing various performative and conceptual aims of the design projects. What evolved from these efforts is an attempt to reposition exteriority as a critical design criterion that encompasses the interrelations of architecture with its surrounding environments, generating a spatial extension of both the interior and the exterior. This article uses the term "exteriority" to refer to the exterior space outside an enclosure in its generic sense and "exterior environment" to represent the immediate surroundings of the built form.

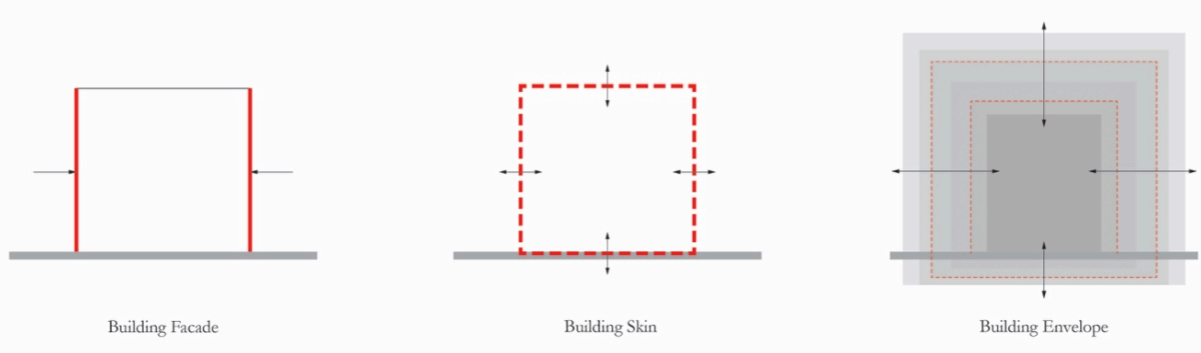

Figure 1. Diagram representation of this research's definition of building façade, building skin, and building envelope – produced by Sareh Saeidi, Spring 2018.

Literature review

The inattentive use of various definitions in the architectural discipline in referring to the outer boundary of the built form often obscures a clear distinction between the notions used and their inherent differences and characteristics. This is the case with the notion of exteriority. Although architectural forms are considered to be both space occupiers as well as space definers (Rowe & Koetter, 1984, p. 79), the discussions of architectural spaces are mainly focused on interior and, sometimes, transitional spaces. Although varying in approaches and focuses, this is apparent in the discourse of many modern and contemporary theorists and architects who discuss architecture mainly in terms of interior spaces, giving less attention to the exterior beyond the exterior expression. Le Corbusier refers to the exterior as a result of the interior, considering the process of architectural design as a plan that proceeds from the inside out (Corbusier, 2007, p. 216). In explaining his viewpoint, he refers to the similarity of a building to a soap bubble that is "perfect and harmonious if the air is evenly distributed and properly ordered from the inside" (2007, p. 216). The primacy of the interior thus overshadows both the role of the exterior in creating effects and conditions for the interior, as well as its potential in accommodating the spatial extension to the interior spaces. There are also other modern architects and theorists who attempt to establish a spatial realisation of architecture, defining it beyond the boundary of the outer wall. Two examples of these design approaches are "breaking the box" by Frank Lloyd Wright (Wright, 2010) and the approaches of Loos (Risselada, 2008) and Mies van der Rohe (Frampton, 2001), who pursued spatial continuity. Concepts such as "breaking the box", which opened up the corners of the intersecting walls to allow the interior to merge with its ambient surroundings, employ walls as means of spatial extension. As a result, architectural design provides a milieu for the built space that is "not only the building's immediate vicinity, but also the greater region surrounding the site" – an extended topography (Leatherbarrow, 2009, p. 145 on Frank Lloyd Wright's projects). Leatherbarrow uses the term *extended topography* to discusses *Raumplan* as an approach utilised for designing interior settings, but also in regard to the exterior. He analyses Adolf Loos's projects to expound on *Raumplan* as a mode of interpreting the relationship and connections between the building's interior and exterior, and enclosed and open spaces, as complementary in creating a unified whole. In his view, no room or collection of rooms in this unified whole is seen "in itself" but is understood or conceived with in respect to one another (Leatherbarrow, 2009, pp. 152–157). Some discourses have taken this discussion further by raising the point that architecture needs to "have an interactive relationship with nature" (Frampton, 2007, p. 383). Nature here doesn't only represent "the topography and site, but also climate and light […] to which built form is necessarily susceptible to a degree" (2007, p. 383). It can be argued that here architecture becomes more than the sum of its parts by incorporating the given context through creating a spatial extension of both its interior and exterior environments. Using Leatherbarrow's

extended topography as inspiration, this research uses the term *extended settings* to refer to design strategies through which the vicinity of the building exterior serves as a complementary extension of the interior spaces, as well as a space that demands attention in its own right.

This research distinguishes between three main approaches in creating an extended setting, based on how the emphasis on the relationship between the interior and the exterior is articulated. These approaches are: 1) *Inside-out*, 2) *Outside-in*, and 3) *Inside-outside* (Figure 2). The *Inside-out* approach emphasises the visual connection between interior and exterior environments, realising the architectural qualities of this relation by emphasising the focus from the interior to the exterior. This approach invariably seems to lead to object orientation of the built form. Similarly, the *Outside-in* approach tends to make the interior space subservient to criteria pertaining to the exterior. Common examples of this approach are semi-open structures that serve as sheltered spaces providing a temporary stay in architectural landscape projects. The *Inside-outside* approach, which underpins this research, emphasises built forms that shape their spatial qualities through the ways in which they meet, incorporate, and interact with circumstances of their local context as one integrated system negotiated by an extended threshold: the architecture envelope.

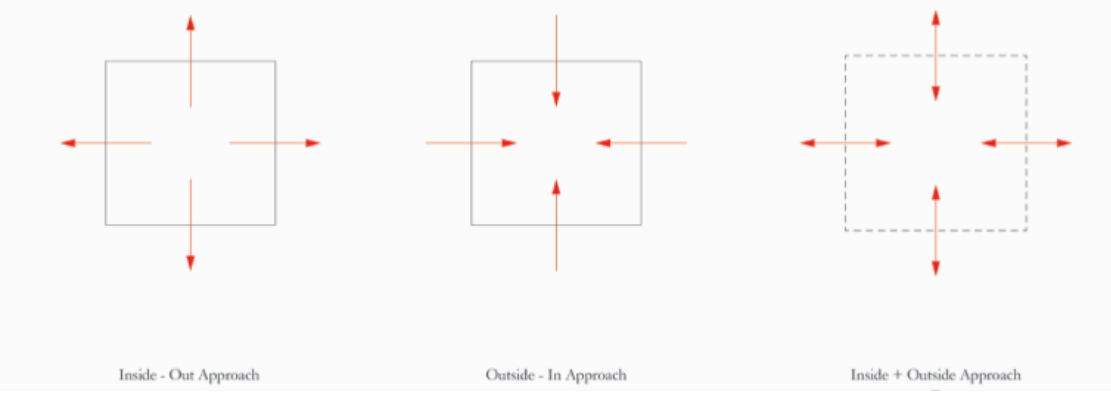

Figure 2. Diagram representation of prevailing approaches in creating an extended setting for the built form – produced by Sareh Saeidi, Spring 2018.

Architecture is “the spatial semblance of a world made visible” (Langer, 1953, pp. 97–98) in a field of invisible forces "that “give[s] shape and rhythm to everyday life of the body” (Kwinter, 2002, p. 14). When considered this way, architecture can be seen as a system of forces, on the one hand, pertaining to

> …‘micro-architectures’ [that consist of] those relations smaller than the object that saturates it and composes it, [and on the other,] those relations or systems that are greater or more extensive than the object, that comprehend or envelope it, the ‘macro-architecture’.
>
> (Kwinter, 2002, p. 14).

If we take this notion of correlated micro and macroscales a step further and define a scale in-between the two, that represents the relations between a selected number of microarchitectures, we could define a mesoscale. This is the scale through which we can discuss the role of architectural envelopes and their relationship with the exterior environment. As part of the mesoscale discussions in architecture, the following paragraphs seek to clarify the notions of milieu, environment, context, and local specificity as the commonly used notions in the discussions of the architectural context or environment.

Architecture consists of elements that affect and are affected by the environment in which it exists. It is therefore essential to first discuss what the definition of environment

entails. A term that is commonly used in various disciplines to refer to the surrounding environment of a subject is *milieu*. Historically imported from mechanics to biology in the 18th century, the notion of milieu has been used across other disciplines as well, including philosophy and physics (Canguilhem, 1980, pp. 1–17). In Canguilhem's view, "the environment [*Umgebung*] is precisely nothing more than a [hu]man's Umwelt", centred on and oriented by human perspectives and pragmatic experiences, which are relative to a living animal (1980, p. 11). Uexküll (1980) classified various realms within this notion of milieu by distinguishing between the environment of behaviour specific to an organism (*Umwelt*), the ordinary geographical environment (*Umgebung*), and the universe of science (*Welt*) (1980, p. 11). The concept of milieu today mostly refers to an "aggregate of influences or conditions which shape or determine the being, development, life, or behavior of a person or a thing" (Spitzer, 1942). This concept is associated with the theories of French philosopher Auguste Comte (1798–1857) and French critic and historian Hippolyte Taine (1828–1893).

An essential aspect of the physical environment is climate. One of the basic tasks of architecture is to provide climatically attuned living spaces. The word climate is "derived from the ancient Greek verb klínein [meaning] "to incline" [which] describes the tilt of the Earth's axis" (Hausladen & Liedl, 2012, p. 12). However, the term "climate" covers a wide range of life, as do many terms in Greek. One definition of the term is "the environment that conditions, ether, space, place – and the ocean embracing the earth" (Spitzer, 1942, p. 11). Another refers to a rather general term "as a protecting, embracing or encompassing thing" (1942, p. 11). In its more common use in contemporary culture, climate, as opposed to weather, refers to the "state of the Earth's atmosphere as established by statistics, over a period of time […] relevant to a location, a region or the whole Earth" (Hausladen & Liedl, 2012, p. 12). Climate is commonly classified in three scales: macroclimate, mesoclimate, and microclimate.

The architecture of closed-systems and steady-state design approaches "tend[s] to be deprived of its inherently mediatory capacity" such as natural ventilation, shading, utilisation of diurnal and seasonal use of space (Frampton, 2007, p. 384). The preoccupation with a building's energy consumption includes excessively relying on benchmarks with little or no discussion of adequate equivalent alternatives. An underestimated design aspect is the fact that "architecture […] has the potential to consciously modify natural microclimates" (Garcia-German, 2017, p. 172) and biological environments. Traditions in vernacular architecture that were adapted to their local conditions, climates, and cultures to temper both indoor and outdoor environments are usually overshadowed in today's architectural practices, while the dependency of buildings on mechanical add-ons has increased. Many of the buildings today are built using "imported abstracted knowledge insensitive to ethnic requirements and oblivious to the subtle wisdom gained by an intimate experience of the local nature and microclimate and architecture's potential for adaptation" (O'Cofaigh, Olley, & Lewis, 1996, p. 2). An effective built form within this definition "exists in the midst of an evolutionary process and is embedded in systems of all kinds, yet has choices and creative ranges about how to deploy itself" (O'Donnell, 2015, p. xvi) or can adapt to unpredictable changes and create atmospheres accordingly. A locally specific form is one that integrates and interacts with its surrounding environment in a unified way while sustaining specific microenvironments.

This research uses the notion of context to refer to the existing surrounding environment of the built form, including conditioned and natural circumstances which the architectural form responds to and interacts with and in which it exists. Context thus distinguishes itself from milieu by regarding not only the physical surrounding environment of the built form, resulting from various interactions and interdependencies, but also aspects of its perception. The definitions of environmental contexts, in their broad sense, have frequently been used to refer to aspects of sustainability and energy efficiency in the past five decades, disregarding the sensory and experiential aspects of the built space. However, before being overloaded with today's environmental and ethical responsibilities, they were focused around aspects of

increasing comfort and creating aesthetic and sensory effects in the immediate experience of architecture (Hardy, Martin, & Poletto, 2008, p. 14).

Of the most notable discussions around spatial moods and atmospheres in the architectural discipline is perhaps what Norberg-Schulz called "the spirit of place" (Norberg-Schulz, 1979) and its role in understanding architecture – a topic that was later picked up and extensively discussed by other contemporary architects. The spirit of place refers to *Genuis loci,* derived from a Roman concept that denotes what a thing is and what it "wants to be" (Kahn [1969] 2013); this defines "a living reality" – although Norberg-Shulz does not name it as such – in a given context (1979, pp. 18–23). However, this description of the spirit of place does not necessarily provide a clear definition of atmosphere and is rather abstract, perhaps intentionally, to make room for individual interpretations of the notion. On the other hand, although more pragmatic and less formally theorised, approaches such as those of Peter Zumthor or Renzo Piano, which define atmosphere through intuitive feelings and practiced-based experiences, are widely recognised as "atmospheric architecture" (Leatherbarrow, 2009, pp. 609–694; C. Borch, 2010, p. 8). Atmospheric architecture could be exemplified by projects such as Sverre Fehn's Storhammarloven or works by Zumthor, Gunnar Asplund, and Sigurd Lewerentz that create a specific architectural experience through their spatial qualities.

In defining architectural quality, Zumthor refers to the state that occurs when a building "moves" him – that is, the feeling it gives him (Zumthor, 2006, p. 11). Atmosphere is the mood of a space that produces a specific feeling in the person who experiences it. It is strongly related to a bodily engagement and to subjective perception. Thus, the atmosphere is perceived through one's emotional sensibility – "a form of perception that works incredibly quickly" (2006, p. 13). According to Böhme, "The notion of atmosphere always concerns a spatial sense of ambience" (Böhme, 2014, p. 43). It is not a singular moment of perception but rather a sustained presence in a situation – a continuum (Pallasmaa, 2014, p. 20). An essential aspect of atmosphere, according to Pallasmaa, is that "it is an immediate experience of the whole, the entity, and only later can one distinguish the details that are part of it" (Pallasmaa, 2014, p. 37). Therefore, the experience of atmospheric quality in architecture is by definition an embodied experience. Conversely, it is something of "the prototypical 'between' phenomenon" (Böhme, 2014, p. 43) that initially arises from the atmosphere – the materials and details of the built space – but is eventually experienced and felt through the individuality and perception of its occupant. Pallasmaa believes that atmospheres are emotionally experienced before being intellectually experienced, and this emotional architectural encounter is a multisensory perception that includes various senses as well as bodily memory (Pallasmaa, 2012). Through his built works, Zumthor shows that the perception of atmosphere is not confined to architectural interiors, but also how architecture and its surrounding environment integrate to form a certain atmosphere (Zumthor, 2006). Included in this discussion is the classical tradition in architectural practice of site visits, through which the architect tries to get a sense of the place. This provides a bodily experience through which he or she gains an understanding of how to position the project in relation to the existing circumstances that even today are an essential part of the design process. This given, or existing, surrounding is in itself a design material, something that the architect works with to capture a specific mood or a desired atmosphere.

The notion of atmosphere in the scope of this research engages with aspects of envelope design that create or intensify the experiences of architectural space by the inhabitant. Therefore, creating atmospheres focuses on *distances* through which the building is experienced and within which a defined environment is governed or conditioned. Leatherbarrow defines three kinds of distances (Figure 3) through which a building is experienced: "the local (even intimate) horizons of enclosure, the ambient surround of the building's immediate vicinity, and the distant reaches of its extended topography" (2009, p. 215). These definitions are employed in design studies and experiments of this research to reflect on the role of architectural envelopes in affecting and shaping not only the interactions

between architecture and its context, but also the experience of the environments and atmospheres of both.

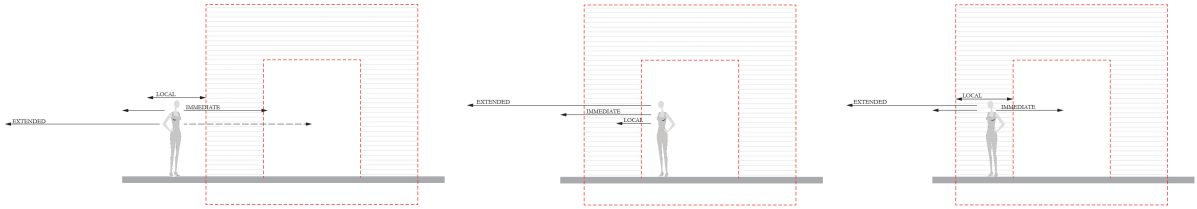

Figure 3. Diagram representation of distances through which a building is experienced based on David Leatherborrow's definition (2009) – produced by Sareh Saeidi, Spring 2018.

The two following sections discuss conceptual and methodological approaches through which the aforementioned scopes are addressed and analysed. The investigation first aims to define ranges of mutual effects and dependencies between interior and exterior environments by way of analysing historical and contemporary case studies. The chosen projects address the design of non-discrete envelopes, focusing on factors of local specificity and atmospheric performance. Non-discrete envelopes (see Hensel, 2013, pp. 31–44) identify built forms that are embedded in their surrounding contexts in such a way that the separation from their surroundings disrupts their architectural means, functions, and character (Saeidi Derakhshi, 2017, p. 16). Architecture's character here refers to the identity of the built form in relation to its local culture, materials, and construction techniques. Second, the studies aim to develop a method through which site-specific datasets and information are translated into knowledge for an informed design process of small-scale design experiments. The experiments were undertaken in master-level student projects in the Research Centre for Architecture and Tectonics (RCAT) and the Advanced Computational Design Laboratory (ACDL) studio at the Oslo School of Architecture and Design (AHO). The studies include identification, collection, application, analysis, and evaluation of context-specific data in correspondence with project-based conceptual approaches that together inform the design process of architectural envelopes.

Case studies

This section explores examples of traditional and contemporary architecture to extract principles that lead to designs which marry exteriority and interiority. The cases encompass integrated design systems that result from the combination of natural and human-made elements or provisioned and un-provisioned design strategies representing the building's flexibility in meeting future changes post-construction. The following paragraphs examine case studies focusing on two main approaches that consider the exterior environment as an integral part of architectural design: climatic and aesthetic. The climatic and functional aspects of the case studies showcase how design specifications create new exteriors in the vicinity of the built form that have an impact on the architectural experience. The outcome of these studies aims to map out conceptual approaches that can inform the development of a working method for the research.

In order to systematically approach and sustain the development of the notion of architectural envelopes, two taxonomies were produced: a) a systematisation of selected conceptual approaches to the notion of envelopes based on review of the literature within the architectural discipline, and b) a taxonomy of envelope types based on an analysis of built projects (Saeidi Derakhshi, 2017). The taxonomy of envelopes attempts to classify the approaches to envelope design by recognising different tendencies towards the emphasis on form versus performance in architectural practice. The analysis distinguishes between three approaches: *discrete* envelopes, *non-discrete* envelopes, and envelopes with a *dual* character.

Non-discrete envelopes are separated into three types: *extended thresholds*, *dissolved thresholds*, and *multiple envelopes*. Extended thresholds have been extensively discussed as transitional spaces that are shaped through multiple, articulated, and animated screens or layers of materials, or thick (wall) structures either through studies of historical cases (Hensel & Sunguroğlu Hensel, 2010a, 2010b, 2010c) or more contemporary examples and discussions (Hensel, 2011; Hensel & Turko, 2015, pp. 38–50 & 178–269). This research's definition of extended thresholds is elaborated in the following paragraph. The notion of dissolved thresholds was inspired by Kengo Kuma's book *Anti-Object,* in which he elaborates on his idea on erasing the architectural object through his works via an approach in which architecture closely integrates, and at times dissolves, into its immediate surroundings (Kuma, 2008). Multiple envelopes represent a design strategy in which envelope layers are arranged and positioned in proximity and in relation to one another to fulfil various design aims, i.e. from providing spatial effects to acting as insulation (Saeidi Derakhshi, 2017, p. 17). Kipnis terms the strategy of "form[ing] a collecting graft, usually by encasing disparate formal and programmatic elements within a neutral, modernist monolith" as *InFormation* (Kipnis, 2004, p. 43). The emerging spaces of this design strategy activate through "visual layering, programmatic innovation, [or] technological effects and events" (2004, p. 43) that define their relation to one another through these in-between spaces. Tschumi refers to the in-between spaces of his work as spatial organisers that, in the case of projects such as Le Fresnoy, have a strong experiential presence and are a "mode of spacing that gives room for the event" (Tschumi et al., 1999, pp. 33–44). These approaches represent a spatial realisation of the building envelope through material organisation, which defines it as an in-between inhabitable space, accommodating various uses of its spaces and atmospheres.

Extended thresholds conceptually represent built forms that provide various climatic and atmospheric conditions through their envelopes' spatial organisation and degrees of enclosure. The notion of extended threshold closely relates to the notion of free-running buildings (de Dear & Brager, 1998) as an integrated design approach that addresses issues of thermal comfort and climatic tolerance through spatial and material organisation. The free-running building method provides a variety of indoor climates due to the joint necessity of non-discrete architectures and the inhabitants' adaptation abilities (Saeidi Derakhshi, 2017, p. 11). Extended threshold is an approach in which the extent of exteriority and its effects on the enclosed lived spaces are more difficult to frame, measure, and analyse. In this approach, the threshold of the building envelope is treated as an extended space, which is either semi-closed or exposed. The envelope becomes a means of creating inhabitable spaces through degrees of shelter. The dissolved threshold is similar to the extended threshold, with the distinguishing difference being that here the definition of enclosure and sheltered space by means of walls is challenged and redefined through the abstraction and removal of wall structures. Among the five projects that are discussed in the following paragraphs, four are extended threshold types and demonstrate two different concepts of constructed exteriors and design provisions. The first two of these case studies are Persian courtyard houses and traditional Japanese houses, in which the constructed exterior environment fulfils the climatic and atmospheric needs of the interior spaces. The other two case examples include two contemporary houses (Lina Bo Bardi's Glass House and John Lautner's Sheats-Goldstein residence) that, through their spatial openness and arrangement, allow for future growth of the surrounding vegetation that co-modulates the microclimate of the built form. The last case study is the Inverted House in Japan. This study characterises the Inverted House as an example of the dissolved threshold. The design approach of the project defines a modulated climatic threshold in which the spaces are mainly exterior, but serve specific activities that are normally placed in fully sheltered interior spaces. The erasure of the exterior wall of the project creates exposed spaces that highlight the limits of a bodily experience by way of nearly full exposure to exterior conditions.

The necessity of architecture corresponding to its local climate has led to well-developed climatic design strategies throughout architectural history, in which "weather shapes

the built environment along with the designer and the inhabitant" (Hill, 2012, p. 3) and "traditional forms […] turn limitations into advantages" (O'Cofaigh et al., 1996, p. 22). Traditional Persian architecture considers the human to be the spirit of the space, and the built space as the body for that soul (Khaghani, 2012) – a body that is carefully adjusted to its local conditions. Iran is divided into four climatic zones, each of which has different architectural typologies and construction principles corresponding to regional weather conditions. Traditional Persian architecture also principally focuses on the strong integration of architecture in its local context, taking into account site conditions, available local materials, climate, and culture. The courtyard houses showcase the most developed design strategies that tame the hostile climate of hot, arid areas by focusing on such principles. Persian courtyard houses are walled-in plots that are surrounded by *Iwans* – the use of which is designed with considerations of the diurnal activities and seasonal changes (2012). Iwan is a vaulted space that is usually closed on three sides and open on one side, accommodating a semi-open inhabitable space adjacent to the enclosed rooms of the house. Iwans could be defined as extensions of open space into the enclosed space that are used, especially during the warm seasons, as autonomous living spaces to prepare for the transition from one condition to another, i.e. from open to closed or light to dark. The courtyard house has an introverted arrangement that is formed by rooms surrounding an inner open quadrilateral yard that integrates spatial, functional, and aesthetical aspects of the house. The most celebrated aspect of the courtyard is its seasonal and climatic design feature, which facilitates the demands of daily life. This seemingly simple form "implicitly [embodies] an intimate knowledge of the locality and its potential for sustainable life" (O'Cofaigh et al., 1996, p. 2). Courtyard houses could be of considerable size, depending on the wealth of the owners, consisting of living spaces, a business chamber, and sections for servants. The biggest inner yard is the private living zone, with smaller ones belonging to servants and the business sections of the house. The lowered courtyard also allows natural light into the basement of the house, which benefits from the ground's thermal capacity to provide a cooler space during the summer and a warmer one during the winter. The ground level rooms are mainly used for daily living activities and receiving guests, while the upper floor consists of smaller rooms that are used as private zones and sleeping areas, positioned in ways to allow the wind to breeze through small windows, which are in many cases covered with sunscreens. Islamic sunscreens or *Mashrabiyah* minimise the effects of intense sunlight and reduce heat while providing fresh air and needed privacy through perforated surfaces. (For further reading on this subject please refer to (Fathy, 1986, pp. 46–49). The inner courtyard of the house is a constructed microclimate and garden, open to the sky, that provides light and fresh air for the living spaces according to seasonal changes and climatic conditions. This microclimatic, conditioned exterior consists of vegetation and water basins that work together as an integrated system to fulfil the comfort needs of the inhabitants of the house. These integrated elements, along with considerations of orientation, avoid undesired climatic factors by blocking excess sunlight and surface reflections through vegetation, redirecting airflow, and evaporative cooling. The vegetation usually consists of deciduous trees that shed their foliage over the course of the seasons, therefore providing favoured seasonal conditions for the living spaces by allowing or blocking sunlight. This characteristic ascribes seasonal patterns of use for the enclosed rooms based on their location and their exposure to the sun and prevailing wind direction in order to capture the summer wind and avoid the undesired wind of the winter (Figure 4).

The spatial organisation of the house is based on increasing degrees of enclosure, starting from the courtyard as the core open space of the house and leading to semi-open Iwan structures that provide a sheltered extended space (Figure 5). The enclosed rooms, being the last of this spatial gradient, are open to Iwans and are provided with openable panels, the number of which varies based on the importance and seasonality of the room. For instance, the room in the summer zone is also usually the gathering space for receiving guests and has five or eight panels that, once open, extend the room into the adjacent Iwan area. The rooms around

the inner yard are interconnected, and the corners of the overall rectangular organisation of the house usually provide the space for service areas such as staircases to upper floor levels. Therefore, the built exterior of the Persian courtyards primarily depends on the aspects of climate and privacy, arranged in four zones around the quadrilateral yard, providing "a conduit for air and light in the midst of the crowded urban fabric while ensuring visual and spatial privacy" (Rabbat, 2010) through its controlled exteriority.

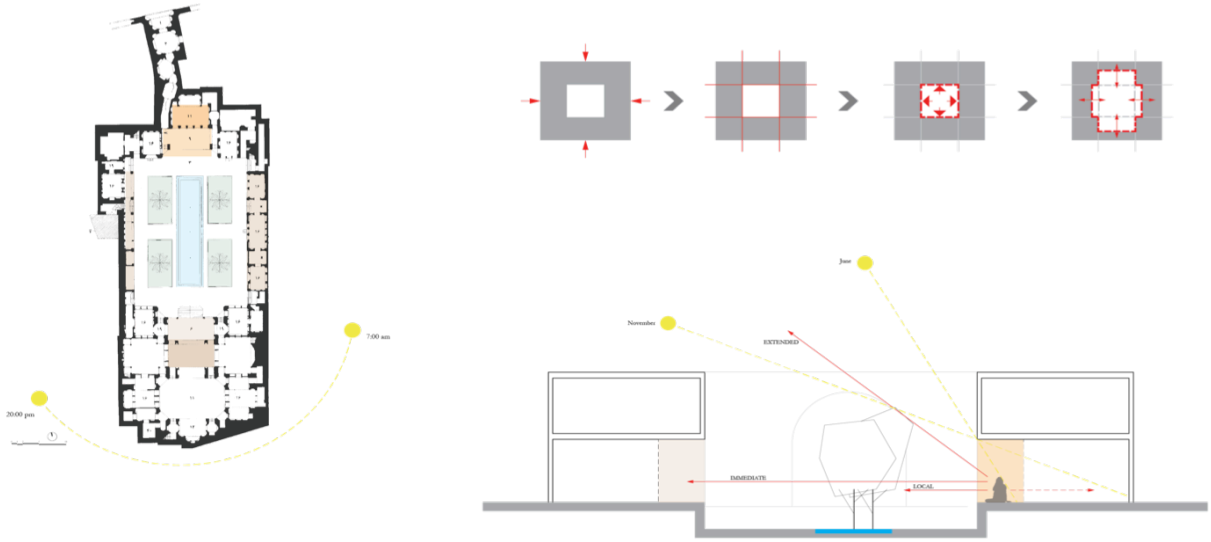

Figure 4. (Right) Plan drawing of Borujerdi's house (built in 1857) in Kashan, Iran. (Right top) The plan organization of traditional courtyard houses of Iran and (Right bottom) diagram representation of the spatial gradience in traditional Persian courtyards – produced by Sareh Saeidi, Spring 2018.

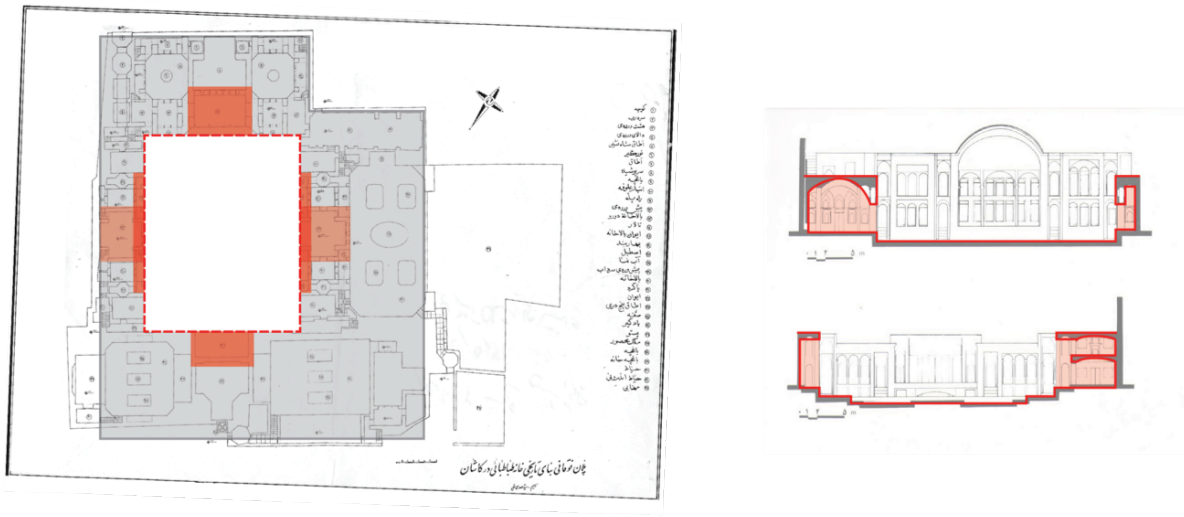

Figure 5. Semi-enclosed Iwans and the lowered courtyard setting at Tabātabāei's house (built in the early 1880s) in Kashan, Iran. The Iwans on the north-south axis in a Persian courtyard house are usually bigger and were used for hosting guests or holding events. These Iwans usually have finer decorations than the east-facing ones.

Similar to the conditioned exterior of courtyard houses, the garden of a traditional Japanese house is also a constructed exterior that is closely integrated with interior spaces. Inhabitants

of these houses are culturally accustomed to an environment intimately linked to nature. In a Japanese garden nature is reinterpreted, redefined, and abstracted to create beauty or to express spiritual or emotional value. Therefore, the garden does not represent nature per se but rather an idealised version of it (Keane & Ohashi, 2012, pp. 117–128). As such, traditional Japanese architecture is positioned in nature in such a way as to accomplish balance and harmony. This entails a certain sophistication that arises from the deep understanding and appreciation of the lessons learnt from nature. Though these gardens are designed to accommodate a range of phenomena, such as tsunamis and earthquakes, they also display the pacifying influence of Buddhism, which sees humans as an integral part of nature, and of the native Shintō religion, whose gods inhabit nature (2012, pp. 117–128). The traditional houses merge with nature rather than stand in opposition to it, treating the building and the environment as equal parts within an ensemble. The constructed garden of the house consists of various types of vegetation that correspond to their adjacent rooms. In other words, the atmospheres and characters of the exterior is meant to compliment the design intentions of the interior.

This could be regarded as an extended setting of the interior, the compositional choices of which correspond to various selections of materials, arrangements, and scales of the indoor spaces. The orientation of the enclosed rooms, which has an interconnected arrangement, is designed to complement the exterior scenery. The limit of the constructed landscape is defined by the garden wall that shapes a separate, enclosed area essential to the creation of a Japanese garden (Bring & Wayembergh, 1981, p. 180). The overall arrangement thus creates an exterior that obstructs undesirable visual aspects, protects the garden from physical intrusion, and allows for a designed miniature garden (1981). The height, orientation, aesthetics, and placement of vegetation, as well as the way the ground is treated and designed for strolling purposes, affect the experience of these environments from both an interior-exterior and exterior-interior point of view (Figure 6 and 7). Other essential elements that establish the close relationship between interior and exterior environments of Japanese houses that work together with this constructed exteriority are architectural elements that define extended spaces, such as Engawa, veranda, and Tsuboniwa. Engawa is a peripheral corridor between the enclosed rooms and the garden. This continuous corridor usually stretches along all sides of the building and provides a climatically sheltered space. Once the adjacent shoji screens are open, the Engawa and inner rooms form a continuum (because they have the same height and floor level) while maintaining the existing visual and spatial threshold conditions between the spaces. Being closed from one side by the interior spaces and sheltered by long eaves, the semi-open Engawa provides a pleasant space for enjoying the constructed garden and its seasonal beauty. Another defined space for enjoying the natural beauty of the constructed exteriority of a Japanese house is the veranda, which is an open platform raised from the ground and usually located at the edge of a small pond or lake. The veranda is specifically known as a moon gazing terrace – an interface between heaven and earth. The shoji screens in Japanese houses redefine the experience of the interior-exterior relationship in a fully enclosed space. The level of transparency of rice paper, when the panels are closed, diffuses the common impression of wall solidity and produces a sublime indirect connection to the outside – not only through the atmospheric ambience of daylight in the interior, but also through the interplay of light and shadow. The pocket garden or Tsuboniwa is a defined closed exterior that functions as an interface between different interior zones, providing access, light, and ventilation similar to the small inner yards of Persian courtyard houses. The Japanese garden is what Yoshinobu Ashihara calls a Positive-Negative space, referring to the positive space (P) as an intentionally planned space, while the negative space (N) is a more spontaneous one (Ashihara, 1981, pp. 20–41). As such, both the Japanese gardens and Persian courtyards can be regarded as P-N spaces due to their intentional separation from natural space for a particular function or quality, while remaining open to unpredictable conditions of the climate and the natural world. This reinforces the relationship between the constructed and the natural by way of spatial organisation.

Figure 6. Representing images of the role of the garden as an extended setting of the interior space in a traditional Japanese house. Photo: (Left) Sanbō-in, Kyoto, Japan, photographed by Haruzo Ohashi – (Right) Stepping stones from the Imperial Carriage Stop to the Gepparo pavilion at Katsura Imperial Villa, near Kyoto, Japan, photographed by Yasuhiro Ishimoto, 1954, gelatin silver print, Kochi Prefecture, Ishimoto Yasuhiro Photo Center.

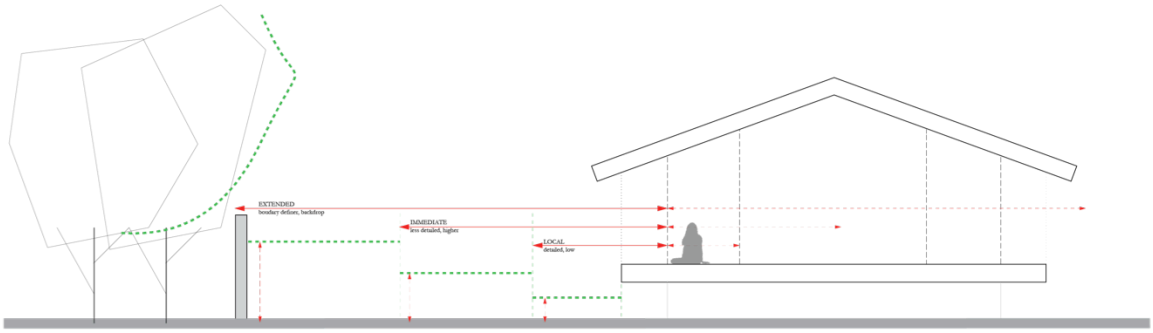

Figure 7. Arrangements of vegetation based on the visual aesthetics of different plants in relation to the spectator's proximity within the framed view. The placement of low vegetation in close proximity to the building allows for a spatial flow that is interrupted by the backdrop vegetation or the garden wall as boundary definers of the extended setting. The diagram is produced by Sareh Saeidi, 2018.

The Inverted House is the prize winner of the 5th LIXIL International University Architectural Competition in 2015, sponsored by the LIXIL JS Foundation, designed by the Oslo School of Architecture and Design (AHO) team, and was built the same year. The competition theme was to design a "House for Enjoying the Harsh Cold" in Hokkaido in Northern Japan. The idea of the design team was, as the project name indicates, to turn the house inside out to embrace the cold of the exterior environment. In this house, the exterior is not for contemplation or to be viewed from the warm interior space. In contrast, the house exposes the inhabitant to a climate that can reach −40 °C in the winter and turn into a mild and gentle environment during the summer (Figure 8). The building is a mediator that provides an inhabitable exterior, partially climatically sheltered by different roof slopes and floor levels. The daily life activities of the house include cooking, dining, taking a bath, or sleeping, which take place in semi-sheltered exterior spaces directly adjacent to the core structure of the house, with the option of sleeping inside during the worst weather conditions. These living spaces challenge the inhabitants' comfort and ability to adapt to the cold, to endure the cold, and what temperature they define as cold (Figure 9). The design illustrates how the architecture envelope, understood as a mediator between inside and outside environments, facilitates the inhabitation of a semi-

sheltered exterior. The Inverted House is an example of tackling flexibility of use and inhabitation, location specificity, extreme climatic conditions of the region, and the culture-related identity of the house as inherent design criteria for a radically different spatial and climatic organisation and experience. Although the house yields to its climatic context, it also shelters from it by redirecting undesired winds or shielding from rain through its roof structure.

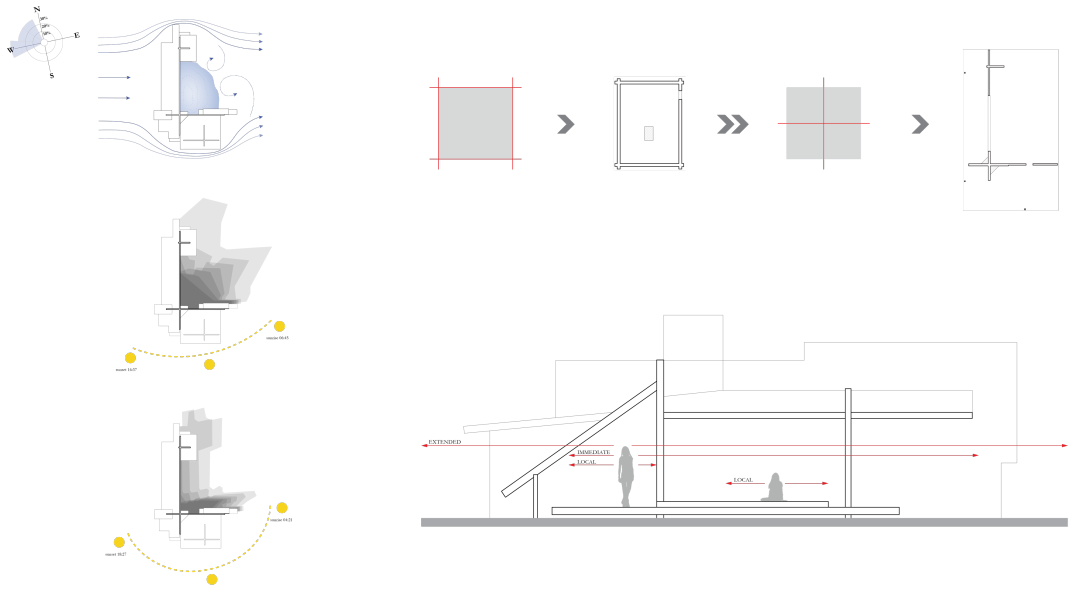

Figure 8. (Left) Diagram representation of the spatial arrangement, wind, and shading analysis for snow collection in the Inverted House in Hokkaido, Japan – by the AHO team in 2015. (Right top) Diagram of the design's concept illustrating the conversion of traditional Japanese introverted plan to an open extroverted organization. (Right bottom) Sectional representation of perceptive distances in the Inverted House's main outdoor rooms – produced by Sareh Saeidi, Spring 2018.

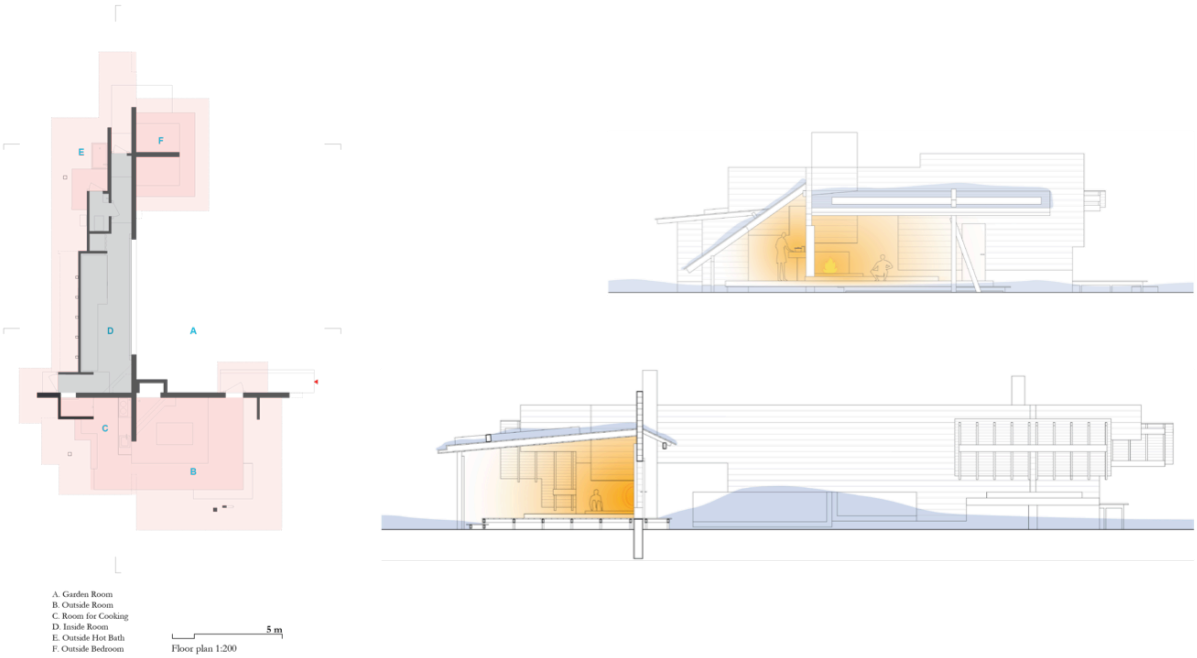

Figure 9. Plan drawing and sections of the Inverted House – produced by the AHO team in 2015.

Today's rapid environmental changes require flexible and adaptive designs that can provide a strong symbiotic relationship between architecture and its surroundings. The task of designing a complete environment could therefore be expressed as the goal to pursue "[t]he ecological balance of human and animal and plant life [to] be correctly adjusted both internally and to the given exterior physical conditions" (Alexander, 1964, p. 3). This includes both individual and collective dynamics of life, economical forces, infrastructure, and other influencing factors in a design in which "its own regeneration and reconstruction does not constantly disrupt its performance" (1964, p. 3). In such an environment, "architectural elements fuse themselves to the latencies of the ambient environment, adopting their capacities for change or movement" (Leatherbarrow, 2009, pp. 37–38). Therefore, spatial configurations of the interior in relation to the exterior need not only have permanent features, but also temporary ones, which allow for contingencies and unpredictable exchanges between the two over time. Indeed, there are various design approaches in architecture that allow for more spatial flexibility. One of these is spatial continuity, which enables the possibility of adjustments to future changes in the built space. Adolf Loos believed that architecture cannot be conceived in plans but through the relations and connectivity of spaces that give rise to a spatial continuum and facilitates certain types of perception (Risselada, 2008). This is clearly captured in the houses he designed, through the spatial order of walls and their wide openings which, while emphasising their phenomenological and structural importance, provide spatial continuity between rooms. In the context of this research, spatial continuity is arguably a well-fitting approach to the *extended threshold* typology. The connectivity of the spaces offers a freedom through which the built form can adapt to and harmonise with given conditions. Space, as such, becomes a lived experience within which change and adaptation define the notion of architectural performance. The following paragraphs examine two examples of buildings that take into account the capacities of architectural design to respond to changing environmental conditions over time.

The first example, the Glass House of Lina Bo Bardi, was constructed in 1950 in São Paulo. The vegetation on the sloped site was removed for the purpose of construction, which, at the time, offered distant views and aided in creating the iconic representation of the building. This condition changed as the vegetation grew back to its full height. The house has a spacious front side, a minimised footprint achieved through pilotis that lift the floor from the ground, and an atrium in the middle of the building that provides light for the core areas. It also gives space needed for the growth of the tree that is in the atrium. These are provisions that facilitate a new relation of adjacency and exposure, resulting in a different interior atmosphere due to the close proximity of the interior to the vegetation (Figure 10 and 11). However, this remains a visual experience separated by the fully glazed outer walls of the living areas. Nevertheless, the closeness of the surrounding vegetation provides an experience of living in a canopy, as well as creating a specific atmosphere through the interplay of light and shadow. This also improves the thermal comfort of the interior by providing shading and reducing solar penetration. Similar relations between the built form and the local climate in regard to vegetation can be seen in numerous historical examples, one of which is the Fin Kiosk in Kashan, Iran. In this garden, the type and height of vegetation is designed to accommodate thermal comfort for the semi-open and enclosed spaces of the built kiosk located in the centre of the garden (Faghih & Sadeghi, 2012, pp. 38–51).

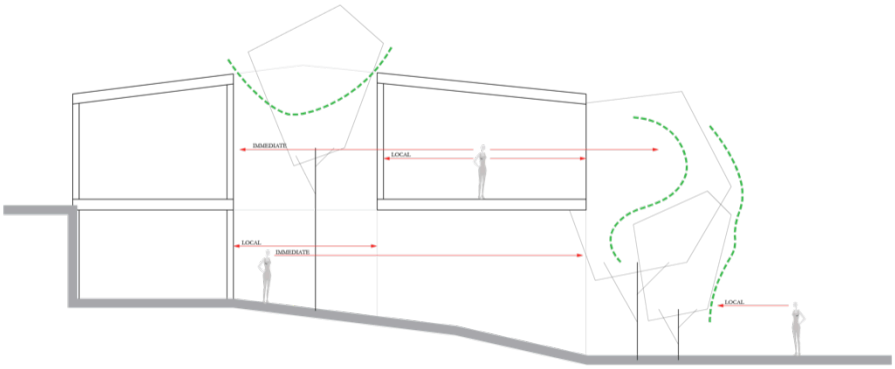

Figure 10. Diagram representation of the spatial relations in the Glass House of Lina Bo Bardi (designed in 1951) – produced by Sareh Saeidi, Spring 2018.

Figure 11. Glass House, Lina Bo Bardi, São Paulo, 1950. Photos of the Glass House after construction, showing the exterior of the house and the extensive exterior views from inside (left column), almost similar photos of these spaces in more recent photos taken from the house (middle column), and the middle atrium (right column).

The second example, the Sheats-Goldstein residence by John Lautner, was completed in 1963 in Los Angeles, California. Its spatial organisation is tailored to mediate between site conditions and design intentions. The house is located on a hillside, meeting the edge of the slope on one side, and dense vegetation on the other. The proximity of the vegetation to the north side of the building promotes specific strategies for material organisation and openness of form. The context is represented by the distant views, openness, and fluidity of the semi-closed and enclosed spaces that are in part framed by local rocks and vegetation (Figure 12). The boundary between the interior and the exterior is often diffused, especially in the way the boundary edges of the building meet the surrounding vegetation. This is achieved through considerations of material organisation, for example through the detailing at the intersection of glass panes and stonewalls, which, apart from obscuring the division between the interior and the exterior, allows for specific degrees of penetration of vegetation into the enclosed rooms. Design considerations that facilitate a unifying expression of spatial flow in the building include the detail of the building's edges meeting vegetation, site conditions, and the use of

glass to disrupt the boundary definition of the enclosure through both transparency and reflection (Figure 13). This provides the adaptability required to create a space in which the exterior and interior environments merge.

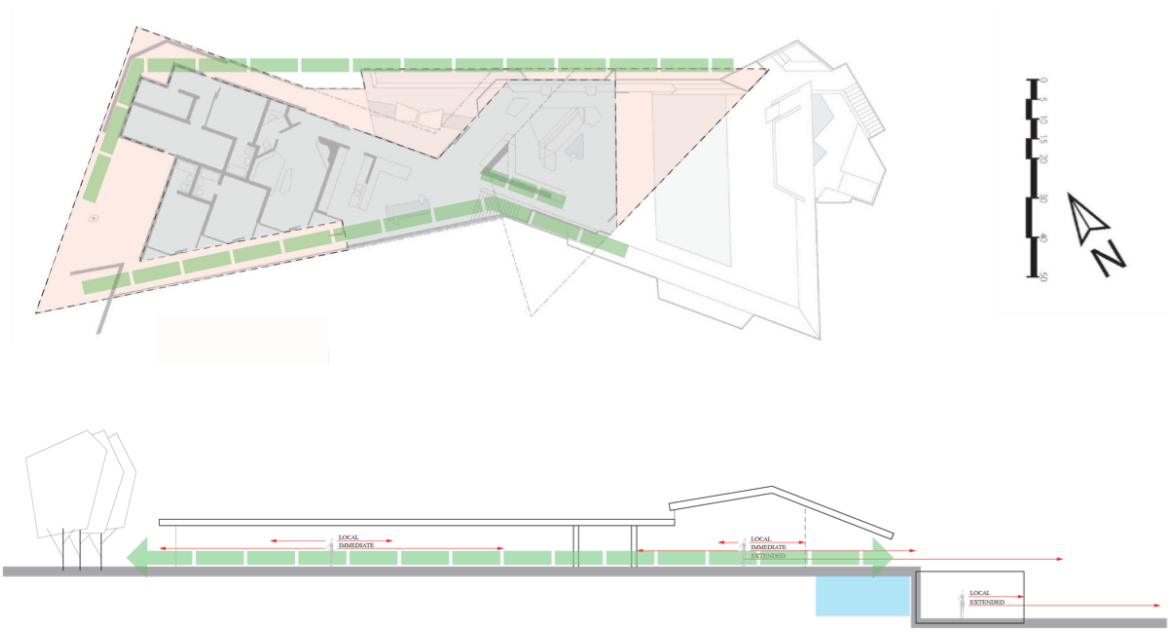

Figure 12. Sheats-Goldstein residence designed by John Lautner, built between 1961–1963 in Los Angeles, California. (Top) Plan drawing in which coloured areas are indicators of the enclosed interior (gray) and the semi-closed extended spaces between interior and exterior spaces (beige). The dashed lines indicate the vegetation growth along the building. (Bottom) Sectional representation of the spatial openness that allows for the vegetation growth along and across – produced by Sareh Saeidi, Spring 2018.

Figure 13. Photos of the Sheats-Goldstein residence, showing the house's main room in its surrounding topography (top left), vegetation growth in the interior spaces (bottom middle), and other photos capturing the close integration of the house with its surrounding vegetation in the extended spaces.

The aforementioned two case examples indicate that the temporary state of an architectural envelope can accommodate transitions between interior and exterior spaces that are both functional and experiential. The exteriority of the built form then becomes a powerful means for design provisions based on local specifications and conditions, which heightens the spatial experience of interior spaces through their exterior context.

Design experiments and developed methodology

In the context of this work, factors for defining suitable relations between interior and exterior environments include qualitative and quantitative analyses of design concepts; the atmospheric effects and climatic comfort aspects of the interior such as ventilation, shading, solar penetration, material organisation; and aspects regarding the proximity (visual distances) of contextual features. The investigations conducted in this section focus on the aforementioned parameters to achieve various climatic and aesthetic experiences of architectural envelopes through a tailored design approach. The experiments address determining factors for designing interior spaces in relation to the exterior environment based on the conceptual aims of the project, and the identification of relevant contextual information sets. This includes a discussion of ways that collected local data can be visualised, applied, and analysed in the design process. A major part of the design approach is comprised of site-specific data identification, collection, and processing based on the project concepts. The investigations include questions on how to correlate and interpret data while acknowledging the relative deficiencies of the collected data (related to the contextual conditions in which they were obtained). The aim was to identify an information-based design process for a locally specific architectural envelope design. The work was undertaken in the RCAT & ACDL master-level studio during the fall semester of 2016. The Advanced Computational Design Laboratory (ACDL) is the innovation laboratory of the Research Centre for Architecture and Tectonics (RCAT) at the Oslo School of Architecture and Design (AHO). The studio brief asked for the design of research facilities and accommodation for six staff members, which could be converted into a vacation home. The site is located in a terraced vineyard called Graspoli, which belongs to Fattoria di Lamole in Chianti, Tuscany, Italy.

Landscapes provide an environment for the co-existence of various species and organisms. Humans systematically constructed rural landscapes in the course of agricultural activity imposed on natural landscapes (Sereni, 1961 in Agnoletti, 2012). Experts frequently posit that cultural landscapes are the result of culture as an agent acting upon natural areas (Sauer, 1926 in Agnoletti, 2006). Such landscapes are therefore the locus of a historical integration of social, ecological, economic, and environmental factors that significantly influence their development and provide their surrounding context with a cultural identity.

Today, rural areas are often diminishing, and the cultural and national identity and knowledge that has been passed down and refined through generations is getting lost. Although some of the productive landscapes are currently regarded as sites of cultural heritage in Tuscany, many others are abandoned, resulting in dense re-forestation and loss of biodiversity. Currently, the layouts and agriculture of these areas are shaped by industrialisation and the use of machines. In the vineyards, these setups are directly dependent on how the owners want to grow the grapevines. Traditionally, the vineyards have been constructed in the form of terraced landscapes to account for steep slopes. Yet, the demand for the use of large machines to facilitate the workload and the maintenance of these landscapes led to the transformation of stepped vineyards into sloped landscapes. This transformation has led to a decrease in the quality of grapes and subsequently the wine. Among the most influential factors in growing grapevines are the altitudinal and thermal conditions of the vineyard. Therefore, the thermal variations between night and day must be carefully considered as one of the main impacts on the quality of the wine produced. Experienced vineyard owners believe that to tackle the questions of the lowered quality, terraced landscapes must be revisited and revalued. The elements and features of a terrace landscape such as dry stonewalls, terrace width, rainwater

management, and grapevine pruning all affect the quality of the wine produced. An example is the significant impact of the dry stonewalls on the photosynthesis of the grapevines and thus the matured grapes: "The [dry stone]walls have a heat-storing function that gives back thermic energy accumulated during the day, creating a peculiar favorable microclimate […] which thrive[s] in dry soil" (Contessa, 2013, p. 30).

The RCAT & ACDL studio engaged with a terraced landscape to contribute to developing an understanding of the current states of such landscapes and ways that architecture can be designed for and integrated with them on multiple levels. The architectural designs were meant to employ local resources and materials and utilise passive means for modulating the microclimate. The design task demanded built forms that emerged from interactions between architecture, climate, and agriculture, such that the proposed architecture would not interrupt the production of the wine and therefore not change the microclimate of the site. Thus, students were asked to investigate the current condition of the vineyard to be able to determine to what degree they could intervene with the existing microclimate of Graspoli's landscape. The design studies were framed around the notion of performance, including both climatic studies and the existing site analysis. The notion of performance within the focus of the author's PhD research emphasises aspects and strategies of architectural design by which the build form can tackle and respond to questions of climatic design and the design's adaptability to changing local conditions. The designs encompassed 200 sqm, one-third of which was used to form transitional spaces. Site-specific data was collected and informed associative modelling for an iterative process of development and analysis of the projects. The design process consisted of testing the concepts within an iterative process of parametric modelling, simulation, and evaluation through which initial ideas were refined and evaluated continuously until they fulfilled the aims of the projects.

The site-specific data included three months of measurements collected by weather stations mounted on site. This data included solar penetration, air and soil temperature and humidity, wind direction and speed, and precipitation. The data was cross-referenced with climatic data from the local meteorological station, which is located at a distance of approximately one kilometre from Graspoli. The orientation and positioning of the projects varied, with some directly positioned next to the grapevine rows and dry stonewalls, and others by the borders of the terraces. The design approaches pursued by the master's students included a) a designed journey through the site, b) proximity as the determining factor in framing views to the natural horizons or borders of the built, and c) climatic conditioning accommodating both human comfort and wine cultivation.

The variety of the design aims and concepts enabled different experiential design processes in the studio. The PhD research benefited from this as it aided in the understanding of the dynamics of the iterative design process. The process also provided the research with methods of identifying relevant tools of analysis and corresponding data based on design concepts. This included ways various focuses must be applied, analysed, and critically reflected upon during the design process, and how to develop the built knowledge further at each stage of the analysis. The design experiments aimed to closely engage with the local context on multiple levels, including both the existing microclimate together with the physical elements and the topography of the site. The three selected projects, which are elaborated on in the following paragraphs, contributed to the development of earlier methods of the research by focusing on the clarification of approaches on thermal comfort and distances in experiencing the aforementioned envelopes. The various skillsets of the students allowed for different modes of investigation, ranging from expressive hand sketches to data-driven simulation and analysis. These included a main methodological approach within each team, together with climatic and site analysis. Team one used hand sketches and photometric studies of the site as a storytelling method to visualise the existing atmospheric qualities of the landscape and how the design aimed to engage with these qualities. Team two utilised serial sections as an analytical tool for developing their integrated design sketches. Meanwhile, team three collected and employed

various datasets that provided information on factors regarding thermal comfort simulation and analysis, as well as algorithmic form optimisation.

The first two teams chose to design a path through which the visitor is guided to experience the site. Team one used hand sketches and sequential photographic studies to design the visitors' experience through a walking path in the vineyard. Their design focused on emphasising on various distances of the body to elements of the site in order to incorporate tactile experiences, along with capturing specific views within the designed path. The primary photometric studies were focused along the main path that led to the selected terrace on which they designed their building (Figure 14). The studies were focused on the atmospheric and perceptive differences of moving uphill or downhill along the slope, and the perceptive differences caused by the proximity of the visitor to the grapevines or distant landscapes created expansive vistas on the horizon. This storytelling method enabled the group to communicate and develop the experiential qualities they were aiming to achieve in their design project. The specific location-dependent features and collected information assisted in unfolding the notion of transitions as changing states of experience along the site. Design considerations included the differences of going uphill versus downhill. The close proximity of landscape elements such as grapevines, grapes, leaves, and dry stonewalls when moving uphill facilitated a bodily experience of the site on a human scale, while going downhill provided views of the valley (Figure 15).

Figure 14. Hand sketches and sequential photographic studies to design the visitors' experience through a walking path in the vineyard. Their design focused on emphasising on various distances of the body to elements of the site in order to incorporate tactile experiences, along with capturing specific views within the designed path. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL), The Oslo School of Architecture and Design (AHO), Fall 2016. The project was designed and visualised by students Ignacio Madinagoitia and Gunnar Sørås.

Figure 15. Diagram representation of spatial relations and perceptive distances of the project's extended setting. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL). The visualizations are produced by the design team (Ignacio Madinagoitia and Gunnar Sørås) and the diagrams are produced by Sareh Saeidi, Spring 2018.

Team two aimed to create a continuous atmospheric effect for their built forms by incorporating the existing dry stonewalls in small semi-closed and closed spaces along, through, and in-between the walls. These integrations with the dry stonewalls were shaped along the main axis of the terraced landscape and slope. The designed interventions were arranged along the main axis of the site, and in the direction of the slope alongside the main downhill water drainage system. The experiences are achieved through the position and movement of the body in relation to the wall. The proximity of the visitor to the stonewall and the ways he or she moves through, along, under, in, or on these structures is designed to activate an experiential understanding of the built interventions and the terraced landscape (Figure 16). These experiences correspond to Leatherbarrow's ways of experiencing architecture in terms of distances between the body and the built form. In this case, local distance is the close adjacency of stonewalls to the body, which provides a tactile experience, while framed views of the surroundings in the immediacy of the walls heighten the experience and understanding of the vineyard. The extended topography, on the other hand, goes beyond the farthest views of the site and reveals extensive vistas of the Tuscan landscape. Another factor from which the designed semi-closed and closed rooms benefit is the thermal inertia of the dry stonewalls, which provides a cooler interior during the day and a warmer one in the evening.

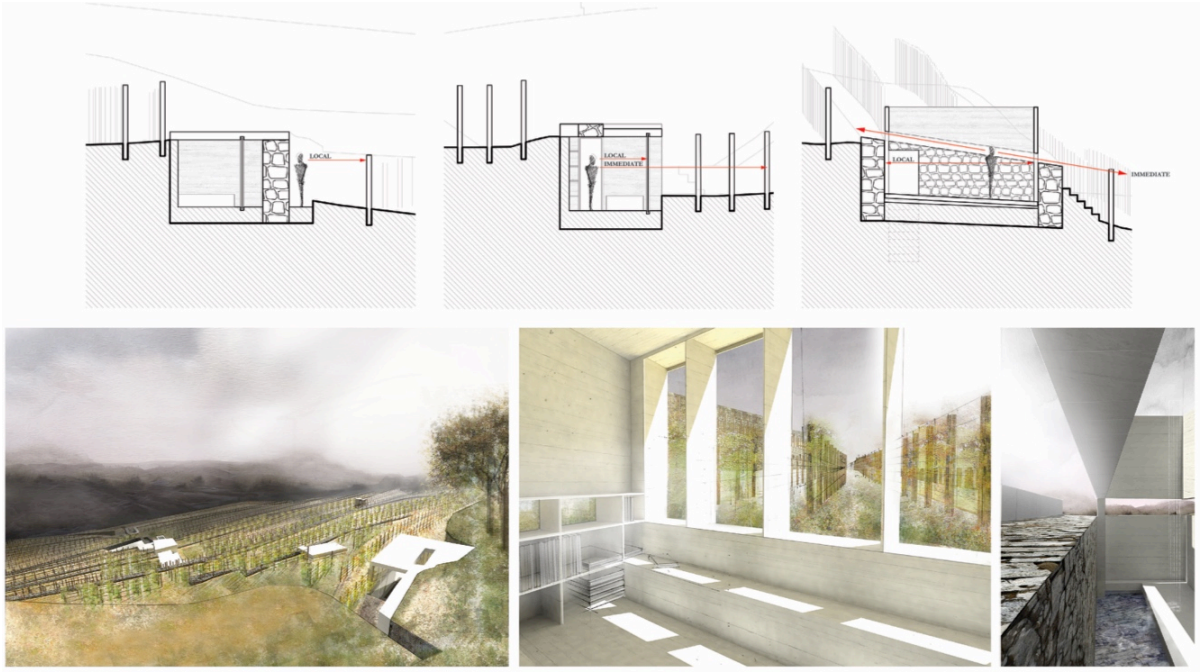

Figure 16. Sectional representations of the perceptive relation of the inhabitant to the existing dry stonewalls that are closely integrated in the terraced landscape, and the visualised views of the distances from and in the designed interventions. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL). The diagrams are produced by Sareh Saeidi, Spring 2018. The project was designed and visualised by students Andra Nicolescu and Kristian Taaksalu.

The third team put the emphasis on spatial provisions within the thematic focus of thermal comfort and human adaptation. The project aimed to create a built form that responds to its microclimate by way of an explicit free-running building (FRB) approach by providing climatically adaptive living zones. FRB provides a variety of indoor climates through implementing strategies related to the topics of inhabitants' acceptance, forgiveness, expectations, and adaptive capacities using clothing, spatial arrangements, thermal inertia, and flexible use of space. The project utilises local climatic conditions to enhance thermal comfort for the built space by focusing on two aspects. The first aspect focuses on ways by which the building integrates with its surrounding landscape and affects its immediate climatic context. This was assessed by extensive solar gain and shading analysis for comfort studies, consisting of temperature, humidity, and wind speed. The other aspect focuses on indoor comfort requirements relative to the inquiries of a research facility and accommodation for researchers. The influencing factors regarding perceived comfort temperature were environmental and human-based. The environmental factors consisted of air temperature, radiant temperature, air velocity, humidity, and related inhabitation factors, including individuals' clothing, activity, and metabolic heat (Figure 17 and 18).

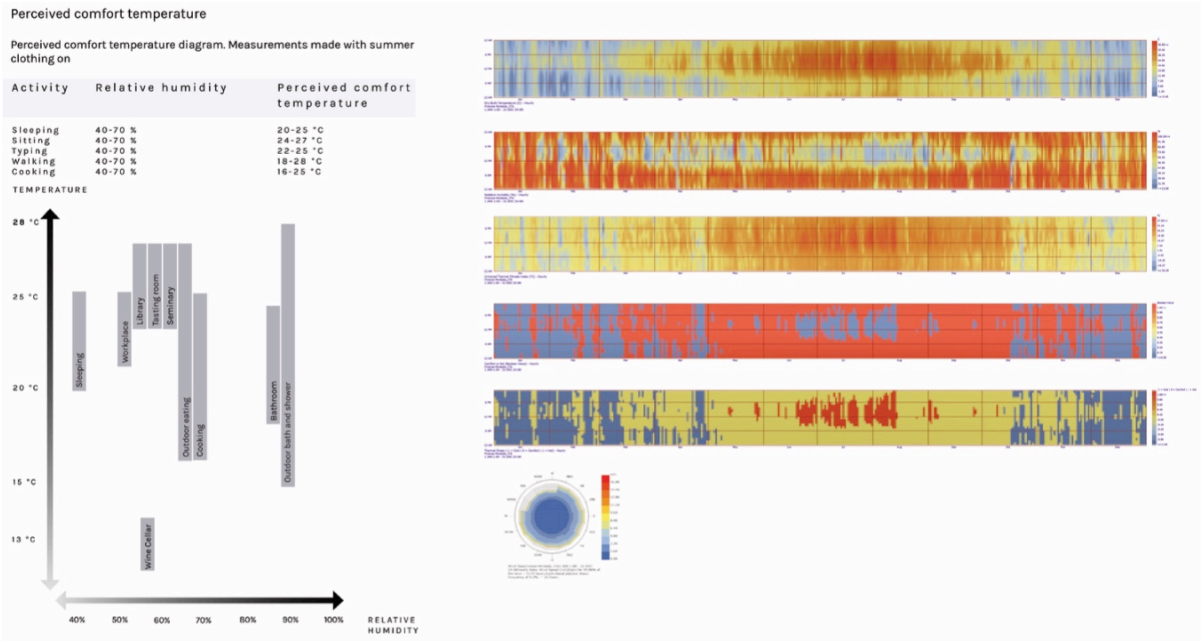

Figure 17. Diagram representation of perceived comfort temperature (left), estimated with summer clothing on, based on the literature review. Visualisation of yearly climatic data (right) for thermal comfort analysis, including relative humidity, dry bulb temperature, and factors of thermal comfort. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL). The project was designed and visualised by students Joar Tjetland and Maria Lagging.

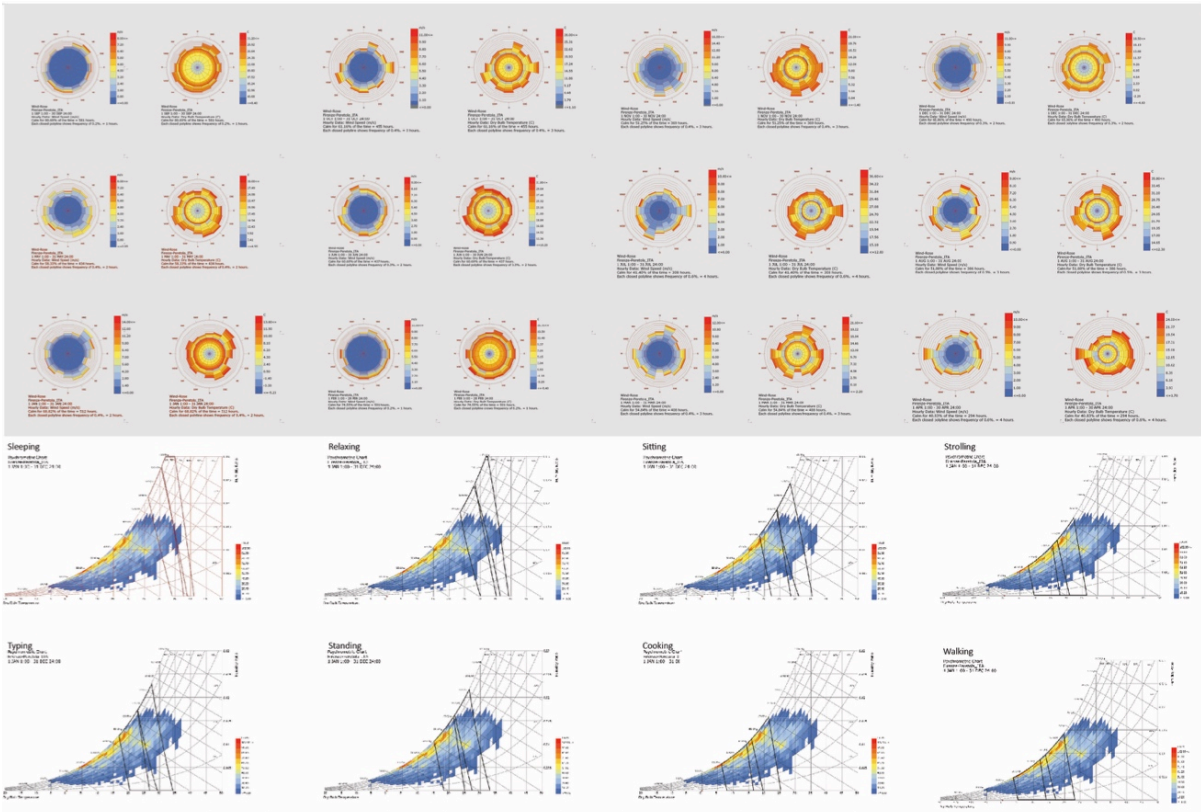

Figure 18. Visualisation of yearly wind analysis and psychometric charts of various activities based on the building's program, which informed the design project and placement of various spaces of the building together with solar radiation studies. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL). The project was designed and visualised by students Joar Tjetland and Maria Lagging.

This project is located on the highest possible altitude of the terraced site, connecting two terraces through a sequence of above- and below-ground spaces. The form optimisation and inclination of the surfaces results from the analysis conducted to ensure a minimal degree of shading by the surroundings, such as grapevines and trees. The required gradients of microclimates are designed using architectural modifiers consisting of walls, flooring, screen walls, roofs, and designated activities of the inhabitants in different spaces of the project. Factors such as materiality, heat storage, shading, natural ventilation, and precipitation are applied as design drivers.

South-facing surfaces are minimised to avoid the impact of solar radiation and the resulting heat gain for exterior and interior spaces. The optimisation analysis was conducted using the *Galapagos Evolutionary Solver*, with the indoor peak temperature in summer as the highest value for the generic optimisation. Galapagos is an open source plugin for *Grasshopper,* providing a generic platform for the application of evolutionary algorithms that can be used for a wide variety of problem solving by non-programmers. Grasshopper is a graphical algorithm editor developed by Robert McNeel & Associates; it is tightly integrated with *Rhinoceros* 3D modelling software. Material choices in various zones of the building correspond to considerations of ventilation, heat gain or release, humidity, and solar gain to fulfil each zone's climatic demands. Considerations of the programmatic distribution and climatic design of various zones mainly accounted for climatised interior and exterior zones that were supplementary to one another in maintaining the overall microclimatic design of the project. On a conceptual level, the semi-open rooms and transitional spaces provide the spatial continuity of the exterior into the semi-sheltered spaces. The bedroom modules, located below ground, follow the course of the terraced landscape, while the rooms for social activities and gatherings are partly integrated on the step between two terraces and are partially embedded in the lower terrace. The below-ground zones benefit from the thermal insulation of the soil and also employ thermal inertia and user-based adaptation (Figure 19).

The design process was based on the extensive use of mind maps and iterative associative modelling, analysis, and simulation. Comfort analysis and simulations were conducted using *Ladybug* and *Honeybee,* two open source plugins for Grasshopper that help explore and analyse environmental performance by evaluating a building's energy consumption, comfort, and daylighting (Sadeghipour Roudsari & Pak, 2013). In order to finalise the design concept, these analyses included shading, airflow, solar gains, and the materiality of the exposed surfaces. The mappings also incorporated aspects such as adjustable seasonal use of various spaces.

The utilisation of advanced digital tools provided an informed mode of design within which various microclimates were iteratively assessed and analysed, resulting in an effective inhabitation model. The main design driver in decisions regarding spatial organisation in relation to comfort temperature was dependent on factors of program, activity, and clothing. Common approaches that have a high focus on energy efficiency can be criticised for utilising standards of human comfort and excluding other influencing aspects, such as the cultural background and its impacts on the perception of thermal comfort. In contrast to this, FRB provides enough flexibility for allowing patterns of adaptations based on individual needs, while also having the capacity for post-occupancy changes.

The various focuses of the aforementioned experiments enabled the research to map and identify the effective relations between the datasets and tools of analysis required for the design concepts. These mappings facilitate an understanding of the workflow and the development towards a synthesised approach for designing with multiple criteria, as well as conceptual approaches to architectural performance and performative envelopes.

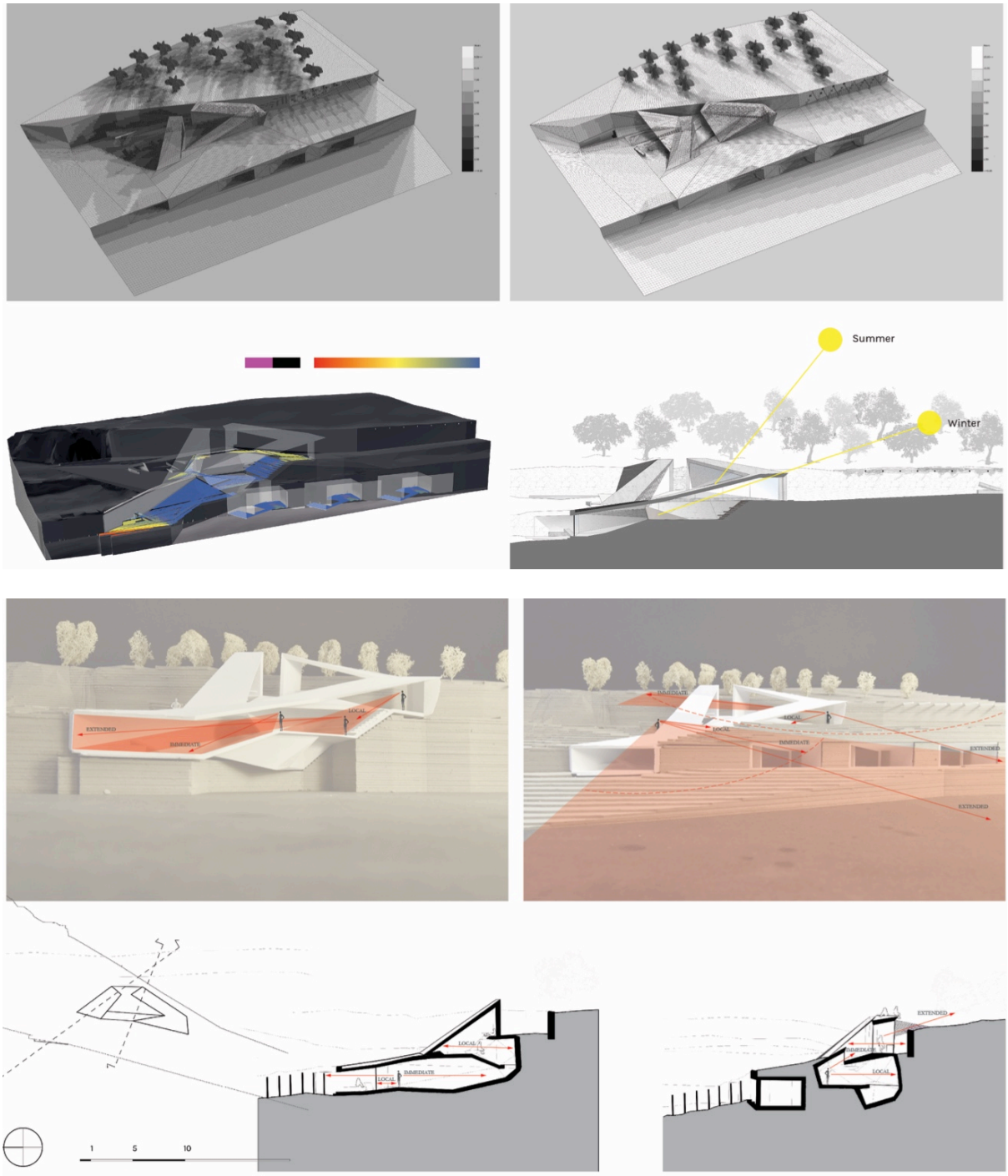

Figure 19. Comparative study of shading analysis and solar radiation between winter (December – top left) and summer (June – top right). The studies were decisive for pairing various activities to programs of zones based on the required thermal comfort (2nd row from top). The four images at the bottom represent the diagrammatic representation of the project's extended setting in relation to enclosed and semi-closed spaces that define the building's threshold. Performative Envelopes II Workshop conducted by Sareh Saeidi at the Advanced Computational Design Laboratory (ACDL). The project was designed and visualised by students Joar Tjetland and Maria Lagging, and the diagrams are produced by Sareh Saeidi, Spring 2018.

Discussion and conclusion

The importance of the role of building façades has been a significant topic within architectural discourse. The discussion tends to fall under four thematic approaches: structural and static; expressive and representational; socio-political and economical; and environmental analysis and issues of sustainability (Saeidi Derakhshi, 2017, p. 33). This research aimed to initiate a repositioning of the relationship between built forms and their surrounding environment with the goal of advancing the role of the locally specific exterior in the conceptual perspective and method. This was systematically approached through a number of case and design studies. The conducted studies demonstrate a design approach that utilises the exterior environment to create climatic, atmospheric, and adaptive qualities for the interior.

The design process of architectural envelopes as extended settings was developed through digital modelling and analyses to facilitate design iteration and application of collected contextual data, such as climatic datasets. Contemporary technological advances, open source platforms, and available tools have enabled architects, engineers, and others in related disciplines to access and gain insight into various data sources easily. The role of information-based processes is to provide a preliminary base for design iteration and analysis that can assist a better understanding of locally specific conditions. The process of translating gathered contextual information into applicable knowledge for the design process includes various steps, starting from the identification of relevant datasets that correspond to the programmatic and conceptual aims of the project. After parsing the relevant information, quantitative and qualitative analysis can be conducted using the available data. Visualising and mapping the interconnections and relations between different sets of information enables a better systematic understanding of the existing conditions. This elevated understanding allows for an informed design process in which design considerations closely incorporate, respond, and interact with the acquired knowledge of the project's contextual circumstances.

However, in the backdrop of open source datasets, modelling and simulation are the prevailing tendencies within current architectural design education and practice, shifting architecture towards data-driven, computer-generated methods. The resulting architecture, therefore, is frequently based not data, with little further critical or reflective thinking, often not formulating and exploring alternative concepts. In addition, the main portion of the conducted analyses is focused on the impact of the buildings' forms on urban microclimates (such as wind tunnels, shading, and solar gain analyses) which is conducted by environmentalists and urban planners. While these big-scale analyses are essential for understanding the bigger context of design, finer analyses and evaluations that examine ways of intervening with microenvironments and the immediate exteriority of the built form remain underexplored. The conducted workshops required the researchers to reflect on and gain insight into the aforementioned concerns of the data-assessment process. The design process clarified various stages of site-specific data handling. It facilitated the understanding of how to parse the needed data in correspondence with design ideas, and consequently assisted with the identification of analytical and simulation tools based on the project inquiries. In addition, it informed this research how to develop a flexible methodological frame to correlate data with design concepts and how to repurpose them in case of unsatisfactory results.

The rising awareness in today's practice of problems of computational and data-driven designs has led to the engagement of architects with questions related to the identification of contextual information and ways of analysing data. Gaining an understanding of information, empowered by interdisciplinary insights, facilitates the transformation of data into applicable knowledge for the design process. What should be emphasised is that implementing contextual knowledge can significantly benefit from recursive thinking and reflection on the subjective realisation of the context, which includes aspects such as social and cultural insights. It is also necessary to bear in mind that although designing in this way results in a built form that corresponds to its local atmospheric and functional needs, the design would still be dependent

on latent contextual changes and must therefore provide a flexible structure to adjust to future needs.

The sections on case studies and design experiments help to clarify this research's definition of performance by distinguishing it from the common definitions of energy efficiency and technological focuses, instead favouring functional aspects of the built form that emerge from the interactions of architecture with its surrounding context. The discussions specifically facilitate identifying the differences between the approaches of the non-discrete envelopes typology, thus further developing the earlier studies of the author's PhD research on the taxonomy of envelopes (Saeidi Derakhshi, 2017, p. 15). These approaches are identified as dissolved threshold and extended threshold, and they articulate the building envelope in ways that provide intermediary semi-open spaces between the interior and exterior environments. The main difference between these two approaches is their degree of enclosure in relation to their adjacent exterior environment, which is considerably higher in dissolved thresholds. This typology refers to design approaches that provide exteriorised interiors, in which the removal of a building's outermost wall forms extended spaces that are considerably exposed to exterior conditions while providing a degree of climatic shelter (such as the Inverted House). Extended thresholds, on the other hand, provide a well-defined microenvironment (formed by a void in the core of the building or a roofed veranda in case of the presented examples) with certain limitations regarding the spatial depth. Furthermore, they are also sheltered and affected by their adjacent enclosed spaces. Within this domain, a considerably difficult task is to define the means of designing extended settings through building envelopes.

This investigation proposes a guideline for designing extended settings as an extension of the notion of the exterior of the built form, based on the findings of the conducted case studies and design experiments. In light of this investigation, the following points need to be considered within the design process of architectural envelopes, including both design approaches and concepts framed in the scope of designing non-discrete architecture and its typologies. The three typologies of non-discrete envelopes consist of: extended thresholds, dissolved thresholds, and multiple envelopes, which are all discussed at length in the case studies section of this article. The typologies provide a spatial extension, which is emphasised either in the interior or exterior realm, by representing various approaches in integrating these two environments through means of building envelopes. In designing an extended setting for the built form, design considerations must articulate functional, aesthetic, and experiential aspects in correspondence with contextual circumstances, or specifically single out one aspect based on the particular aims of the project. The functional aspects mainly incorporate programmatic, climatic, and comfort design factors, while aesthetic ones include strong visual connections between the interior and the exterior. The integration of these two aspects can intensify the experience of the extended setting through a conscious design of emerging atmospheres and spatial interactions.

Various design concepts that assist in designing the immediate exterior of the built form as an inherent extension of the interior are: graded enclosure (interstitial/ transitional spaces providing spatial sequences), controlled spatial continuity (interiorised exteriors accommodating microenvironments through semi-open spaces), and spatial openness (exteriorised interiors acclimatised to the exterior environment, challenging the notion of interiority as a spatial enclosure). As conceptualised in the case studies section of this article, each of these concepts includes architectural elements that shape the envelopes' spatial definitions in different typologies. Two main design approaches for creating the gradient of spatial enclosure are the material organisation of envelope surfaces and positioning multiple layers of envelopes in correspondence to one another, forming a visual or permeable gradient. Elements and design approaches that develop a controlled spatial continuity also provide semi-open spaces between the two architectural realms of the interior and the exterior. These spaces are usually defined through a kind of mass subtraction of the building form to generate a conditioned space, such as courtyards or pocket gardens, Iwans, Engawa, veranda structures,

or even niches, as an inhabitable extension of the exterior environment. Another design strategy, which creates both a controlled microenvironment and sequential degrees of enclosure, is the elevated ground – or pilotis – that allows an intermediate space through an uninterrupted exteriority. The last design strategy is spatial openness, which is similar to the other two but is differentiated by challenging the notion of building envelopes through the erasure of a building's outermost wall to accommodate a semi-open transitional space. In this approach, various interrelated aspects of the exterior directly affect the inhabitation patterns of these interiorised spaces, the experience of which is highly dependent on subjective perception.

This article contributes to advancing the earlier discussions of the research in architectural envelopes, which explained their role towards the interior environments, by defining their close relations with the (locally specific) exterior environments. The studies indicate design strategies for articulating spatial extensions that provide conditioned exteriors which are supplementary to interior spaces. These strategies marry experiential and functional concepts by extending the spatial relation between the interior and exterior environments. The presented research thus seeks to further develop the earlier proposed conceptual approaches by identifying challenges and ways of integrating conceptual ideas and specific contextual knowledge for creating atmospheric qualities through the climatic conditioning of architectural envelopes. These efforts led to a design process for architectural envelopes, the spatial qualities of which emerge from iterative processes and discussions, rather than preconceived ideas of designing locally specific architecture. The diagrams extracted from the case studies can serve to expand the conceptual approach and act as design guidelines. As such, the diagrams constitute generalised principles that need to be re-contextualised and adapted to specific settings. Therefore, these principles are not generally applicable regardless of context and the specific exterior environment. On an overarching systematic level, the diagrams also serve to illustrate and embody concepts and approaches that can serve to advance and refine the architectural envelope concepts and taxonomy produced in an earlier stage of this research. The next stage of the research will test select diagrams and architectural envelope taxonomies in a design project conducted by the author with the aim of refining the methodological approach to architectural envelopes.

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A3

Advancing Architectural Envelope Design Focusing on Transitional Spaces

Towards linking measurable and immeasurable design criteria

Abstract:
This article portrays the development of a systematic approach for integrating qualitative and quantitative methods in designing architectural envelopes as defined by the author. A research-by-design experiment explored the design of transitional spaces or extended thresholds. Modulated by local climate and site-specific features, these spaces connect inside and outside environments and create specified intermediary climatic conditions with desired atmospheres. The design instance focused on daylight as a criterion for creating different qualitative (atmospheres) and quantitative conditions, which entailed coupling different analyses and assessing design instances via computational methods and tools. The design process integrated design sketching with computational parametric modelling and computational tools, such as evolutionary optimization and automatized iterative analyses, to evaluate and develop architectural concepts in different design stages and -iterations. Additionally, the analysis and evaluation include a qualitatively-oriented assessment seeking to convey and elaborate the perception of atmospheres. The resulting operative approach raises further research questions and needs for specific method development.

Keywords: *architectural envelope, extended threshold, transitional spaces, daylight atmosphere, locally-specific design, data analysis.*

1. Introduction

Technological and material advances in contemporary architectural practice create constant tension between globally uniform architectures and bespoke locally-specific designs. Many sustainable design solutions use strategies focusing on energy efficiency and optimization, leading to zero-energy buildings or "green" architectural approaches. Although advantages – e.g. reduced energy use and emissions – are evident in these, many tend to result in rigid, self-governing architectural entities overloaded with advanced technologies for a controlled interior environment (Moussavi, 2005). Vernacular architecture achieved livable and comfortable spaces by considering local materials and spatial organization (Hensel & Gharleghi, 2012). How then might we utilize current design methods while working with specific local conditions to reach required/desired quantifiable and unquantifiable aims?

The article continues ongoing research focused on developing an alternative notion of architectural envelopes (Saeidi Derakhshi, 2017). The research is a critique of interiors disconnected through strict boundary conditions and entails a redefinition for building envelopes as thresholds that can be inhabited and spatially experienced – an extended space that creates a relationship between inside and outside environments "as though [they] were coextensive" (Leatherbarrow, 2009, p. 39). Therefore, local site-specific conditions are key in designing these envelopes' experiential features.

The research is based on systematic inquiry through research-by-design experiments, entailing: (a) discussion of selected conceptual approaches to the notion of envelopes based on literature, (b) a proposed taxonomy of envelope types based on subjective analysis of built projects (Saeidi Derakhshi, 2017), (c) selected case studies that consider exteriority as design criteria resulting in principle diagrams for design (Saeidi, 2019), and (d) formulation of a design approach by integrating quantitative and qualitative methods. The research also includes reflections and learning-from-design experiments undertaken in the author's workshops in-master-level studios during the PhD research phase; these used envelope taxonomy and conceptual mapping as design tools. Applying these tools encouraged understanding of ways to combine a systematic approach with design thinking. The workshops took place between 2015-2017 at the Research Centre for Architecture and Tectonics & Advanced Computational Design Laboratory [ACDL], Oslo School of Architecture and Design [AHO].

The RCAT & ACDL studio have engaged with research on productive landscapes since 2016 to develop an approach to integrate landscape and architecture. The site was the terraced vineyard Grospoli, in Tuscany. The aim was to develop an information-based design process (Hensel & Sørensen, 2014; Sørensen, 2015) focused on locally-specific conditions to integrate landscape and architecture on multiple levels. The team mounted several weather stations on two terraces at Grospoli in September 2016 to collect site-specific climatic data; they were positioned to provide comparable datasets on impacts of dry stonewalls on the microclimate of different terraces. The stations collected data from September 2016-September 2018.

In autumn 2017, the RCAT & ACDL studio design brief requested a 200sqm visitor's center with work and research spaces; with one third being transitional spaces between exterior and interior. The author assisted students with design development and evaluation, which led to the author's self-tailored design experiment for the site with more time for iterative processes as presented in this article. Parsing the collected weather data revealed that a full annual cycle's datasets were incomplete due to communication issues between the mounted stations. The research thus proceeded with meteorological data for Florence, the nearest weather station.

The design experiment aimed to develop an iterative design approach combining qualitative and quantitative methods to link climatic data with experiential goals for transitional spaces. This encompasses the utilization of computational tools, i.e. a parametric model, computer-aided analyses, simulation, and optimization, within an iterative process. This facilitated the evaluation of trade-offs within a specified, designer-defined output range, and continual evaluation of key design criteria and related inputs during the design process. Engineering tools were utilized to analyze and fulfill the architectural design objectives. This is defined here as a design-authored process: an alternative method to current approaches of architectural practice, using evolutionary algorithms and automated iterative processes exclusively for

design optimization. This research calls this approach a value-authored process, where design decisions are based on quantitative outputs of the analyses.

About the design experiment's envelope typology, principles and conceptual approaches

The research includes definitions of key concepts for architectural envelopes and a related taxonomy that classifies envelope design approaches in selected built projects by realizing their emphasis on form versus design performance (Saeidi Derakhshi, 2017). The analysis distinguishes three approaches: *discrete* (Kuma, 2008) and *non-discrete* (Hensel, 2013) envelopes, and those with a *dual character*. This article only elaborates the envelope type in focus for the design experiment presented here.

Non-discrete envelopes can be differentiated in three types: *extended thresholds* (Hensel, 2011, 2013; Hensel & Sunguroğlu Hensel, 2010), *dissolved thresholds* (See Kuma, 2008), and *multiple envelopes* (Hensel & Turko, 2015). This exploration focused on the extended threshold type as a conceptual representation of built forms providing various climatic and atmospheric conditions through their envelopes' spatial organization and degrees of enclosure. The approach treats the threshold of the building envelope as a habitable space, semi-closed or exposed, yet still sheltered. It closely relates to the notion of Free-Running Buildings (de Dear & Brager, 1998) as an integrated design approach addressing issues of thermal comfort and inhabitants' climatic tolerance through spatial and material organization.

Design considerations on extended thresholds must articulate functional, aesthetic, and experiential aspects corresponding to contextual circumstances. Design principles that assist in designing the immediate exterior of built form as an extension of interior space include graded enclosure, controlled spatial continuity, and spatial openness (Saeidi, 2019). This design experiment incorporates controlled spatial continuity with thickened walls and breathing walls (Leatherbarrow, 2009) as integrated concepts to modulate daylight in the project's spaces and create the resulting spatial experience.

Spatial Continuity

Spatial continuity in architectural discourse usually concerns design approaches accommodating visual connections, e.g. Frank Lloyd Wright's "breaking the box" or Adolf Loos's "Raumplan". The former creates continuous space by opening up the corners of intersecting walls to allow the interior to visually merge with its ambient surrounding; the latter unifies the ensemble of rooms so they can be conceived with respect to another (Leatherbarrow, 2009, pp. 152–157). Loos believed that architecture cannot be conceived in plans but through the relations and connectivity of spaces giving rise to a spatial continuum and perception (Risselada, 2008). Besides these approaches that mainly focus on visual aspects of connecting spaces, designing semi-open or semi-closed spaces with varying degrees of climatic comfort can also be considered a design strategy of spatial continuity, especially regarding the exterior. The in-between conditions of semi-closed spaces provide a spatial and a temporal dimension for an aesthetical, functional, or

climatic transformation in space. Controlled spatial continuity through semi-closed or semi-open spaces is usually formed by a specific organization of architectural or structural elements, e.g. breathing walls (elaborated below) or a courtyard, pocket garden, *iwan* (a vaulted semi-closed entrance in Islamic architecture), or veranda.

The design experiment presented here focuses on the specific organization of architectural and structural elements in creating semi-closed or semi-open spaces that lead to effects and atmospheres focused on daylight's visual and thermal effects. Kahn believed that "[a]rchitecture appears […] when the sunlight hits a wall" (Kahn, 2013, p. 26), implying that architectural space and light depend on one another for visibility. "The first effect of light qua brightness is that it opens up a space that is created by light […] this space is not the physical, measurable space but one that involves space as we experience it, and only in the sense of a particular experience" (Böhme, 2018, p. 207). However, "light is not the only condition of visibility [… although it is] the condition for seeing; [yet] darkness is, in interaction with light, the condition for seeing something [driven by] conditions providing delimitation, articulation, and certainty" (Böhme, 2017, p. 148). Concepts of brightness and darkness must thus be revisited in creating architectural atmospheres within discussions of architectural envelopes via articulation of the wall and degree of enclosure.

Thickened Walls

Within the intermediate space of architectural envelopes is the experience of a crossing "where entry and invitation are offered and interior and exterior are felt that reveals the continuity and discontinuity of a spatial wrapper" (Meisenheimer, 2011, p. 626). As the spatial wrapper, the wall shapes a zone between interior and exterior and defines the relationship between mass and void. "[T]here is both history and poetry embedded in a thick wall" (2011, p. 625), making it possible to discover a space in that thickness, which virtually exists between the layers making up the wall – spaces that created the façade before the elimination of wall's different layers [or thickness] (Iñiguez, 2001, p. 145). Wall thickness can enable creation of specific conditions in the interior space and provide possible inhabitable spaces. Today the working body of architecture seems predominately defined by the preference for a thin skin, leading to the disappearance of threshold (2011, p. 627) and thus to only a visual connection of the exterior and interior through transparent façades. Glass façades and the notion of transparency have also diminished some architectural experiences, e.g. delayed enclosure being the process of crossing through thresholds when arriving from the exposed to the enclosed. This could be provided by the opaqueness of the wall among other architectonic elements.

Interstitial spaces span the sequence of passing through a door to a room with a specific architectural quality; they range from spaces between property lines to voids between major functions (Fjeld, Chan, Vistica, & Zingmark, 1987, p. 126). Yet, they can also be designed to accommodate a temporary inhabitable space or intensify the experience of architectural space in relation to other surrounding spaces. "The idea of using the wall's thickness to create interstitial spaces can be found in several examples of different ages […] within the evolution of stereotomic systems […] that

demonstrate expressive and functional possibilities of the wall's thickness from inside the building to the outside" (2001, p. 145). Semper distinguished the wall's role into two distinct parts: the structural – primary and more permanent – and covering – secondary and more temporal (Semper, 1989). Comparably, Kenneth Frampton described the poetics of construction as tectonics, emphasizing expressive potentials of construction techniques and volumetric character of architectural forms (Frampton, 2001, pp. 1–27).

In the late 1950s, Kahn's preoccupation with hollow spaces at different scales led to his use of "structure as the potential generator of space" (Frampton, 2001, p. 227). The "idea of [the] wall as a place for habitable environments developed [in his works] since the early Fifties as a prelude to the famous distinction between servant and served spaces, and the interest for lighting" (Cacciatore, 2016, p. 43). The stereotomic character and possibilities of construction techniques allow for a spatial realization from which various interstitial spaces and in-between conditions emerge. This research explores the notion of the thickened wall – presented as a solid form or hollowed structure, or a servant or served space – to enable studies on creating capacities, interstitial spaces, and in-between climatic conditions.

Breathing Walls

Le Corbusier's *brise-soleil* is a modern example of an expressive instrument orchestrating climatic control that "counteract[ed] the vulnerability of the fully glazed façade" (Colquhoun, 1991, p. 179). Through their design, orientation and depth, the three-dimensional elements of *brise-soleil* can intensify or lessen climatic effects (i.e. redirecting, accelerating or decelerating wind) or provide semi-sheltered inhabitable spaces.

David Leatherbarrow described "the connections between one of life's bare necessities (shelter) and its expression (art)" through a single wall in a single building (Leatherbarrow, 2009, p. 21). This thick, permeable wall allows fresh air to enter while stale air exits from inside Henry Klumb's Church of San Martin de Porres (1950). Leatherbarrow calls these Breathing Walls (2009, pp. 21–42). The wall's lamella structures provide operational and atmospheric functions for the built space with experiential qualities revealed by the location of the body and perceptive distances. Breathing walls allow for atmospheres resulting from the building's function and behavior, by both function and effects of building's static elements well positioned in the surrounding context. Leatherbarrow calls this productive architecture (2009, pp. 33–41). In breathing walls, "structure is the maker of light, [and thus, the atmosphere] because structure releases the spaces between and that is light giving" (Kahn, 1972).

This investigation incorporates the aforementioned concepts for their conceptual and spatial relevance when designing extended thresholds with a focus on daylight. Each of these concepts is further examined in the transitional spaces of the design experiment and coupled with atmospheric aims of each space.

2. Methods

Data-Driven Design – Research-by-Design

Today an increasing number of architectural design approaches rely on information-based systems. Data accessibility and open-source platforms and technological advancements facilitating data collection have accelerated the spread of data-driven approaches. "We are learning that computers can work better and faster […] and we increasingly find it easier to let computers solve problems in their own way" (Carpo & Davidson, 2017, p. 7). This approach risks placing architects in a state of blind acceptance, distancing them from reflective and critical thinking towards generated design outputs. Careful consideration is required when utilizing computer-aided design involving automated form-generation.

It is first necessary to establish the difference between data and information and to discuss ways of translating information to knowledge. Any input that can be used in the decision-making process can be regarded as data, but data must be parsed and organized with a shared meaning to become information (Savoie, 2012, pp. 12–13). Savoie's proposed information ladder – the process of translating data into knowledge – is based on Longworth's Learning Ladder (Longworth, 2003, pp. 78–84). If systematically translated into knowledge, the information becomes a useful tool that can facilitate well-informed decisions in the design process. The translation process includes critical and reflective thinking for acting on information, and thus, knowledge is produced (2012, p. 13). Information can facilitate knowledge-building through acts of abstraction and generalization of insights that enable their broad application. The last stage of data processing is when created knowledge elevates designers' understanding of when and on what to act, and how to integrate intuition with digitally-analyzed information – namely design insight. Rasmussen described the cognitive learning process and the resulting knowledge as an ingrained bodily experience (Rasmussen, 1964, pp. 16–20), exemplifying several learning instances: one is a repeated tactile experience of someone throwing a stone, first trying to "get the feeling of it, turning it over and over until he has the right grip of it, and then weighing it in his hand" (1964, p. 18). Such repetition, he stated, results in learned knowledge: in time, one is "able to tell what a stone is like without touching it at all; a mere glance is sufficient" (1964, p. 18). Knowledge and design insight thus seemingly imply complimentary inquiries for the architectural design process.

Complex, interrelated societal, political, urban and architectural inquiries today yield new questions and increased complexities in design projects that architectural practices must address and fulfill. Consequently, many contemporary practices have started to build different organizational structures. Emerging design processes in such practices engage research and a wider range of disciplines early on for deeper understanding of the project's demands. Design research is thus a progressive tool for design development and knowledge production that occur simultaneously through the act of design. This explorative process is "interpretive and conditional, at least when design is seen as projection, not production" (Leatherbarrow, 2012, p. 11). Hence, project-making in architectural practice "can be understood as a form of scientific research when both are seen as projective activities" (2012, p. 11). Research-by-design is then a

mode of scientific and artistic research, often conducted through means of design and explorative inquiry (Hensel & Nilsson, 2016, p. xiv), and also means for exploring different techniques and tools for carrying out a design, including sketches and mappings, etc. (De Queiroz Barbosa, DeMeulder, & Gerrits, 2014).

A current challenge of architectural design is correlating qualitative and quantitative design criteria and related methods in early design stages. Typically, the project's qualitative aims are incorporated early on through concept development; quantitative aspects are usually utilized later, when designs are largely determined. Quantitative aspects tend to be treated as engineering-related and separate from the project's conceptual aims. A drawback of this approach is the design's strong dependency on a preconceived concept, which renders other design aspects subservient.

This research explores a way of working that attempts to integrate both information and intuition early on, to inform and develop architectural concepts. This entails identifying required data and where/ when to collect/ apply it, and what to include/exclude from datasets and various outputs. It also maps out how the design process assesses the validity of initial concepts, enables iterative adjustments, and builds a way for tackling predictable and unpredictable outcomes. The design experiment described here utilizes conceptual mapping and envelope taxonomy with a mind map produced at the initial design stage to help clarify the design experiment's aims. These tools are a framework for this investigation, in which computer-aided design and analysis is a driving design research method in assessing the design concept's validity.

The research's mixed-method mode enabled a linking of relevant tools. Mixed methods are used, firstly, for the diversity of data forms used for the research framework and the recursive evaluation of its objectives. Secondly, it provided the framework to combine different design tools, from conceptual views and typologies to instrumental measurements and simulation. The conceptual mapping and envelope taxonomy delivered the reflective lens needed to evaluate and improve design methods. Data collection, analysis, interpretation, and reflection shaped the framework of iterative assessment and reflective thinking during the design process. Mixing data occurred at both conceptual and analytical steps of the experiment by integrating various datasets (Creswell, 2014, pp. 206–215). Integration refers here to how taxonomy and conceptual mapping of the research were utilized to create the design experiment's initial structure. The qualitative and quantitative data were integrated by transforming the qualitative data to quantitative means to enable data comparison and interpretation, aiming to develop the experiment's atmospheric aims.

3. Design Project and Process

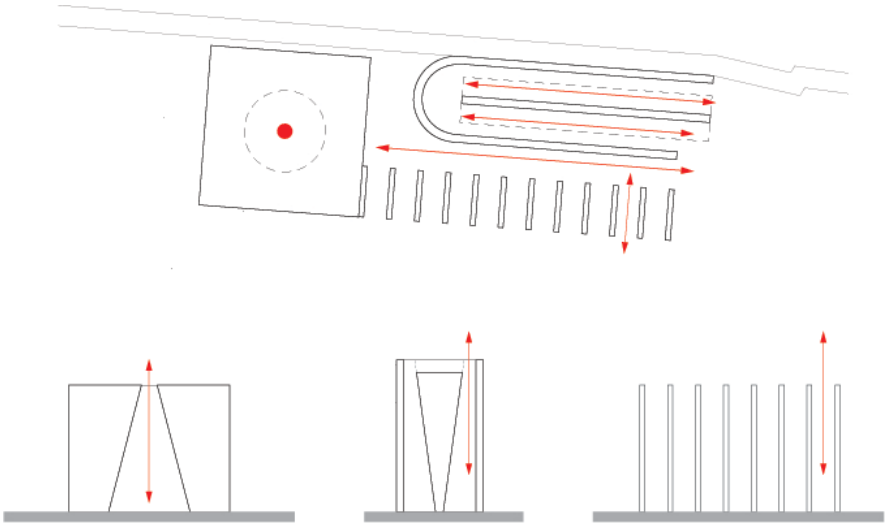
The Design Experiment: What – why – how?

Unless the envelope is positioned as the main conceptual driver of an architectural design project, the design process usually starts with plan layouts or the formal expression of the design. Computational modeling and simulation are common tools in today's architectural practices, specifically used when optimization and time efficiency are main demands for project development. Being able to interrelate design criteria enables assessment of various design scenarios and facilitates identification of possible compromises. Modeling complex environmental simulations of architectural designs usually belongs to post-design optimization instead of informing early design stages. This research hence seeks to develop a way of integrating some simulation and analyses early on, using available digital tools. The decision-making process in developing concepts can thus be better informed, and the design adjustment process between engineers and architects can advance beyond current levels. Working this way could also deliver insights and understandings necessary for an interdisciplinary design process.

This research employs various analysis and simulation tools in a parametric model integrated with atmospheric visualizations to enable comparative assessment of the design concepts. The associative parametric modeling process facilitates the implementation of climatic data and provides geometrical flexibility needed for iterative adjustments of the design. However, how to relate location-specific data and design? How can climatic data be implemented early on to meet the needs for examining an architectural space's spatial qualities? How can daylight simulation and analysis, as the selected climatic factor here, inform and influence the project's experiential aims? To address these questions, the experiment encompasses a way of working with locally-specific data to create experiential aspects derived from the relationship between interior and exterior environments while accommodating climatic comfort.

The project brief tests the development of a design approach rather than representing an exemplary design. The design aims at creating spatial experiences emerging from the interactions of the semi-closed, climatically-sheltered built forms with their surrounding environment. The project provides atmospheres of semi-closed spaces through daylight intensity and various degrees of shelter. These spaces accommodate a temporal stay for three main activities: exhibition space related to wine production, wine-tasting room, and open space for enjoying panoramas. The wall organization of three spaces defines the degree of enclosure in accordance with the program of the space and the desired thermal and daylight conditions, from fully exposed to enclosed. The design uses breathing walls and thickened walls concepts to explore spatial continuity in the extended thresholds [Diagram 1].

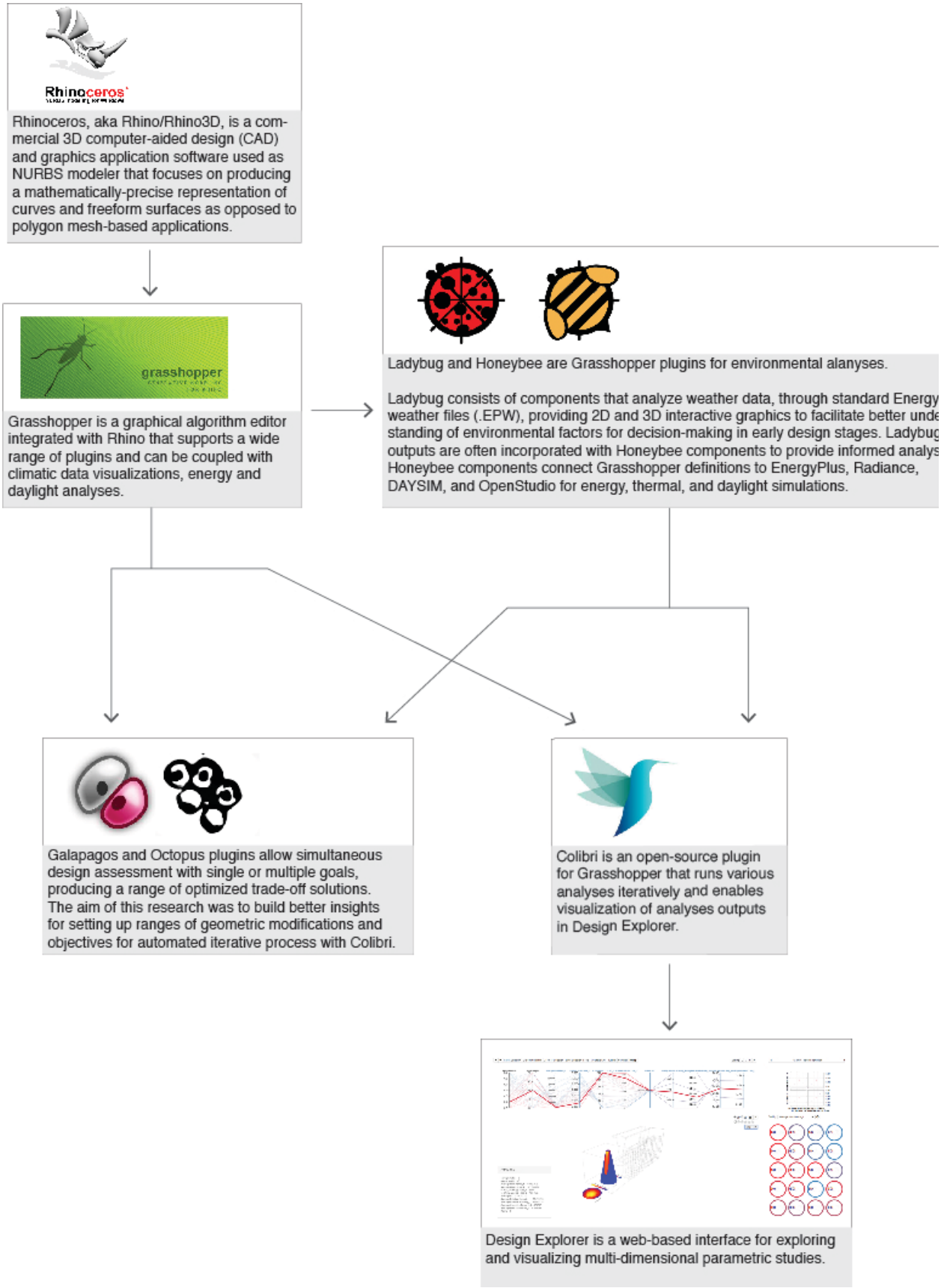
Diagram 1: Planar and sectional representation of spatial continuity in the three spaces from most exposed to the most enclosed. Sareh Saeidi, 2018.



The research's focus on experience incorporates visual and thermal aspects of daylight to create specific atmospheres in these semi-closed spaces. The design addresses the threshold as a conditioned boundary in which a change occurs that results in an atmosphere. Atmosphere is the mood of a space that produces a specific feeling in the person experiencing it – thus strongly connected to a bodily and subjective perception (Saeidi, 2019, p. 7). It "concerns a spatial sense of ambience" (Böhme, 2014, p. 43) and is not a singular moment of perception but a sustained being in a situation (Pallasmaa, 2014, p. 20).

Positioning the relation of specific local data to inform design decision-making requires laying out a self-tailored process with a good workflow and enough flexibility for design's experiential nature; this became possible through the parametric framework and application of various plugins. The experimental design is modeled parametrically in Grasshopper, a plugin for Rhino, and the daylight simulations and analysis were conducted with Ladybug and Honeybee [Illustration 1]. Integrating Ladybug and Honeybee enables a dynamic coupling between Grasshopper's flexible, component-based, visual programming interface and validated environmental data sets and simulation engines (Sadeghipour Roudsari & Pak, 2013).

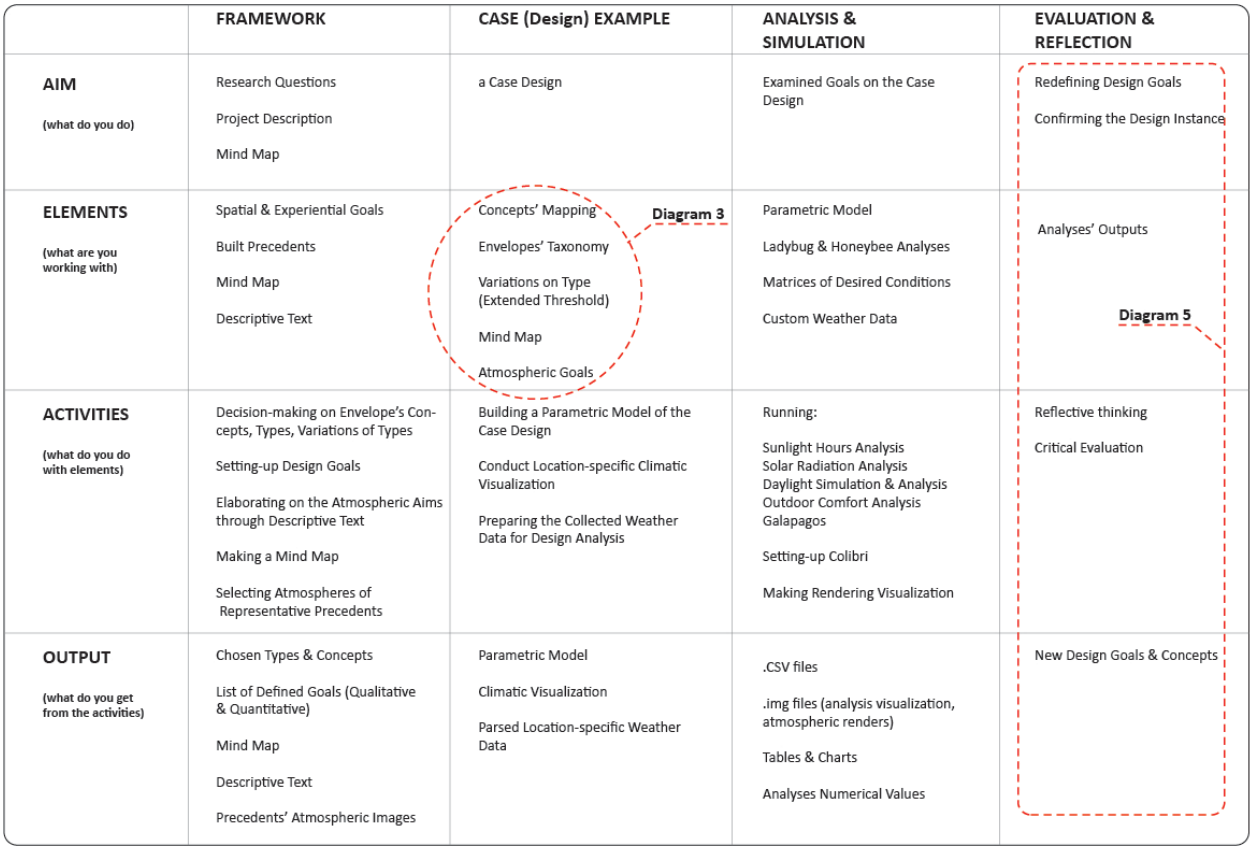
Illustration 1: The research's modeling, simulation, and analysis tools. Sareh Saeidi, 2018.



Design Process

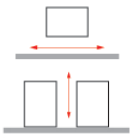
The design process comprised three main stages: 1) contextualizing and setting up the project framework, 2) modeling a design instance, 3) running analyses and simulation, 4) reflecting and evaluating [Diagram 2].

Diagram 2: Illustration of various stages of the design instance and their inquiries. Sareh Saeidi, 2018.



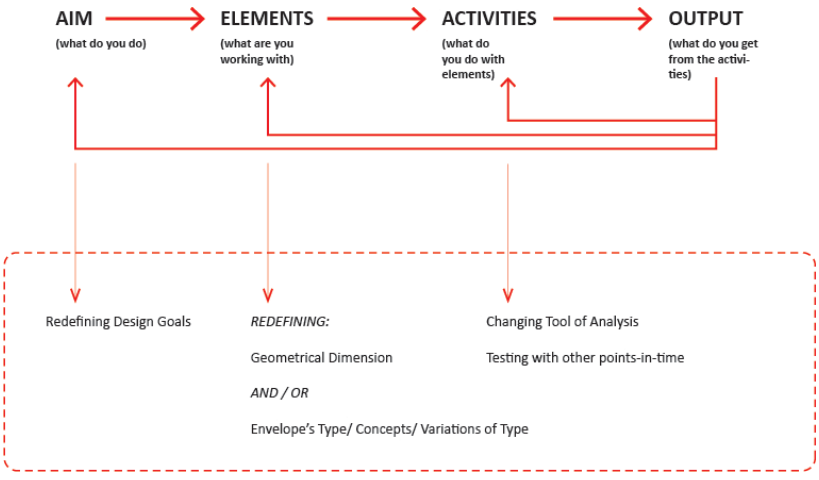
The first stage focuses on the necessity of the investigation, research questions, and the project brief, utilizing earlier studies and developed tools of the research (taxonomy; conceptual mapping) and a mind map. Here, setting specific spatial and experiential goals created the framework for the design and evaluation of the iterative workflow. The design utilizes the extended threshold type, incorporating typological variations as design principles. The spatial goals aim at elaborating spatial continuity by applying the concepts of breathing, and thickened walls. The experiential goals specify both atmospheric (visual) and comfort (thermal) aims introduced by descriptive texts and images of similar atmospheric moods in existing built projects. The descriptions are accompanied by value-based quantitative goals for light intensity corresponding to the atmospheric aims of each space. The value-based goals are based on findings presented in existing research (Fang, 2017) and energy models [Diagram 3].

Diagram 3: Illustration of required elements for the experiment's framework. Sareh Saeidi, 2018.

	SPATIAL ENCLOSURE	SPATIAL GOALS (CONCEPTS)	TYPE	VARIATION OF TYPE	BUILT PRECEDENTS	Experiential Goals Qualitative — Quantitative	
AIM (what do you do)	Enclosed Semi- Closed Semi- Open	Embedded Thickness Spatial Continuity Breathing Walls	Extended Threshold		Envision & Exemplify	Sublime Dark, Heavy Immerse, Airy, Inviting	< 1000 < 300 same tempera-ture as outside
ELEMENTS (what are you working with)	Wall Thickness Degree of Openness	Concepts' Mapping	Envelopes' Taxonomy	Built Precedents Design Principle Diagrams	Built projects (both historical & contemporary)	Subjective Descriptive Text	Fang, Y., 2017, UC Berkeley
ACTIVITIES (what do you do with elements)	Building a Parametric Model Building a 3D model for Rendering	Conducted Literature Studies (Saeidi Derakhshi, 2017)	Conducted Analysis (Saeidi Derakhshi, 2017)	Conducted Precedents Studies (Saeidi Derakhshi, 2018)	Describing the selected projects Analyzing chosen atmospheres	Making 3D model for rendering visualization	Running Daylight Simulation & Analysis
OUTPUT (what do you get from the activities)	3D Model Parametric Geometries	Concepts' Mapping	Envelopes' Taxonomy	Design Principle Diagrams for Extended Threshold	Atmospheric Images	Rendering Visualization	Lux Values Colored Mesh Analyses images

The second stage was to define a design instance for testing design ideas and concepts; this included sketching ideas, setting up a parametric model of the sketches, general weather data analysis, and weather data parsing and preparation. It also included possible redefinitions of spatial and experiential goals if analysis outputs did not fulfill set goals [Diagram 4].

Diagram 4: Illustration of the experiment's iterative process. Sareh Saeidi, 2018.



The third stage focused on analyses and simulation in an iterative process. The fourth stage – reflection and evaluation – incorporates all analysis outputs and reflective thinking on the findings that determine the readjustments of geometrical form, changes to analysis types, and redefinition of various project goals [Diagram 5].

Diagram 5: Representation of the modules of computational analysis and simulation in the experiment and their inherent inquiries and outcomes. Sareh Saeidi, 2018.

	SUNLIGHT HOURS	RADIATION ANALYSIS	DAYLIGHT & SIMULATION ANALYSIS	OUTDOOR COMFORT	GALAPAGOS — OCTOPUS GRASSHOPPER PLUG-INS	COLIBRI	RENDERINGS
AIM (what do you do)	Sun-Shade Studies	Solar Impact Studies	(Useful) Daylight Studies	Comfort Studies	Goal fulfillment, Possible trade-offs,	Iterative setup	Visualization of design's atmospheres
ELEMENTS (what are you working with)	Parametric model of the case (design) example Climatic Data Specific Time for Analysis	Parametric model of the case (design) example Climatic Data Specific Time for Analysis	Parametric model of the case (design) example defined with Honeybee geometries & radiance materials Climatic Data Specific Time for Analysis	Parametric model of the case (design) example Climatic Data Annual Analysis	Analysis Output Defined Objectives	Analyses' outputs parametric geometry Visualizations' settings	Location-specific daylight setting 3D model of the test geometry Analysis period / point-in-time 3D Material settings
ACTIVITIES (what do you do with elements)	Inputting the paramteric target geometry, context geometry, climatic data for a specific point-in-time and Running the Analysis	Inputting the paramteric target geometry, context geometry, climatic data for a specific point-in-time and Running the Analysis	Inputting the target surface of paramteric model defined with Ladybug & Honeybee inquiries, climatic data for a specific point-in-time and Running the Analysis	Inputting wind, humidity & temperature readings of the climatic data file, specifying an analysis period / point-in-time and Running the Analysis	Running the analysis with single (Galapagos) or multiple (Octopus) objectives Selecting the preffered solutions Saving a solution(s) as a Grasshopper state or Re-run Galapagos/ Octopus with changed objectives Finally exporting to text files	Designate: Genomes (design inputs) & Phenomes (analyses inputs) Allocate file path Indicate 3D model views to be saved	Testing various material settings until reaching the desired atmoshere Testing renders with daylight simulation to assure renders' daylight setting corresponds to the simulation results
OUTPUT (what do you get from the activities)	Numerical Values Images visualizing Colored Mesh surfaces with Analysis Values	Numerical Values Images visualizing Colored Mesh surfaces with Analysis Values	Numerical Values Images visualizing Colored Mesh surfaces with Analysis Values & depending on way of parsing analysis's output values: data.csv files ,etc	Numerical Values	Numerical Values Solutions' 3D models Trade-offs between 2–X goals 2D & 3D charts Visualization of all possible variations Exported text files	Numerical Values (data.csv files) analyses' images 3D model visualizations	Rendering Visualizations (images)

Step-by-step guide to the parametric model – analyses – Iterative process after setting up project framework

The design experiment commenced with a detailed mind map and Florence's annual weather data visualization. The mappings are a catalyzer to formulate inquiries for various spatial, conceptual and climatic aspects in accordance with the intended programs, orientation, and location on-site. The mind map included three categories: (a) spatial aims related to literature readings focusing on form, (b) qualitative aims related to desired atmospheres focusing on daylight, (c) quantifiable criteria corresponding to spatial and qualitative aims. The quantitative criteria was divided into three categories: geometrical variables (height, width, depth, etc.), value-based variables from the analyses' output (daylight simulation), and the automated iterative setup. This step facilitated identification of available analytical tools,

necessary data types for the evaluation process (output-oriented thinking), and adjusting quantifiable goals based on the experiential project goals and analytical tools.

Subsequently, intuitive design through sketching served to define a design instance for testing project ideas and goals through computational analysis and simulation. This enabled setting up desired design specifications. The design sketch consisted of three semi-closed spaces with different degrees of enclosure and specific light conditions, varying from a constrained space with controlled light to an open space that can be immersed in daylight.

1. *Sketching an idea, making it parametric*

After sketching an idea, an associative parametric model of the sketched geometries was set up, enabling independent modification of the geometries and facilitating various tests during the iterative process.

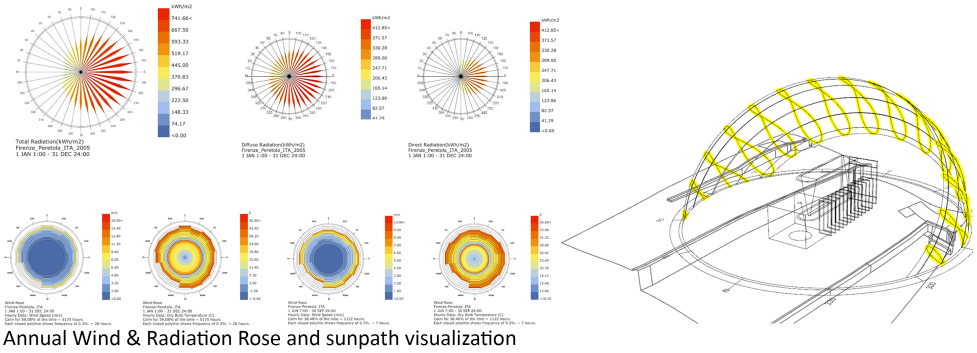
2. *Running general climatic data analysis*

Climatic data visualization facilitated preliminary understanding of the conditions to meet. Ladybug components that read and visualize standard Energy Plus weather file format (.EPW) enabled analysis and visualization of Florence's annual weather data. If locally-collected weather data is available, the weather stations' text-based log files can be parsed in Excel to .csv format. Elements is a free open-source cross-platform tool that allows editing .epw files and overwriting custom data for building energy modeling. Lacking a full annual cycle, the research could not build a custom .epw file for the analyses. This step also involved literature research on various studies conducted at Grospoli and in similar landscapes (Agnoletti, 2006, 2012; Agnoletti & Emanueli, 2016; Contessa, 2013; Prosdocimi et al., 2016; Sereni, 1997; Tarolli, Preti, & Romano, 2014).

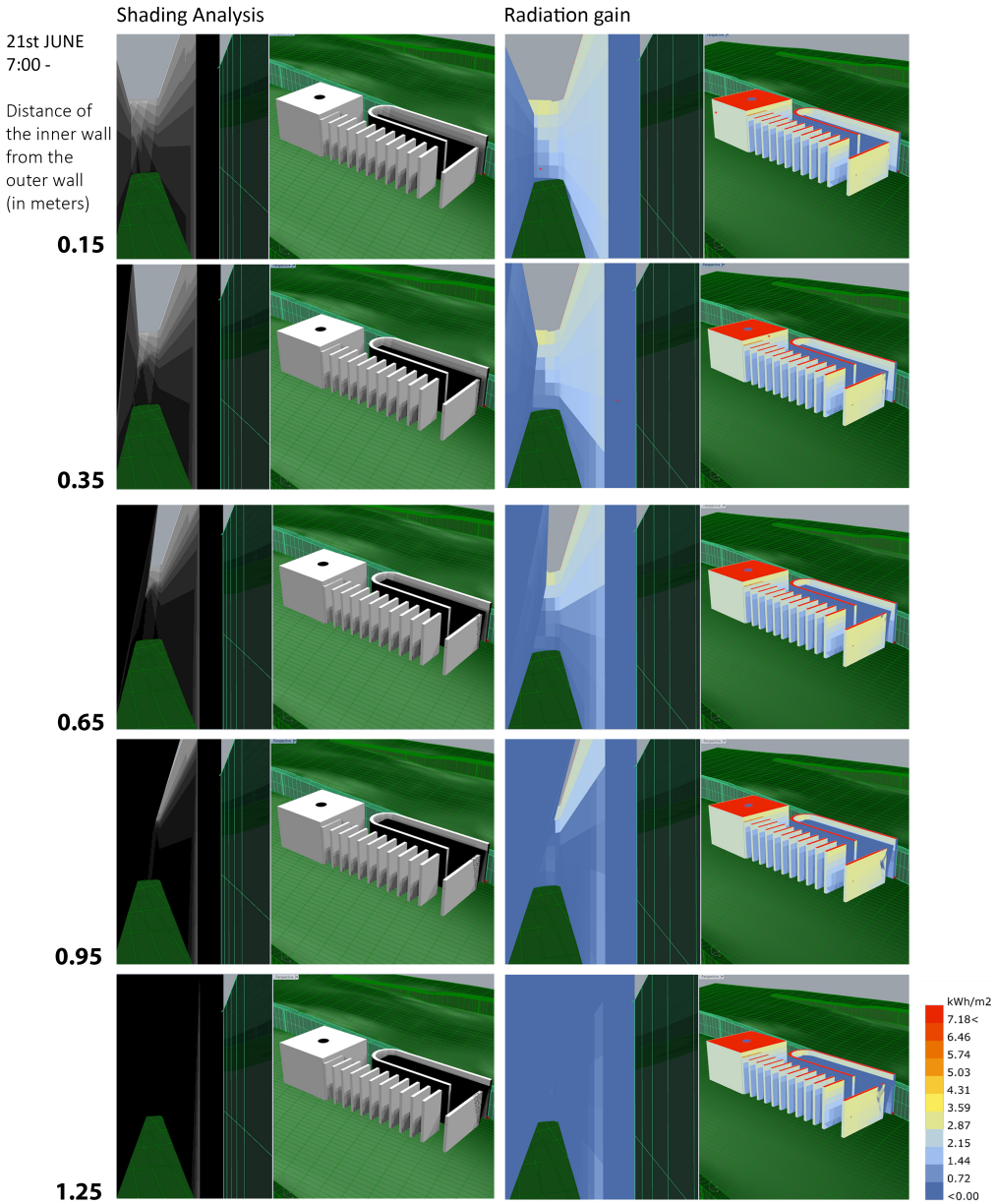
3. *Running Ladybug's sunlight hours, solar radiation analyses and outdoor comfort calculator*

This step included radiation and sunlight analysis of the preliminary design in Ladybug. A yearly analysis is useful for an overall understanding of the range of conditions faced annually. The results of shading and solar radiation analyses of the geometries facilitate better understanding of thermal exposure and the orientation of the geometries in relation to location [Illustration 2].

Illustration 2: Annual weather data analysis; Florence, Italy. Sareh Saeidi, 2018.



Annual Wind & Radiation Rose and sunpath visualization



4. *Running daylight simulation for the design at a specific time*

Daylight simulation provides image outputs by which experiential goals for the chosen geometrical setup can be assessed. This analysis was at the summer solstice, when sunlight and thermal exposure were greatest. The results demonstrate lux values and their visual representation by a colored mesh. The analysis outputs indicate whether the project's value-based aims were realistic or required redefinition. If within analysis output range, the value-based goals could be set as the objective for the Galapagos solver (step 6). If not, the daylight analysis must be conducted on a modified geometry. The geometry changes are exploratory and applied until a satisfactory geometry corresponding to an adequate output range is reached. In this case, optimization tools can be useful for fine-tuning.

5. *Identifying necessary outputs and analysis tools based on spatial and experiential goals/ Reestablishing quantifiable analysis goals*

After defining desired conditions and acquiring preliminary understanding of the daylight specifications, the researcher must revisit the project goals, if required, to identify further necessary analyses and tool choice. This step includes establishing quantifiable aims for the analysis in accordance with findings of the previous step (i.e. an illuminance value to obtain the desired atmospheric darkness). Based on the analyses' output, the feasibility of achieving various experiential goals can be evaluated and assessed, and the necessity of redefining the project goals determined. Here, a helpful tool was the descriptive text and images of built examples with similar spatial moods, which defined and visualized atmospheres and experiential goals of the spaces.

6. *Running Galapagos optimization solver as an assessment tool for concept-developing*

Galapagos provides a generic platform for the application of Evolutionary Algorithms used to solve many problems. Each space of the design experiment was set up through adjustable values and examined separately because of different spatial and experiential criteria. In case of shared spatial aims, all geometries can be examined simultaneously. Based on daylight analysis results of different spaces, an optimization test with Galapagos can help determine a suitable geometrical setup for the desired illumination condition. The geometrical values were the inputs of Galapagos genome. The desired illuminance value from daylight analysis was set as a fitness criterion; fitness criteria were driven by daylight analysis results but restricted in accordance with various illuminance goals.

The Grasshopper plugin Octopus was used to test inputting multiple objectives, searching for several goals at once, which produces a range of optimized trade-off solutions between different goals. Export solutions were unsatisfactory; Colibri was thus used as an alternative tool to incorporate multi-objective iteration loops into the design process.

7. *Defining ranges of flexibility and change in geometrical definitions*

If geometrical parameters are not restrained to determine a limited range of modifications, Galapagos outputs can result in senseless dimensions and an infinite number of iterations. Controlling the input ranges limits the number of loops in the iterative process. Restricting the range of geometrical changes allows for supervision, positioning the architect's decision-making role within this automated generative process. Daylight simulation results facilitated an understanding for setting geometrical variations limits.

8. *Re-running Galapagos and daylight simulation*

Once geometrical values are defined, daylight simulation and Galapagos are used again to determine strengths, limitations, and suitable design alternatives. Galapagos' outputs visualize all possible combinations between the geometrical inputs of each space; these outputs also include variations that best fit the daylight goals of the chosen space in correspondence with the project's quantifiable aims.

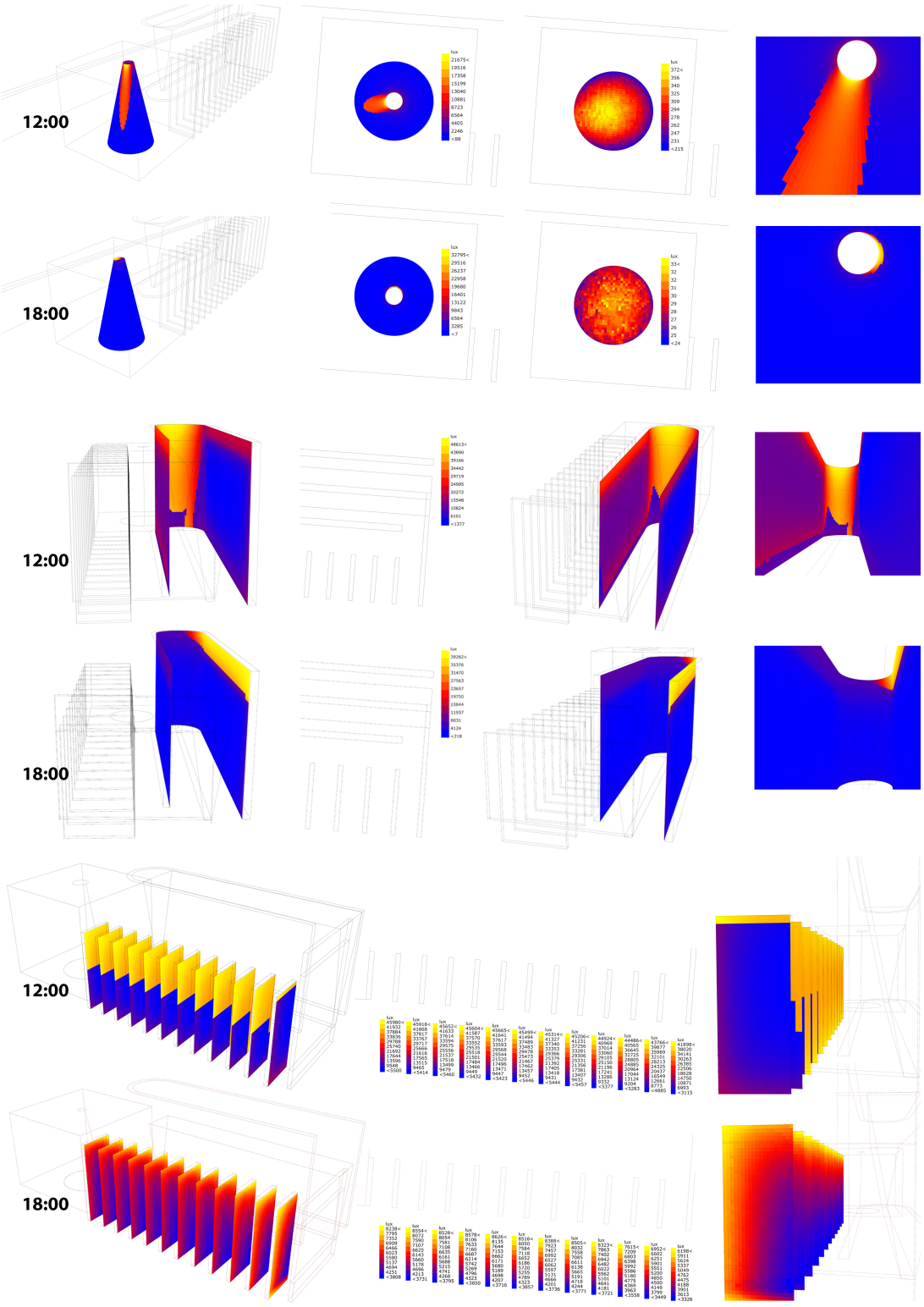
9. *Setting up an annual atmospheric condition matrix*

After determining how to examine the spaces' atmospheric aims, atmospheric matrices were developed for the three spaces to elaborate ranges of experiences the design should provide for. The matrices included all seasons with desired morning, afternoon, and evening atmospheres, and comprised specifications on illuminance and comfort values as sets of quantifiable goals for the experiential aspects.

10. *Running daylight analyses for the design instance in all selected times*

The design variations were then further analyzed for daylight with the Honeybee plugin according to atmospheric aims chosen from the matrix. Summer and winter solstice and spring equinox were selected to represent annual extremes and average daylight and comfort conditions [Illustration 3].

Illustration 3: Daylight simulation and analysis of the selected dimensions for the three geometries corresponding to atmospheric aims of the project through Colibri. The images illustrate daylight conditions on June 21st, a hot summer day, at 12:00 and at 18.00, when tourists start spending time in the facility. Sareh Saeidi, 2018.



11. *Setting up the iterative process through Colibri*

The Colibri workflow is divided into iteration and aggregation. The Colibri Iterator component enables definition of the number of iterations through the input parameters, letting users control the size of their model and design space. Creating combinations from the inputs, the iterator generates the necessary genomes for the Colibri Aggregator component, which gathers design data including Genomes (design inputs), Phenomes (design performance data) and images and Spectacles models (allows Grasshopper 3D-geometries to be viewed online, free) into a data.csv file that Design Explorer can open. While the Iterator is iterating upstream in the Grasshopper definition, the Aggregator component collects the data that Design Explorer needs by gathering inputs from the Iterator, outputs (performance metrics) from the Grasshopper definition, and generates images, names images and Spectacles files, and writes all data into one data.csv file.

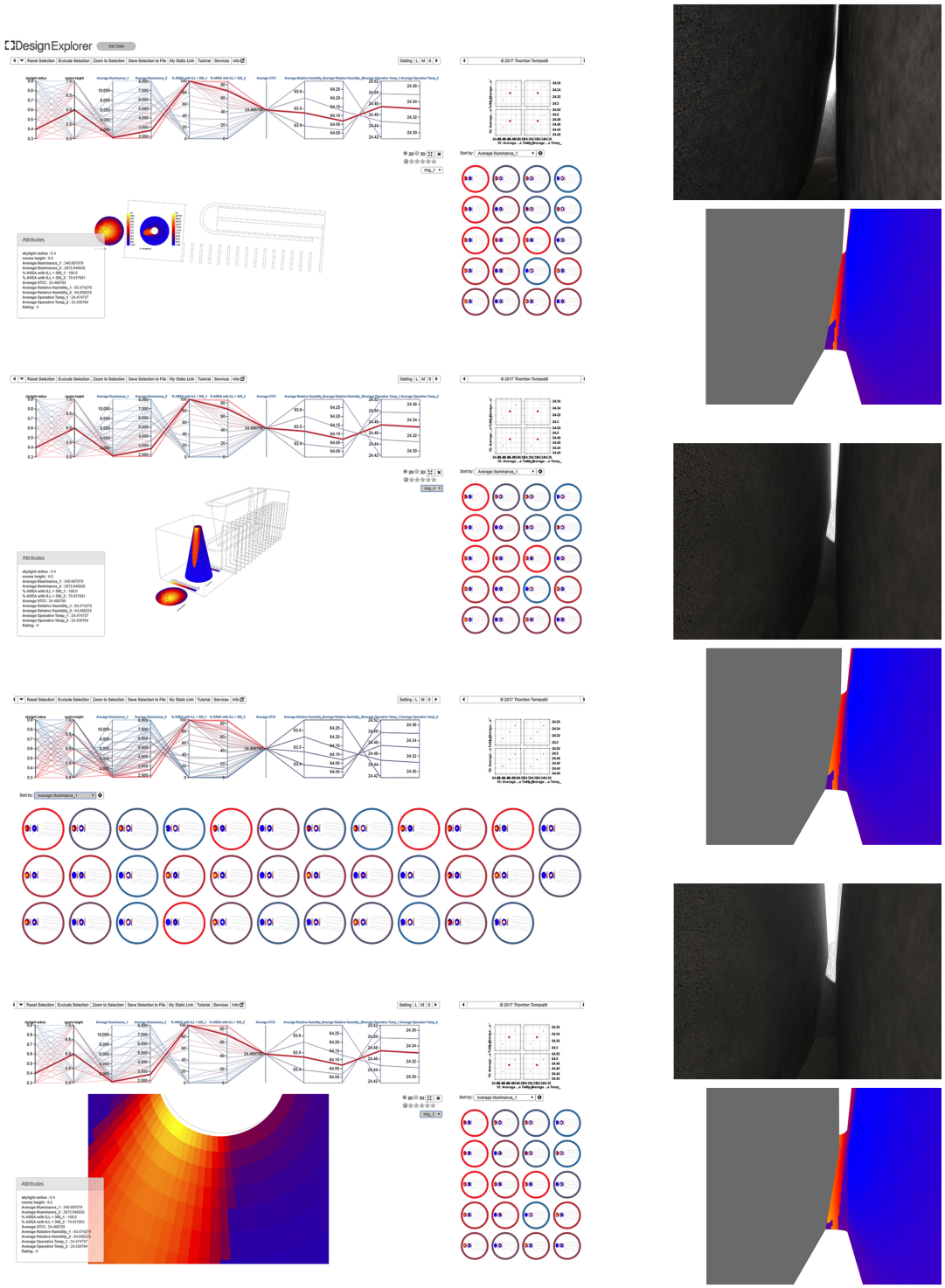
12. *Visualizing and illustrating results through Design Explorer*

An open-source tool for exploring design spaces, Design Explorer provides an interface for visualizing and filtering groups of iterations. Iteration sets consist of design solutions across a large high-dimensional possibility space. Users export their design spaces from parametric modeling applications as data.csv files and a series of images and Spectacles model by which Design Explorer generates 2D-visualizations.

13. *Visualizing the atmosphere of the spaces through renderings*

Conducting a daylight simulation in Ladybug with each spaces' value-based atmospheric aims facilitated setting daylight intensity goals. This guided the ranges of geometrical changes for Colibri Iterator and Aggregator components. Colibri recorded all possible geometrical variations within the constrained ranges together with stamped values of daylight. The geometrical variation settings that corresponded best with the spatial aims guided the settings of the project's atmospheric renderings, which were conducted by V-RAY plugin in Rhino [Illustration 4].

Illustration 4: Variations of atmospheric studies through renderings informed by daylight simulations (left) and Design Explorer (right) as the interface for visualizing and filtering groups of iterations from the daylight simulation results. Sareh Saeidi, 2018.



The Designed Spaces

The three designed spaces are exhibition space related to wine production, a wine-tasting room, and an open space for enjoying sweeping landscapes; the spatial conditions go from most enclosed to most exposed. The spaces' atmospheres and thermal experiences were defined respectively as dark and cool, sublimely lit and comfortable, immersed in daylight and receptive to outdoor temperature. The goals were defined by imagining a point of time with knowledge of seasonal and diurnal changes.

A tapered concrete wall in section shapes the exhibition space and creates a dark space; the wall limits light penetration and controls the degree of darkness, and its angle and the narrow corridor create a sense of heaviness. A circular opening at the top of the conically-shaped wine-tasting room allows direct light to reach stone-lined circular interior surfaces, where daylight can change shape. On a sunny December day, the light is thin; by June, daylight pours in and creates a grand oval at the edge of the skylight, almost reaching the floor. The research calls the mood created by the daylight 'sublimely lit'. In both the exhibition and the wine-tasting spaces, the continuity of the exterior in the interiorized space and the thickness of the wall are essential factors in creating the atmospheres. The wall thickness in the wine-tasting space fulfills the thermal requirements for storing wine and provides space needed for storage and service areas. The open space functions as a viewing platform and is most receptive to weather and daylight conditions.

Reflections and discussions on the design process

Computational simulation and analysis were chosen as analytical tools for their capacity to provide a platform for climatic data integration; for tackling complexity, especially when scaling up the project, providing quick feedback, and facilitating necessary flexibility for evaluating different solutions simultaneously. Nevertheless, Computational tools and algorithm use is also criticized because of generative design aspects. Some would impartially argue that results from computational analysis and simulation are only partly reliable, as simulations are a generated condition affected by the specific method/tool's inner logic or restrictions (Lorenzo-Eiroa, 2013, pp. 10–22). Despite that, combining different methods/tools allowed the implementation of various local data and enabled turning real-world information into actionable knowledge – thus working within the reaches of a conceivable reality. By examining the design experiment through this approach, the author could simulate a possible condition with real data, and the design could be assessed for specific performances. The selected tools are widely used in architecture today, and applying them did not limit critical and reflective thinking during the design process or the integration of various methods for evaluating analysis and simulation outcomes. When using existing tools for simulation and analysis, the risk is that a designer might rely on developers' logics, unheeding of their limitations. Uncritical users "can be blind-sighted by the end product performance due to hidden assumptions" (Braasch, 2016). The architect can to some extent circumnavigate

this by obtaining knowledge about the conceptual basis of methods and tools of interest, and based on the critical review and assess of outputs.

One main challenge of the design experiment was defining value-based goals regarding the spaces' atmospheric aims. This also determined the iterative model setup and design choices. The research utilized optimization studies on daylight and energy performance conducted at UC Berkeley (Fang, 2017) to define value-based goals. For instance, the atmospheric aim of the exhibition room was a dark, heavy space. Fang considers a space lit by less than 300 lux as dark space, but in some cases a space lit by less than 100 lux can be considered dark space. The author used Fang's 'Useful Daylight Factors' studies as test settings for the analyses. The research also faced difficulties adjusting the 3D-model's sun settings with illumination factors from daylight simulation, but the location and time for these could be set and used for the atmospheric rendering investigations. The evaluation of the design's atmospheric aims was based on a subjective comparison of renderings and analysis images of daylight simulation as relative representations of the design's possible conditions.

The comfort analysis was discarded from the investigations due to difficulties in developing an energy simulation model for thermal analysis. The energy simulation modeling requires closed geometries to define energy zones of a building, contradicting the spatial construct of extended thresholds. The time span of the analyses and simulations was another practical issue; although a powerful computer conducted the investigations and the design was significantly simplified, the iterations of daylight analyses took considerable time.

The design experiment presented here attempted to link approaches that seemed difficult to integrate to find a way of working that engages with current challenges and discussions in architectural design processes and practice. During the analyses and simulations, returning to earlier stages of the design process was often necessary; design framework was then readjusted and explored anew.

4. Discussion and conclusion

The investigations presented here seek answers to theoretical and methodological questions. Theoretically, the experiment seeks to elevate research discussions on experiential aspects of the architectural envelope by exploring how the experience of semi-closed spaces can be defined. Methodologically, it seeks a design approach by integrating unquantifiable (design concepts) and quantifiable (parametric analyses) methods. The investigations address questions of specific local conditions and climatic design to incorporate the scopes of the PhD research project. The taxonomy and conceptual approaches of architectural envelopes, with a mind map of the design experiment, are systematic methods for information classification through which the research conducted its explorations; they thus work to clarify the research's definitions and arguments that make them progressively developing documents.

On the theoretical level, the chosen concepts for the investigation were further investigated through the research's design approach. The design experiment allowed the examination of concepts in relation to envelope types, thus deepening earlier studies of the research; accordingly, the concept mapping and envelope taxonomy systematically provide the ground of the design experiment. The approach also enabled the research to closely examine the relationship between climatic and atmospheric focuses of the PhD project through a locally-specific design.

The design explorations on transitional spaces helped enhance the PhD research discussions on the architectural envelope as a semi-closed threshold. The design included investigations on articulation and treatment of the wall as the key element defining the enclosure. The experiment's designed transitional spaces provide climatic shelter while creating an atmospheric quality through the interactions of the built space with its exterior surrounding. The accommodated climatic condition provides both shelter from bad weather and thermal comfort. Microclimatic simulation and adaptive thermal comfort analysis would have been constructive studies for more design insights. However, this investigation proceeded without these, as software limitations in modeling semi-closed spaces would lead to unreliable outputs.

Evaluating design with computational analyses had strengths and shortcomings in regards to the project's experiential aims. Examining a design by simulating a possible reality through real-world data repositions the choice of design from a preconceived, immeasurable choice to an assessed selection. The approach enables further assessment of the atmospheric and environmental performances by materializing abstract concepts and ideas. In addition, visualizing atmospheres with 3D software makes it possible to illustrate a mental image and communicate its spatial qualities. The design approach provided a meaningful platform for examining the project's concepts through daylight analysis. However, the atmospheric examinations of the project remained dependent on the software setup, and inadequate due to limitations of sunlight settings. The renderings were thus partly dependent on post-processing to convey the intended atmospheres. Furthermore, the investigations helped to position the integration of local weather data within the design process and address the notion of locally specific data in design. However, the design experiment did not incorporate the thermal capacities of dry stonewalls due to a lacking of locally collected data. In subsequent stages of the research the aim would be to incorporate photometric analysis of physical scaled models and test other available tools for examining atmospheres, and thermal capacities of the design.

Combined, these tools made it possible to concurrently examine and understand how poetic and abstract ideas can be correlated with real-world information. Therefore, a contribution of the exploration is to encourage reconsideration of how existing tools of analysis and simulation are used beyond their common applications in architectural design processes, rethinking and utilizing specific engineering and computational software as explorative design tools.

This investigation aimed to test a self-tailored process that examines how existing processes and methods can be reframed and rethought for designing architectural envelopes. This could be developed further to guide architectural practices, while incorporating wider mappings on relations between various concepts, types, and possible assessment tools. The research seeks to expand the envelope concepts and taxonomy by framing their interrelations and dependencies. Further investigations attempt to define the character of the threshold by investigating different envelope types' atmospheric potentials and design factors that determine the local integration of various types of envelopes.

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