



Redefining contemporary housing spaces through architectural transformation

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Abstract

Today, the need for designing appropriate housing spaces becomes a fundamental aspect of architecture. To ensure the operation of these spaces and their sustainability, an architectural approach is needed. Transformable architecture, which encompasses designs that can be transformed according to different functions and used for many purposes, is the architectural approach for enhancing housing spaces that might adapt with the ongoing process of changing needs. Hence, architects are challenged to create innovative spaces to satisfy the needs of all users. Therefore, the main aim of this research is to explore the role of transformable architecture in redefining contemporary housing spaces in respect to the various needs of users in different psychological, environmental and economic contexts. To achieve this aim, this research employs a scientific methodology starting by reviewing the literature that provides knowledge about transformable architecture and its implementation in contemporary housing spaces; then analyzing four selected international case studies: Suitcase house in China, Safe house in Poland, Living Room House in Germany, and Sharifi-ha House in Iran and comparing them. These facts serve as the foundation for the authors' argument that transformable architecture is a good stand point for suitable design strategies to improve the functionality of housing spaces and to respond to diverse users' needs. A set of recommendations regarding the application of this architectural approach are drawn as guidelines in designing contemporary housing spaces.

Keywords: Transformable architecture, redefinition of contemporary housing spaces.

1. Introduction

In the current interchangeable conditions, human needs are changing quite quickly. Creating an environment that provides users with opportunities to extend their knowledge and satisfaction is one of the essential responsibilities of architects in this ever-changing world. Therefore, architects have a significant role in designing spaces that guarantee a mutual interaction between the users and their environments. As a result, this gives rise to a brand-new type of architecture which goes above and beyond the simple task of giving its users shelter to provide an interactive space in which they can control and redesign their environment in accordance with their continuously changing expectations, behaviors, and ambitions. One of the most recent trends in architecture is transformable architecture, which becomes a key factor for a more innovative and dynamic interaction between people and their spaces. Regardless of the transformation model being used, this approach offers options that enhance the building's economic, aesthetically pleasing, functional, and environmental properties. In order to more effectively adapt to the users' ambitions and needs, the concept of transformation might reinvent the identity of today's architecture.

The fast pace of life encourages the adoption of adaptive spaces that change to accommodate their occupants' demands. Since houses have a significant role in determining a person's personality and quality of life, it makes sense that it begins there. This indicates that there is a high demand for transformable housing spaces that can adapt to different functions and adjust in line with current requirements and needs that are always changing. To meet these changing needs, a new architectural method has been devised. As it seeks to meet these evolving needs, there are questions concerning the effectiveness of this newly developed approach of architecture in improving living environments.

This research investigates the significance of transformable architecture in the design of contemporary housing spaces. It starts by examining the concept and purpose of transformable architecture, as well as its modes and mechanisms of movements. It also explores the principles and the key influences of transformable architecture in contemporary housing spaces, shedding light on the psychological meanings of house as a basic residential space. The next step is to select several transformable projects that serve as case studies. The following criteria were taken into consideration when choosing these reference projects: numerous projects from different regions of the world, various transformational approaches, varying contexts and purposes of the projects, as well as the accessibility of data for the selected case studies. They are analyzed in accordance with the following four specific parameters deduced from the theoretical section: purpose of transformation, key influences of transformation, transformation model, and principles of movement. Finally, a comparison is made followed by a discussion. The findings are supported by a list of recommendations that serve as design guidelines for assisting architects to create adaptable contemporary houses.

2. Literature review

The concept of architectural design of houses can be complex; Individuals has always looked for environments that meet their needs over the course of time, but in housing projects, it is crucial to create spaces that preserve each person's privacy. Other times, the necessity to employ extra spaces arises from a temporary change in the purpose of areas like guest rooms, which are rarely used in daily routine. Flexible spaces with blurred boundaries that alter based on the identified current demand are therefore recommended. Modern architectural approaches are looking for ways to meet these evolving needs, which invites debate of the role of transformable architecture in optimizing the layout of housing spaces.

2.1. Concept of transformable architecture

The word transformation can be defined as coming into a form different from the original one or occupying a new position [1]. Transformation is the process of applying change to something, in the appearance, form, function, or characteristics. Depending on the purpose, it may make a small or significant change.

Transformable architecture is defined “as buildings - in a fixed place - that can change its form, configuration and properties, for a need or a purpose. Its applications are varied from moving the roof structure, building spaces, façade components, interior components and furnishing equipment” [2].

The progress made during the architectural design process should satisfy the users' expectations and needs. The more these issues are taken into consideration, the more effective and optimal the architecture that is created. This can be accomplished using the innovative architectural model of transformability. A transformable building can involve its user before, during and after the design process. Therefore, a redefinition of architectural spaces is possible even after construction. Extendibility, multi-functionality, transportability, flexibility, environmental control and remote control of architecture, are opportunities that transformable architecture can offer to its users [3]. Architecture goes through the process of evolution in terms of the configuration of spaces, formal arrangement and organization, and most importantly, the types and numbers of metaphors incorporated and how these are interpreted by the users and viewers. Architectural transformation can be categorized into spatial configuration which is a depiction of the social setup of the community; formal configurations which guide towards the prevailing aesthetic values; and metaphors and clues which have more to do with the cultural norms followed by the community [4].

Architects are using dynamic strategies to respond to people's changing needs as a result of the current demand for adaptable environments. The transformable systems became a milestone that not only leads to various proposals of geometric shapes, but also achieved the transportation of spaces and structures from a place to another various times. This can lead to structures with multi-functions that can separate indoor from outdoor spaces, or create instantaneous shelters for certain events [5].



Figure 1: The Sliding House

Source: <https://thelittledesignstall.wordpress.com/2012/02/23/a-sliding-house/>

2.2. Purpose of transformable architecture

Architecture - being the dominant component of the human-built environment - is continuously transforming and evolving in terms of its use of space, form, function, and purpose. Transformation of architecture depends upon a number of factors which affect the evolutionary process, such as natural disasters, technological innovations, advancements in the construction materials and changes in cultural norms and patterns. However, shifts in theoretical paradigms may also culminate in the accelerated process of architectural transformation [6].

Transformable architecture is a suitable strategy for buildings and architectural structures that need to be reconfigured, either by being folded to a compact form for ease of erection and transportation or by changing their geometry and shape, in order to be able to respond to altering functional and aesthetic requirements [3]. Additionally, transformable architecture is a crucial strategy for meeting human needs and spatial constraints. It offers structures that need to be reconfigured, creating dynamic spaces altering various functions for the same space. This creates a responsive interaction with the surrounding environment and ensures the required interaction for the user. The change in form consequently leads to change in function as well, so any modification in the geometry or relation between forms create new spaces. The required environmental conditions of a space can also be achieved through transformable architecture, driving the building to save energy and reduce the active cost [7].

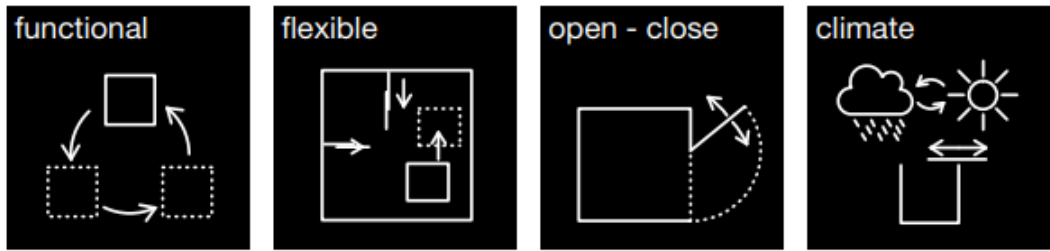


Figure 2: Purpose of transformable architecture

Source: Raphael Reuter, Space-saving techniques by the use of transformable architecture

2.3. Modes of movements in transformable architecture

Buildings move in a variety of ways, but there are only two main ways that they move. First, translation, which is the linear movement on a specific axis with no change in the orientation. Second, rotation, which is the opposite; the orientation of the space around an axis preserving its position. Cases can merge both to have a combination of both translation and rotation at the same time. Of course, that pertains to freedom in the three dimensions as shown in figure 3.



Figure 3: (a) Translation (b) Rotation (c) Combination.

Source: <https://www.news.ucsb.edu/2019/019416/more-just-pretty-fa-ade>

2.4. Mechanisms of movements in transformable architecture

Mechanisms for the movement of elements vary from manual to automatic to machines. It depends on the function and the response of the element, as well as its scale and form, not to forget its type of transformation. The understanding of these mechanisms can insure the use of the appropriate transformation of elements to achieve the purpose behind this transformation as shown in figure 4.



Figure 4: (a) Automatic (b) Human force (c) Ropes and weights.

Source: <https://architizer.com/blog/inspiration/collections/kinetic-buildings-environmental-control/>

2.5. Transformable architecture in contemporary housing spaces

In order to meet their psychological, social, and environmental demands, humans have always had to adapt to changing environments and settings. The actual meaning of a house is revealed by a transformable home, which also introduces the fourth dimension of time, the cornerstone of transformable architecture and the foundation for users' lifecycles. The function of residential housing is directly impacted by the ongoing changes in users' needs and technology innovation. The concept of transformable housing is a response from conventional residential structures to the user's unknowable future aspirations.

2.5.1. The psychology of housing spaces

“Housing is essential for the experience of home. Indeed, this is why the United Nations identifies the need for adequate human shelter – housing – as a fundamental human right” [8].

The house is the first building created by humans, from which all others have evolved. The meaning people associate with a house is "home"; it is an evolving psychological construct based on people's cultures, traditions, and personality traits. Home is not only a physical place where people live, rather, it is a notion produced by the way in which those individuals perceive, interact and engage with these places. By extending their sense of self to include their environments, people frequently try to personalize it. Personalization often reflects self-identity thus the manner in which people expect and decorate their homes reflects their self-images [9].

People build enduring bonds with their homes that evolve over time. Home, then is more than an accommodation (a hotel or a shelter can be that) and something profoundly more than an economic commodity. “Michael Walzer” describes home as “a dense moral culture within which people feel sense of belonging”. Moreover, home is considered as a symbol of self and self-identity. Therefore, “home shapes us and, in turn, is shaped in our image” [10]. Houses become homes when they embody the stories of the people who have made these spaces into places of significance, meaning and memory. Home is first and foremost a place of connection, of relationships that are foundational and life-giving [11].

Psychological resources guide researchers toward many approaches of conceptualizing, understanding, and developing notions of “home.” Research on person-environment relationships includes the study of living spaces. Environmental psychologists have documented qualities that people are exposed in their homes, like noise levels, toxins, emotional climates, crowding (or its absence), and their impact on all aspects of experience, from the personal (biological, cognitive, emotional, behavioral) to the social. Another branch, architectural psychology, focuses on the impact of design to amplify positive or minimize negative impact. Applications range from single person dwellings to community institutions, from a tree house to a hospital [12].

Therefore, environmental psychology, memory and attachment theory, a hierarchy of needs, and identity must be integrated into architects’ and designers’ perspectives on the design of home.

Environmental psychology holds that a person's home environment has a specific meaning that is personal, social, and emotional. Home is frequently associated with place meaning, which refers to a state of mind rather than a physical place. What a place means to someone shapes its meaning which is an important concept relating to the self, others, and surroundings. People's experiences, personalities, interactions with others, and the physical environment, interact to define the meanings that they attribute to places. Place attachment, which refers to a person's attachment to a physical setting, is closely related to place meaning. Individuals develop attachment to places that provide them a sense of freedom and belonging in addition to helping them define or express who they are (their self-images) or who they want to be seen as. Place attachment is an affiliation between a person and a place that develops over time; it is a personal sense of connection that elicits feelings of comfort and security [9].

Environmental psychologists and architects work together to give people a sense of place and to generate a place meaning. Consequently, architects may create the most appropriate design by being aware how individuals perceive their homes. In order to achieve a design that the client will approve, they must first understand the client's personality, lifestyle, interests, preferences, familial structure, and cultural identity. They can anticipate and satisfy their clients' home preferences by leveraging their personal factors and the housing attributes. Residential satisfaction involves multiple contributing factors that include cultural identification, personality, values, expectations, and aspirations; social influences relating to

independence, security, privacy, neighbors and psychological attributes of the physical residence [9].

It is worth noting that throughout the COVID-19 pandemic, people all across the world developed new forms of interest in homes. They sought housing opportunities that would provide them more interior space and access to the outdoors. The Maslow hierarchy of needs comes to mind when examining what those who moved during the pandemic were seeking: greater focus on addressing survival needs for food, shelter, hygiene, safety, work and replacing inadequate social systems with external sources of spiritual and cultural nourishment. Many people concentrated on their current homes, what they might potentially provide, and what maintenance they needed, rather than looking for other living arrangements like a different home [12].

The concept of home is shaped over the centuries, considered the best model that illustrates changes in the architectural design. It effectively illustrates the differences in lifestyle, social development and the altered habitation. Social changes, acceptance and openness increase the experimental projects and innovative housing models. Due to a number of variables, including increased user and designer awareness, the need for multipurpose and universal solutions in smaller apartments and condensing public spaces, there is certain advancement in the design of housing spaces in a more flexible approach [13]. It is essential to note that the occupants want their homes distinctive and different from others, therefore the architects who had to develop multiple homes in the same region had to come up with diverse ideas. The demand of the clients that their personalities be reflected supports the architect's aim for architectural plasticity [14].

According to a report from ATTOM Data Solutions (2019), people face shortages of affordable housing, home prices are rising and housing choices are being impacted by climate change. As more communities seek to house residents in more interconnected and less oil-dependent settings, many experts believe that future homes will be smaller, denser, and elevated. Shrinking residential space doesn't mean that our homes have to be reduced to "machines for living," as 20th-century Swiss-French modernist architect "Le Corbusier" promoted. In fact, if the solution to the housing crisis is to build smaller and denser, it's more vital than ever to design living spaces in ways that enhance emotional comfort happiness and well-being, as science has consistently proven. Fortunately, we can make decisions that are intended to do that. Taking a creative approach to housing has benefits for everyone, whether it's personalizing our own home or supporting affordable development in our community, taking a creative role in housing yields benefits for all. Thankfully, there are current design trends that can make homes more restorative by emulating the natural environments where humans evolved to thrive [15].

Adaptability of the housing space took the form of its transformability in a short time, taking into account the fourth dimension of space - time. The openness of architecture is manifested in the possibility of dividing and joining spaces depending on functional needs, using dividing and protective surfaces and transformable elements of equipment. The concept of transformability in housing spaces is one that many architects and inhabitants themselves take up in an effort to add value by making it more variable and flexible [13].

2.5.2. Principles of transformable architecture in contemporary housing spaces

Residential structures dominate other types of spaces with a changeable spatio-physical structure, according to an analysis of the evolution and application of transformation principles in architectural design from the beginning of the 20th century to the present. The study of transformable houses establishes architectural design principles as strategies applied on the inner plan or exterior membrane, as solutions for the various and quickly varying functions in housing spaces. In the recent decades, and due to the migration as well as natural disasters, flexible units were introduced. The 20th century emerged new technologies, which later became more complex and advanced leading to the transformable houses of the 21st century [16].

The implementation of transformation principles in the architectural design of contemporary houses enables the establishment of new design strategies and initiates their further development. These principles treat different art forms, but they all have the same conclusion, which is that the transformation principles represent the basis of the transformable architecture [17]. Four basic transformation principles are established in accordance with parameters provided for reference examples of transformable residential architecture: [18]

1. The principle of opening and closing



2. The principle of expanding and contracting



3. The principle of joining and division



4. The principle of pulling in and drawing out



The ongoing change in human needs and technological advancement impacts directly the function of housing spaces. The concept of transformable housing is a reflection of the non-adapting residential units to the users' unknown expectations. The transformation includes the inner spatial plans of the residential housing as well as the exterior membrane. The change in the characteristics of these elements such as orientation or position leads to the physical modification of the house structure. This process includes the period after construction as well, which consequently leads to functional modification as required by the user. Houses became exposed to the exterior, integrated with the surrounding environment. The interior is left exposed for visitors to enter and closed when they leave. Movable walls and opening roofs give the best view and natural conditions. A space is now multifunctional and cheaper due to flexible partition and changing exterior elements as shown in figure 5.



Figure 5: Massive stone walls rotate to bring natural light inside home
 Source: <https://inhabitat.com/massive-stone-walls-rotate-to-bring-natural-light-inside-this-extraordinary-indian-home>

2.6. The key influences of transformable architecture on contemporary houses

A fundamental component of architectural discourse is the incorporation of transformational concepts in the architectural design of contemporary homes. Individuality and singularity of users’ needs and requirements constitute the fundamental issue that must be resolved by adaptive solutions. The transformability concept of housing is related to the social context, technological advancement, economic resources, and spatial spaces required. Noticing that the implementation of new construction techniques and simulation tools is now easier to evaluate and generate models of the changeable elements, expanding the variety of potential solutions [18].

3. Cases studies of transformable contemporary housing spaces

This research adopts qualitative research approach on the basis of collecting reference projects. Four case studies are selected and categorized using the previously given literature review and the subsequent transformation parameters to create an analytical database.

Table 1: Parameters of transformable architecture in contemporary houses


Purpose of transformation	Key influences of transformation	Transformation model	Principles of movement
1. Climate conditions 2. Flexibility 3. Functionality 4. Interaction with context	1.Social aspects 2.Physical spatial context 3.Technological aspects 4.Economic aspects	1. Inner space layout a) Primary b) Secondary 2. The exterior membrane a) With modification b) Without modification	1.Opening and closing 2.Expanding and contracting 3.Joining and dividing 4.Pulling in and drawing out

The following criteria were taken into consideration when choosing the four case studies: projects from the previous decade, transformable homes from different regions of the world, various methods of transformation in each, various contexts and purposes of the projects, as well as the accessibility of detailed information for the selected case studies.

3.1. Case study 1: Suitcase House – Beijing, China (2001)

The house is located in Badaling, close to Beijing, and was finished in 2001. All of the main areas of the house can be seen while seated, including the Great Wall of China. The suitcase house hotel, arranged around the concept of stacked strata and perched above the dips of the Chinese terrain, is the first architectural realization of a long-standing idea of customizable spaces. The designer “Gary Chang” questions the potential for fluidity in livable spaces and multifunctional objects.

Table 2: ID card for Suitcase House, Beijing China

Suitcase House ID card	
	
<p>Figure 6. Suitcase house exterior</p> <p>Source: http://archikey.com/building/read/5535/Suitcase-House/</p>	
Name	Suitcase house
Location	Badaling Highway Exit at Shuiguan, Beijing - China
Building type	Private housing – Hostel
Year	2001
Architect/s	Gary Chang
Area	250 m2
Material	Timber

Structure System	Steel structure supported by and cantilevered out from the concrete base
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a. Analyzing purpose of transformation of Suitcase house

Maximum flexibility is the main purpose behind the approach of transformation in this house, due to the continuous change in use of the house in general and each space alone specifically. It achieves the main concept behind the project for its dual use of private house and public hostel. The idea of flexibility continues to reach the exterior cladding, with opens and close according to the surrounding environment. In addition to the large sliding partition along the north-south axe that allows benefiting from the sun’s exposure [19].

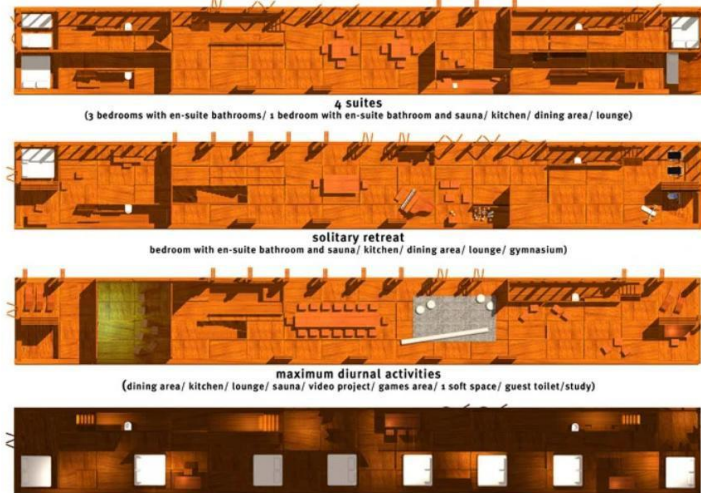


Figure 7: Flexibility in program of Suitcase house.

Source: <https://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/>

b. Analyzing key influences of transformation of Suitcase house

The social aspect highly influences the development of transformability in this project, taking into consideration that it can absorb fourteen users at a time. It deals with unfamiliar users as guests, and familiar users with different needs. In addition to the spatio-physical context, first with the outer context when the exterior façade is opened to the physical surrounding, and second with the inner context as planes of the floor open to create more flexible spaces to use [7].



Figure 8: (a) Meeting room, (b) kitchen, (c) Relaxation/bedrooms inside Suitcase house
 Source: <http://thesuitcasehouse.blogspot.com/2010/03/blog-post.html> (photos by: Mariana, 2010)

c. Analyzing the transformation models of Suitcase house

A primary transformation of the inner space layout takes place. First by the flexible surfaces opened from the floor, second by the disposition of large movable partitions. A secondary transformation of the interior furniture is also applied at some furniture are replaced by others according to the current use of the space. Also, the exterior membrane is transformed without modification in structure's dimensions, that is the opening and closing of the vertical wooden screens according to the needed environment [20].

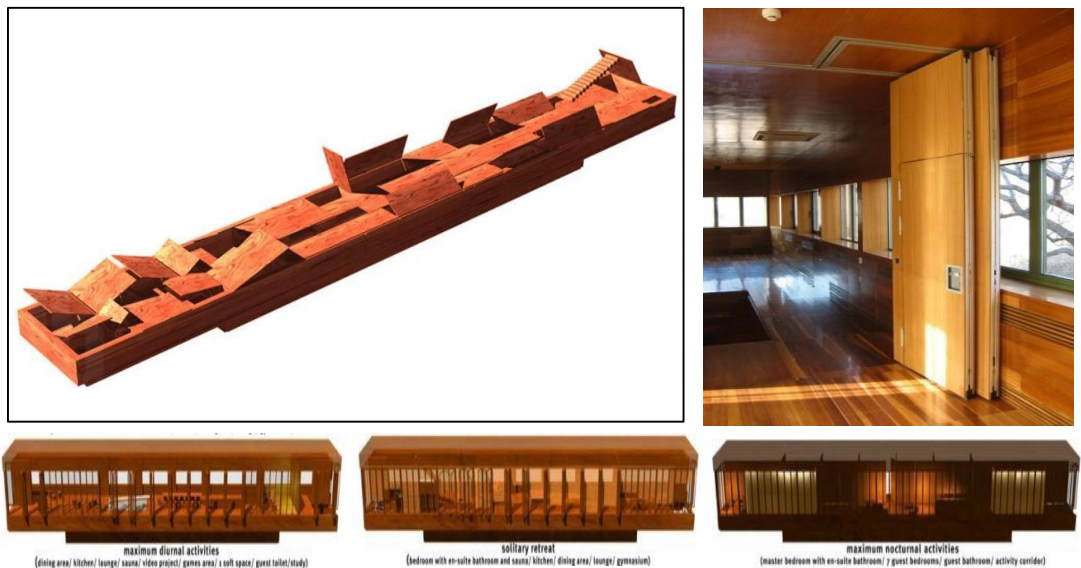


Figure 9: (a) Hidden rooms beneath flexible surfaces, (b) Large transportable partitions, (c) Different scenarios of exterior vertical screens.

Source: <https://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides->

d. Analyzing the principles of movement of Suitcase house

The main transformable element behind the concept of this project is multitask plans opening and closing out of the wooden floor. This movement clearly identifies when the space is in use or not and allow its contact with other spaces. Another type of movement can be observed in the exterior façade, which is the joining and dividing of the vertical wooden screens.

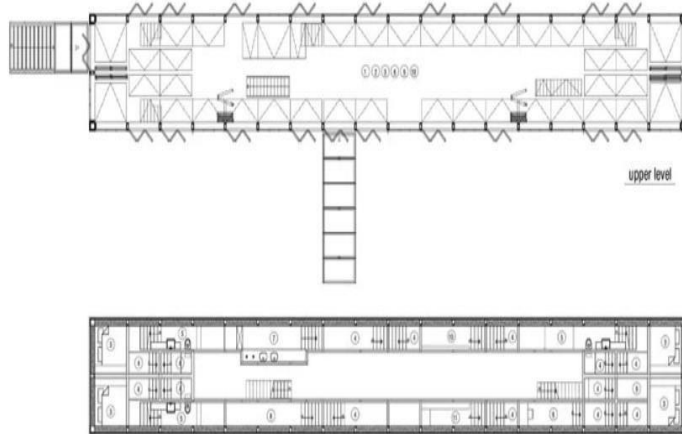



Figure 10: Floor plans showing the opening of floor surfaces, and division and joining of exterior vertical screens.

Source: <https://www.designboom.com/architecture/suitcase-house-by-gary-chang-hides-program-beneath-ground/>

e. Conclusion of case study 1: Suitcase house – Beijing, China (2001)

Case study	Purpose of transformation	Key influences of transformation	Transformation models	Principles of movement
	1. Climate conditions 2. Flexibility 3. Functionality 4. Interaction with context	1. Social aspects 2. Physical spatial context 3. Technological aspects 4. Economic aspects	1. Inner space layout a) Primary b) Secondary 2. The exterior membrane a) With modification b) Without modification	1. Opening and closing 2. Expanding and contacting 3. Joining and dividing 4. Pulling in and drawing out


In accordance with the international standards guiding the use of transformable architecture, this project is attaining flexibility as purpose of transformation, social aspects, physical spatial context and economic aspects as key influences of transformation, primary and secondary inner

space layout with no modification in the exterior membrane as models of transformation, opening and closing as well joining and dividing as principles of movement.

3.2. Case study 2: Living Room House – Gelnhausen, Germany (2005)

In order to maximize their small amount of living space, a German architect couple in Gelnhausen, close to Frankfurt, has developed a unique concept. They converted a listed building, and one of the rooms can be instantly transformed into a balcony. In a medieval town center's historic texture, Living Room creates a timeless statement. The residence blurs the lines between inside and out, public and private, and other conventional divisions. Viewers outside can gaze inside and see what they would often anticipate to see outside: a rocky environment. Above are suspended private areas.

Table 3: ID card for Living Room House - Gelnhausen, Germany

Living Room House ID card	
	
<p>Figure 11: Living room house exterior. Source: https://miesarch.com/work/2183 (photo by: Quirin Leppert)</p>	
Name	Living Room House
Location	no.15 Kuhgasse, Gelnhausen - Germany
Building type	Single house
Year	2005
Architect/s	Gabriela Seifert and Goetz Stoeckmann
Area	20 m2
Material	Powder-coated-aluminum skin

Structure System	Concrete and stone
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a. Analyzing purpose of transformation of Living Room House

The primary factor to implement transformation in the project's spaces was the climate conditions. When the weather is favorable, the major transformable space, the living room, is pulled out so that it can be exposed to sunlight. This approach transforms the project into a much more sustainable house, where the rooms gain heat in the winter and save a good amount of energy. In bad weather conditions, such as rain and cold or high wind pressure, the living room is closed and protected in the interior.



Figure 12: (a) Exterior and (b) interior shots showing features of sustainability in Living room house

Source: <https://www.trendir.com/unique-urban-living-room-house-1/>

b. Analyzing key influences of transformation of Living Room House

Located in a historical area, the project had to respect the context with explains its form and volume. However, the transformation applied Influences the immediate physical surroundings, especially when the living room is drawn out. The transformation is also affected by technical technological aspects as it is connected to a series of sensors controlling its elements according to the weather condition, which gives the user guidance as to control the opening and closing of the living room's elements [21].



Figure 13: Perspective view showing the respectful Living room house with its surrounding historical context

Source: <https://www.designboom.com/architecture/living-room-by-formalhaut/>

c. Analyzing the transformation models of Living Room House

A primary transformation in the interior space layout of the house is applied. That is through the disposition of the whole space of the living room, due to the translation of the interior partition elements, which are the main walls of this space, as they are pulled to the exterior. This consequently affects the transformation of the exterior wall without a change in the dimensions of structures, only the disposition of it.



Figure 14: (a) Human eye and (b) bird view shots showing translation on interior partitions outside the house

Source: <https://www.designboom.com/architecture/living-room-by-formalhaut/>

d. Analyzing the principles of movement of Living Room House

As a drawer, the living room expands to reach the outside environment and interacts with the interior spaces. This transformation is based on steel structural elements that allow the living room to slide in one axe of direction in or out. Thus, this house can draw out one room, which is the living room, out of the envelope but without any roof. The expansion of space, with the help of sensors, is mostly done manually by the user.

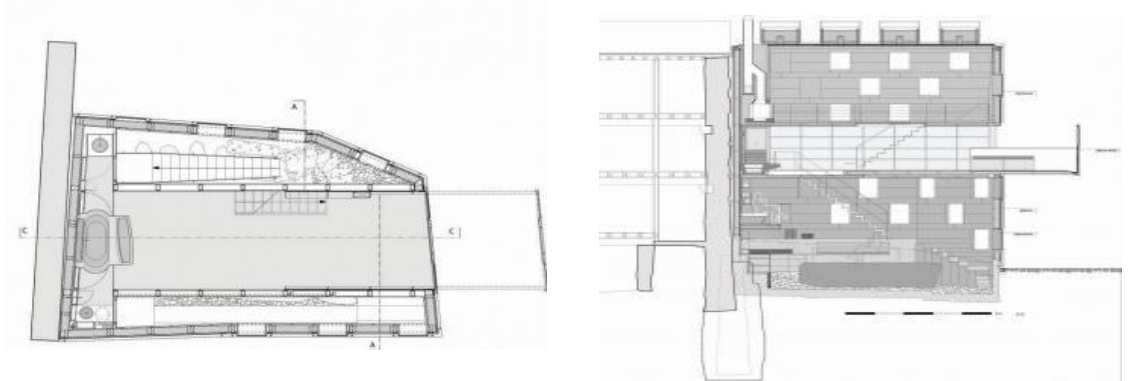



Figure 15: (a) plan and (b) section showing the expansion of the living room as it's pulled out

Source: <https://miesarch.com/work/2183>

e. Conclusion of case study 2: Living room house – Gelnhausen, Germany (2005)


Case study	Purpose of transformation	Key influences of transformation	Transformation models	Principles of movement
	<ol style="list-style-type: none"> 1. Climate conditions 2. Flexibility 3. Functionality 4. Interaction with context 	<ol style="list-style-type: none"> 1. Social aspects 2. Physical spatial context 3. Technological aspects 4. Economic aspects 	<ol style="list-style-type: none"> 1. Inner space layout <ol style="list-style-type: none"> a) Primary b) Secondary 2. The exterior membrane <ol style="list-style-type: none"> a) With modification b) Without modification 	<ol style="list-style-type: none"> 1. Opening and closing 2. Expanding and contracting 3. Joining and dividing 4. Pulling in and drawing out

In accordance with the international standards guiding the use of transformable architecture, this project is attaining climate as purpose of transformation, social aspects, physical spatial context and technological aspects as key influences of transformation, primary inner space layout with no modification in the exterior membrane as models of transformation, expanding and contracting as well pulling in and drawing out as principles of movement.

3.3. Case study 3: Safe house - Warsaw, Poland (2009)

Designed by the Polish architectural firm KWK Promes, it is situated in the village of Okrzeszyn, a short distance from Warsaw. This monolithic, urban bunker that can change its outward shape to suit any security requirements. To further emphasize its unwavering commitment to home protection, the completed structure was even given the name "Safe House." Despite appearing monolithic from the outside, the Safe House is actually extremely organic since it can adapt its design and functionality to fit any given situation.

Table 4: ID card for Safe House - Warsaw, Poland

Safe House ID card	
	
<p>Figure 16: Safe house exterior Source: https://www.kwkpromes.pl/en/safe-house/2248 (by KWK Promes)</p>	
Name	Safe house
Location	Warsaw, Poland
Building type	Single family bunker
Year	2009
Architect/s	Robert Konieczny
Area	2500 m2
Material	Concrete
Structure System	Concrete and light steel structure

a. Analyzing purpose of transformation of Safe house

This single family house was designed to act as a bunker to provide maximum security against any kind of threat from climate change to wars, or even apocalypse. The first glance a person can visualize is a solid concrete steel block from the outside that is until the transformable elements of the house start to move. So other than its transformation in contact with the climatic conditions, the house itself tells guests whether they are welcomed or not, whether the house is closed against the context or interacts with it [22].



Figure 17: Conceptual and architecture plans showing the different between open and closed house in transformation of safe house.

Source: <https://miesarch.com/work/2128> (by KWK Promes)

b. Analyzing key influences of transformation of Safe house

The user's needs in such a house can vary drastically according to the conditions of the context. Once users have complete security, they can open all the elements to socialize with each other and interact with their surroundings. Furthermore, certain elements themselves have many uses depending on the user's need at the moment, such as the rolling gate that becomes a screen for the projector. In cases where the users need maximum security, such as bad climate of wars, the solid concrete block is closed vividly and the house is completely intruded from the surrounding context. It can transform from sealed fortress to inviting home with just a few quick maneuvers [23].



Figure 18: Perspectives showing influence of different scenarios on social and spatial aspect.
 Source: <https://www.businessinsider.com/safe-house-warsaw-2011-5#when-the-walls-and-shutters-retract-the-revealed-structure-looks-more-like-a-modern-home-4>

c. Analyzing the transformation models of Safe house

The transformation in this house is applied on the exterior membrane without modifying any of its actual features. The aluminum gate and the external concrete walls that open are the elements that allow penetration of sunlight. Shutters, along with walls, retract to expose the interior light partitions that are mainly made of glass structures, which reveal the truth behind the black concrete block. The pool which is enclosed inside metal walls possesses a terrace that is accessible from the home after the drawbridge links the two blocks [24].



Figure 19: Transformable exterior elements on elevation in safe house.

Source: <https://www.businessinsider.com/safe-house-warsaw-2011-5#when-the-walls-and-shutters-retract-the-revealed-structure-looks-more-like-a-modern-home-4>

d. Analyzing the principles of movement of Safe house

Movement in this house takes place in every corner by either opening or closing element, or by expanding and contacting with each other. Exterior walls slide to expose doors, swing to reveal windows rotate to transform into bridges, and translate to become fences; even gates roll down to close the house or to watch a movie, and open to transform the space into outdoor area.

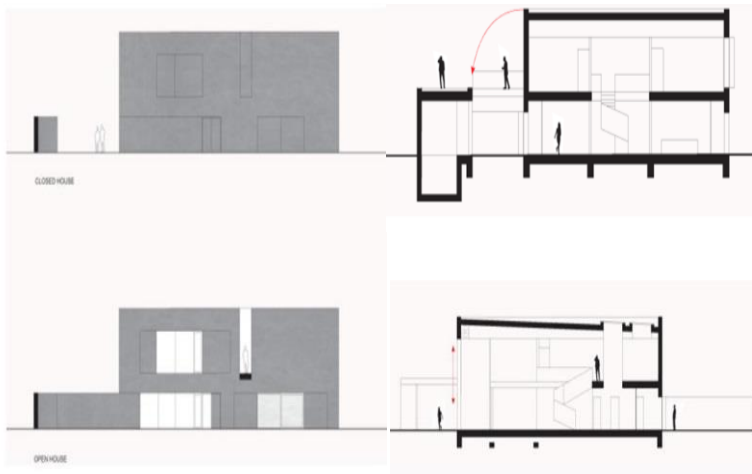



Figure 20: Principles of movement in elevation and sections of safe house.

Source: <https://www.designboom.com/architecture/kwk-promes-safe-house/>

e. Conclusion of case study 3: Safe house – Warsaw, Poland (2009)

Case study	Purpose of transformation	Key influences of transformation	Transformation Models	Principles of movement
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	<ol style="list-style-type: none"> 1. Climate conditions 2. Flexibility 3. Functionality 4. Interaction with context 	<ol style="list-style-type: none"> 1. Social aspects 2. Physical spatial context 3. Technological aspects 4. Economic aspects 	<ol style="list-style-type: none"> 1. Inner space layout <ol style="list-style-type: none"> a) Primary b) Secondary 2. The exterior membrane <ol style="list-style-type: none"> a) With modification b) Without modification 	<ol style="list-style-type: none"> 1. Opening and closing 2. Expanding and contacting 3. Joining and dividing 4. Pulling in and drawing out
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In accordance with the international standards guiding the use of transformable architecture, this project is attaining climate conditions and interaction with context as purpose of transformation, social aspects and physical spatial context as key influences of transformation, no modification in the exterior membrane as models of transformation, opening and closing as well expanding and contacting as principles of movement.

3.4. Case study 4: Sharifi-ha house - Tehran, Iran (2014)

The core ideas behind Sharifi-ha House's design are uncertainty and adaptability. The displacement of turning boxes that cause the building volume to become open or closed, getting introverted or extroverted character, immediately responds to the sensational, spatial aspects of the interiors as well as the formal arrangement of its exterior. These modifications could be brought on by the varying seasons or the practical applications of floor plans.

Table 3.4: ID card for Sharifi-ha House - Tehran, Iran

Sharifi-ha House ID card




Figure 21: Sharifi-ha house exterior.
Source: https://archnet.org/sites/16044/media_contents/117150

(Photo by: Parham Taghioff)	
Name	Sharifi-ha house
Location	Tehran, Iran
Building type	Residential house
Year	2014
Architect/s	Next Office – Alireza Taghaboni
Area	1400 m2
Material	Plaster and wood
Structure System	I beams steel structure

a. Analyzing purpose of transformation of Sharifi-ha house

The transformation of the Sharifi-ha house is a response of the changing functional scenarios of floor plans as well as changing seasons. The rotating boxes transform the building's volume to become open or closed, obtaining an introverted or extroverted character that also refer to the traditional Iranian houses, which contain both summer and winter living rooms.

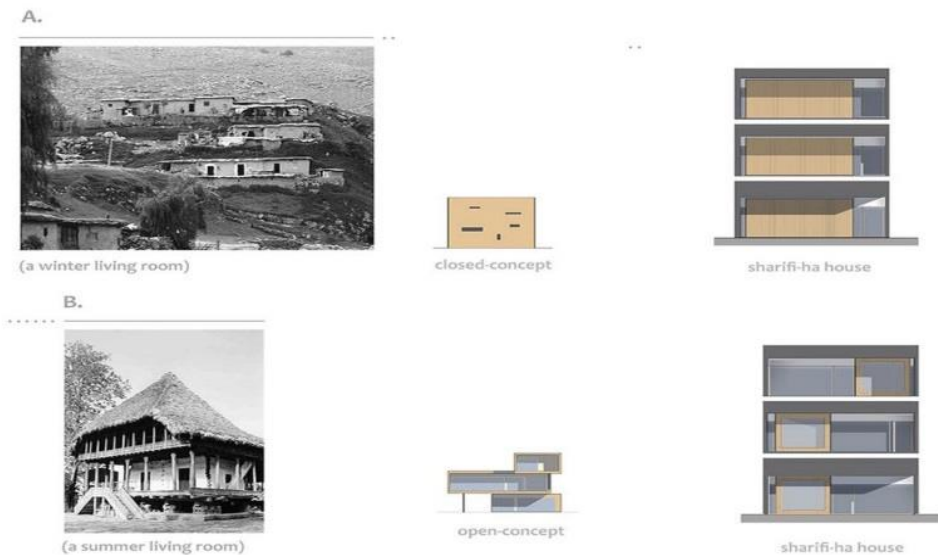


Figure 22: Sharifi-ha house concept inspired by traditional Iranian housing

Source: https://www.archdaily.com/522344/sharifi-ha-house-nextoffice/53b20eeac07a806b4b0001b2-sharifi-ha-house-nextoffice-diagram-1?next_project=no

b. Analyzing key influences of transformation of Sharifi-ha house

The simple rotation of these boxes creates a complex of spatial relationships between the spaces inside the house and with the context, sometimes as introvert and others as extrovert. The user's needs determine how the spaces are changed, such as the transition in the third floor between a kitchen space and library space just by the rotation of one box. This daring concept has triggered some technological aspects both in software for the computation of actual load scenarios, and hardware using the German-fabricated mechanism as used in theatrical scenes.

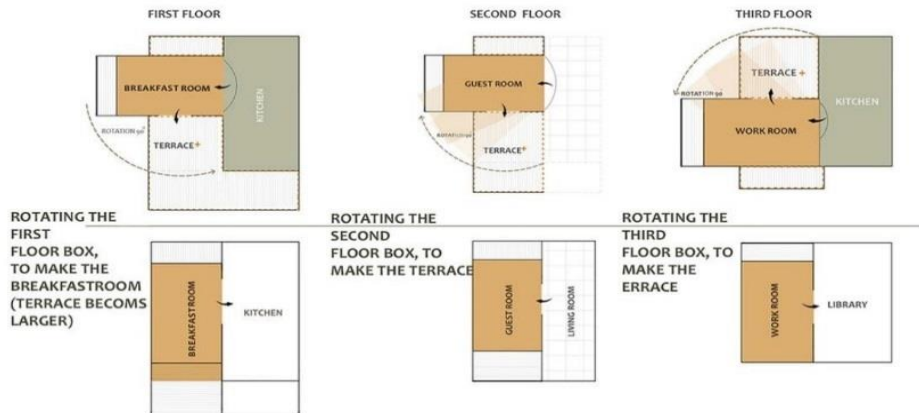


Figure 23: Changing spaces in Sharifi-ha house

Source: <https://www.archdaily.com/522344/sharifi-ha-house-nextoffice/>

[53b20eeac07a806b4b0001b2- sharifi-ha-house-nextoffice-diagram-1?next_project=no](https://www.archdaily.com/522344/sharifi-ha-house-nextoffice/53b20eeac07a806b4b0001b2-sharifi-ha-house-nextoffice-diagram-1?next_project=no)

c. Analyzing the transformation models of Sharifi-ha house

The transformation model can be clearly seen from the exterior as a two dimensional façade is transformed in a three dimensional, which is to compensate the loss in area of façade due to the narrow length of the land plot. This requires that the inner partition must change in position and orientation.

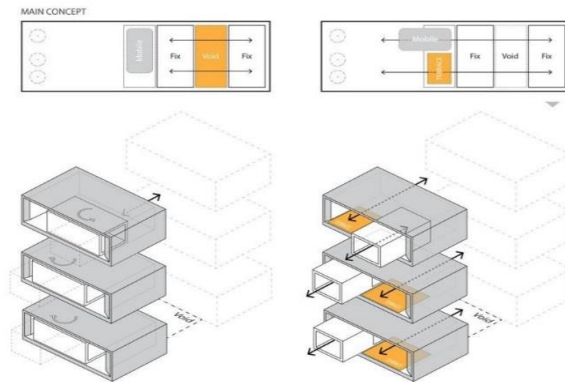


Figure 24: Transformation in interior partitions and exterior membrane

Source: [Sharifi-ha house in Tehran, Iran - next office paper](#)

d. Analyzing the principles of movement of Sharifi-ha house

The axe drawn creates a fixed point which the boxes rotate around, opening and closing according the function needed by the user. This mechanism requires to automatically drawing the box out when in need and the puling it back when the use is done [25].

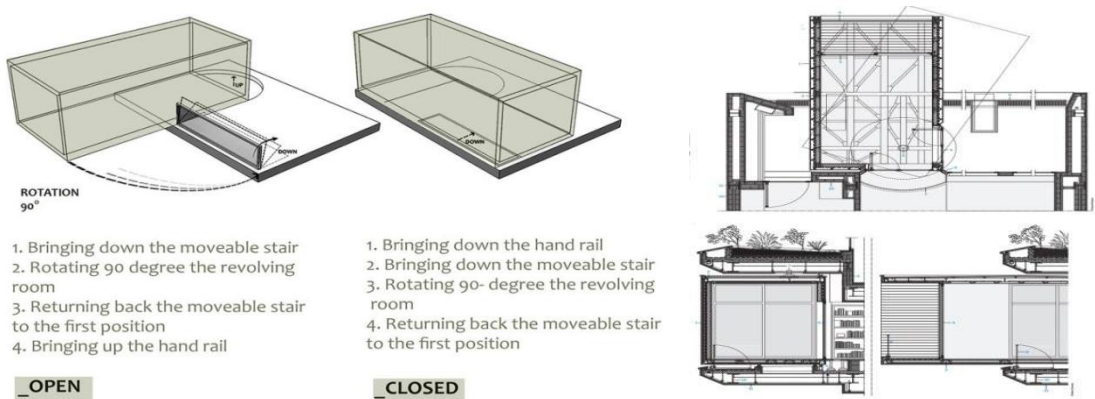



Figure 25: Methods of rotation and detail drawings

Source: [Sharifi-ha house in Tehran, Iran - next office paper](#)
(Diagrams by Parham Taghioff, Salar Motahari)


e. Conclusion of case study 4: Sharifi-ha house - Tehran, Iran (2014)




Case study	Purpose of transformation	Key influences of transformation	Transformation models	Principles of movement
	<ol style="list-style-type: none"> 1. Climate conditions 2. Flexibility 3. Functionality 4. Interaction with context 	<ol style="list-style-type: none"> 1. Social aspects 2. Physical spatial context 3. Technological aspects 4. Economic aspects 	<ol style="list-style-type: none"> 1. Inner space layout <ol style="list-style-type: none"> a) Primary b) Secondary 2. The exterior membrane <ol style="list-style-type: none"> a) With modification b) Without modification 	<ol style="list-style-type: none"> 1. Opening and closing 2. Expanding and contacting 3. Joining and dividing 4. Pulling in and drawing out

In accordance with the international standards guiding the use of transformable architecture, this project is attaining climate conditions and functionality as purpose of transformation, social aspects, physical spatial context and technological aspects as key influences of transformation, primary inner space layout with no modification in the exterior membrane as models of transformation, opening and closing as well pulling in and drawing out as principles of movement.

3.5. Comparison between the four case studies

In order to improve the functional and sustainable use of each project, having its own principles and models of transformation, a comparison is made between the analyzed four case studies, aiming to demonstrate the achieved transformation and its various objectives.

Parameters	Purpose of transformation	Key influences of transformation	Transformation models	Principles of movement
Case study				
Suitcase house- Beijing, China (2001) 	✓ Flexibility	<ol style="list-style-type: none"> ✓ Social aspects ✓ Physical spatial context ✓ Economic aspects 	<ol style="list-style-type: none"> ✓ Inner space layout <ol style="list-style-type: none"> Primary Secondary ✓ The exterior membrane <ol style="list-style-type: none"> Without modification 	<ol style="list-style-type: none"> ✓ Opening and closing ✓ Joining and dividing

<p>Living Room House- Gelnhausen, Germany (2005)</p> 	<ul style="list-style-type: none"> ✓ Climate conditions 	<ul style="list-style-type: none"> ✓ Social aspects ✓ Physical spatial context ✓ Technological aspects 	<ul style="list-style-type: none"> ✓ Inner space layout Primary ✓ The exterior membrane without modification 	<ul style="list-style-type: none"> ✓ Expanding and contacting ✓ Pulling in and drawing out
<p>Safe house - Warsaw. Poland (2009)</p> 	<ul style="list-style-type: none"> ✓ Climate conditions ✓ Interaction with context 	<ul style="list-style-type: none"> ✓ Social aspects ✓ Physical spatial context 	<ul style="list-style-type: none"> ✓ The exterior membrane without modification 	<ul style="list-style-type: none"> ✓ Opening and closing ✓ Expanding and contacting
<p>Sharifi-ha house- Tehran, Iran (2014)</p> 	<ul style="list-style-type: none"> ✓ Climate conditions ✓ Functionality 	<ul style="list-style-type: none"> ✓ Social aspects ✓ Physical spatial context ✓ Technological aspects 	<ul style="list-style-type: none"> ✓ Inner space layout Primary ✓ The exterior membrane with modification 	<ul style="list-style-type: none"> ✓ Opening and closing ✓ Pulling in and drawing out

4. Discussions

This research reveals a dynamic recent approach towards the design of contemporary housing spaces: it explores the importance of transformable architecture in upgrading these spaces. Contemporary houses have undergone transformations to make practical areas more sustainable and adaptable for many occupants with various demands and different needs. Each modern house has its own transformational concepts to fit with the aspirations and needs of its users. This is made clear by the literature review that has been presented and the case studies that have been examined, which demonstrate the significance of this type of architecture distinguished by its simplicity, adaptability, functionality, and aesthetic features. Additionally, the analysis of these reference projects illustrates they are adapted to accommodate the individual needs and preferences of their users, as well as the same space was altered to suit diverse users and various settings. Moreover, it indicates the potential of modifying the space' use and purpose by introducing transformation and changing functionalities. At the same time, it ensures everyone living in this space has autonomy, mobility, satisfaction and individualization. The comparison of the four chosen case studies

clarifies the numerous purposes of transformation such as flexibility, functionality, adaptability with climate conditions and interaction with context. Besides, it assumes the key influences of transformation manifested by social aspects, spatio-physical structures, economic aspects and technological advancements. In addition, it demonstrates the functional implementation of transformation models and principle of movements. Altogether, it constitutes a strong framework to support the objectives of this research and pave the way to design solutions of contemporary houses that take into account the importance of these spaces on both an architectural and psychological level.

5. Conclusion and recommendations

Architecture is becoming more adaptable and versatile in effort to fit into the appropriate setting. Transformable architecture must be understood in order to enable the use of an appropriate architectural transformation model and to achieve the objectives driving its application in housing spaces. According to this research, the concept of transformability may adapt to the changing needs of users and enable them to realize their aspirations through the architectural design process. As a result, it shows how transformable architecture is altering the way architectural characteristics are assigned to housing spaces, since it is a crucial premise for enhancing human satisfaction in their environments.

The researchers would like to provide the following suggestions in light of this:

- Designing innovative spaces that provide users with opportunities to interact and use their environment in flexible and sustainable ways.
- Following the new architectural trends to meet psychological, social, environmental and economic needs of the users in varied contexts.
- Providing appropriate solutions to design issues of contemporary housing spaces.
- Raising awareness of the use of transformable architecture in all types of spaces.

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