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Some assembly required : an architectural systems approach to future requirements

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SOME ASSEMBLY REQUIRED: AN ARCHITECTURAL SYSTEMS APPROACH TO
FUTURE REQUIREMENTS

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A design thesis|project
presented to Ryerson University
in partial fulfillment of the
requirements for the degree of
Master of Architecture

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Master of Architecture 2009

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Abstract

This thesis examines how a building can respond to changes in user needs. Specifically, the research component of this publication seeks to understand how and why buildings change, using primarily a typomorphological based approach to the urban condition. Research methods used in this thesis include literature reviews, case studies, and design experimentation. The design portion of this thesis responds by taking a systems approach to architecture that can be used to deal with user issues of program and form over time. The design proposal utilizes a prefabricated system that is comprised of 5 main elements. Combined, these elements produce multiple design opportunities that allow for future changes through the standardization of fabrication and construction techniques. The system is designed for future modifications through modular structure and elements. This allows for the addition, replacement, and upgrade of rooms, floors, walls, or entire buildings as its user needs change.

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Introduction

There have been many attempts to reinvent buildings, using strategies such as adaptive reuse, mat buildings, and interior flexibility; all of these projects however leave unanswered questions about the nature of a truly adaptable space.

Through the analysis of different communities, architectural projects and writings, and by understanding what the positive and negative aspects are, we can begin to imagine and create design solutions that can better respond to our needs. This is because a city changes over time, and is evident through its people, buildings, and infrastructure. However, the city will also change through a number of other variables that are not always visible or permanent, but rather dynamic and active like financial capital, globalization, politics, and social structures. These variables can be impossible to predict and can have a large impact on a site. These variables create interesting opportunities for architecture because they cannot be specified or prepared for through a traditional static design response.

These suggest that another approach must be taken, one that is adaptive and open to change, is flexible, anticipating changes to site conditions, human needs, and the city. I believe that a systems approach to architecture can be used to deal with user changes in program and form over time.

This brings up questions about how to create a design response that is inherently flexible and open to different variables, how to create architecture that allows for change in both its structure and its program, and how to create an architecture that allows its users to modify their environment needs. Those are the issue that will be addressed within this text and will be looked at through an exploration of a series of related projects, theories, and discussions.

This text is divided into six main sections that include a background chapter which looks at past projects and design options, a theoretical discourse and literature review which looks at proposed projects and present approaches, case studies on a community, past project, and proposed project, a response to research, the design proposal, and a section on its future directions.

Chapter 1: Background

1.1 Urban Conditions

Cities have often been compared to systems and organisms because each of them has many parts that work together to make up the whole. Our culture is an element within those cities that is said to be represented in our architecture, and our architecture is said to represent our culture throughout history. Amos Rapoport describes culture this way:

culture may be said to be about a group of people who have a set of values and beliefs which embody ideals, and are transmitted to members of the group through enculturation. These lead to a world view-the characteristic way of looking at the world and, in the case of design, of shaping the world. The world is shaped by applying rules which lead to systematic and consistent choices... whether in creating a life-style, a building style, a landscape, or a settlement. (Amos Rapoport, 1987, p. 10)

By taking a typomorphological approach to studying how changes have occurred throughout the urban condition, future designs can be integrated into the city and be ready for whatever changes may be required. A typomorphological approach helps us to understand buildings in their historic context, and it works best when there is a base type of building that we can then observe to see the alterations and adaptations that have occurred to this type.

Typomorphological studies reveal the physical and spatial structure of cities. They are typological and morphological because they describe urban form (morphology) based on detail classifications of buildings and open spaces by type (typology). (Moudon, 1994, p.289)

Typomorphological studies require that one think in a larger context, and think about the volumetric spaces that connect with open spaces as well, which relates to the land that then connects the site to the city. And one of the most important concepts within typomorphology is the unit of time, because it is within time that these changes take place.

The Italian Muratorian School's contribution to this field was to build a theory of design based on the traditional processes of city building, but this limits designers to the principles of what has already been achieved. Giulio Carlo Argans defines a first and second moment of design decisions. The first moment of design was called "a posteriori," and was about understanding the rules of designs used in past responses. The second moment of design decision which he calls the "a priori" offers what he says is a more critical approach to design that is about

invention by answering historical and cultural questions. While it is important to take lessons from his first moment, the second, “a priori” allows the designer to interpret the city. The second moment also encourages imaginative thinking when considering future projects, and a rethinking of the relationships that occur within those projects.

Re-imagining and being critical of our urban conditions needs to occur if we are to create a better environment in which to live. The typomorphological approach is a way to look at and analyze existing projects. It can be a useful tool when exploring future forms and how to properly create them to allow for future permutations.

A typomorphology approach is directly related to performative architecture as it is the study of how buildings change. Through the tools of typomorphological analysis we can figure out what changed in certain buildings, and gather evidence about why and how these changes occurred. This data can be useful for the analysis of architectural change over time, and in addition provide a way to apply strategies in the design process.

1.2 Adaptive Reuse

Adaptive reuse projects have shown that a building's primary function can be changed into another, and that these projects can often help to save money, time, and materials in the process. Predominate features that are common to many adaptive reuse projects are repeating structural elements, which help to adapt buildings to new programs easily and efficiently (i.e. warehouses being converted into residential lofts. And while there have been many historic successful cases of adaptive reuse projects like the Hagia Sophia (Church – Mosque – Museum), there is a concern that many of these projects new identities could be lost or even mistranslated in their reading. For example, while you may see a bank or a factory on the exterior, in reality you have a restaurant or a residence in the interior. This begins to raise questions of language and identity within these types of adaptive projects, and how they make their newly acquired space their own.

A notable example of an adaptive reuse project that still has its past identity known in its current permutation is the Musée d'Orsay in Paris by Gae Aulenti. This museum was originally designed and built in 1900 as a train station called the Gare d'Orsay and functioned as the head of the southwestern French railway until 1939, and as a local station afterwards. In 1986 it changed into its current function into the museum it is today. Much of its original form from its original function has remained visible. This is seen in both its large vaulted ceiling that is seen

traditionally in train stations, and the original clock that still exists within the building. While it has changed function, it has done so successfully. Why then is this successful we must ask? What is the characteristic of this building that has allowed it to so easily be modified to its new task? Through observation and study, the open spaces created by the large spans of the building have allowed it to be transferred over so easily. It is a relatively simple structure with large spans, and an open plan that has allowed the curators and architects to modify this building to its current form.

This is because developers have been able to purchase old factory buildings close to downtown cores that have been left because of rising land taxes and more economic options for industry on the outskirts of cities. Alan Berger writes of this in his Drosscapes essay in the *Landscape Urbanism Reader* and attributes this phenomenon of the “decentralization and recentralization caused by urban horizontal expansion (suburban sprawl)” (Alan Berger in Waldheim, 2007). Many of these old factory buildings were built in a very rational sense and their structures were based on a rigid geometric grid that allowed many of these developers to change the nature of the space within these buildings to fulfill their new desires. A local example of this is the Tip Top lofts near Lakeshore Road and Stadium Road in Toronto. This was the old Tip Top Tailor factory that was converted into residential lofts by Architectural Alliance Architects. The architects reused the existing structure to layout the loft spaces in the old section of the building, while adding transfer beams and connecting it to the old structural system for the addition. The repetitive nature of the existing structure of the Tip Top Lofts was what allowed for this relatively easy adaption of structures to happen.

These are but a few examples of adaptive reuse projects, as they come in a wide variety of responses.

Adaptive reuse projects serve as a good example at determining what aspects of a building are desirable for function, form, or programming use. In most cases a prime variable that is sought after when looking for a building with adaptive reuse potential appears to be a simple rigid geometrically based structure, and large spans within the building itself.

1.3 Flexibility

1.3.1 Flexible Architecture in Japan

Flexibility or adaptable architecture has been intrinsic to the architecture of Eastern Cultures (particularly Japan). This can be seen in the way that they organize their homes. The Japanese home has been traditionally built upon a modular system of flexibility, and has used the ken as its building block. This modular system also includes the use of rice mats (tatami), and are based on a 3' (1/2 ken) x 6' (ken) rectangle. The mats are used in an almost grid like fashion to define the interior space within the homes and can be arranged in different patterns to produce a plethora of spacial options depending on its users needs at the time. This system works well because it offers an internal order to the building, and it is based on its structural elements, and thus acts as an interior planning device (Drexler, 1955, p.65-68).

Figure 1.1 - Tatami mat possibilities

Other elements used within the Japanese home are the structural columns, which act as a decorative piece and as its main support system. It is also used in a way so that the facades of

the buildings can be left open and changed, as well as allowing the use of moveable interior partitions (shoji) that can be arranged freely.

The Japanese home offers a model where its structural system used in conjunction with a series of modular elements allows for a multitude of space designs within the building itself. It allows the user to organize the tatami and shoji in different fashions at different times to allow for different space planning as their needs see fit. This style of organization through a modular system that allows for flexibility through its elements could serve as element within performative architecture which in conjunction with other elements could make up a truly flexible system.

1.3.2 Flexibility in modernism

Flexibility is not first word that comes to mind when you say modernism, as these designs tend to be very prescriptive and functional to the design that they were created for. Ellinor DeGory in Jonathan Hill book *Actions of Architecture: Architects and creative users* suggests:

That functionalist theory, which relies heavily on ideas of spatial determinism and demands a passivity and obedience of the user, is in clear contradiction to notions of flexibility which suggest an active if not creative user. (Hill, 2003, pg.31)

However there have been a number of examples that have intentionally or unintentionally been branded. Le Corbusier's Pessac is an example of an unintentional flexibility because of the changes its users have made to it over time. While Pierre Chareau's Maison de Verre, or Gerrit Rietveld's Schroder House projects act as an example of intended interior flexibility within modernism.

Built in 1924, and designed by Gerrit Rietveld's, Schroder House still displays its De Stijl principles within. De Stijl principles are based on simplifying visual compositions to geometric shapes and primary colours, reducing designs to simple abstracts. While the first level of the Schroder House may seem fairly conventional in plan, the second level starts to make you ask questions about its programmatic and functioning relationship. This is because the house uses a series of moveable partitions, panels, and walls in order to separate and create new spaces. The design of the Schroder house required one to interact with the design in order for it to come alive. The sleeping areas could be partitioned off with sliding walls, privacy from the exterior required one to place screens in front of the windows, and the bathroom was created by

opening a wall. Changing the interior relationship of space is a conscious act and requires the user to engage with the home.

The Schroder House can be looked at as an example of how to prepare for freedom of use in a design. In modernism, flexibility is sometimes viewed as its own type of functionalism; looking at flexibility as a means to prepare for a user's future needs. In this way the Schroder House can be used and viewed to understand and prepare for future needs. Its modifiable interior does this by staging the program and not directing it, which allows its users to make their own decisions about how they will activate and ultimately live in the space.

Chapter 2: Theoretical Discourse + Literature Review

2.1 Processes over time

The discourse of Landscape urbanism questions the city form. This has come from frustration about the city's current modernist explanation, plan and form, which landscape urbanists claim has been caused by the failure of all professions including architecture through the designs produced in the modern movement. Theories within landscape urbanism have raised many issues about the practice of design, most notably exploring the notion of designing for processes over time. In their exploration of how to better read and design for the city, they propose to think about the city as a system, in which natural processes within are prepared for and anticipated, rather than ignored. This refers to the multiple variables that are inherent within the urban realm, and is described by James Corner as the idea that "capital accumulation, deregulation, globalization, environmental protection, and so on are much more significant for the shaping of urban relationships than are the spatial forms of urbanism in and of themselves (Waldheim, 2006, p.29)." This suggests that these types of external variables have a strong impact on shaping a site over its lifetime, and that they are often not properly prepared for.

2.2 Performative Spaces

Performative surfaces are those which are able to perform multiple programs in the same space. Because they have no direct programmable definition they are able to house a variety of activities either separately or at the same time. The simplest example of this type of space is an open field. It can be used for a multitude of sports, and leisure activities, yet it is not dedicated to any one of them in particular.

These types of performative spaces have become increasingly popular within the landscape community, and are often seen as a way to address the different processes over time that affect a site. Performative spaces have been presented in recent design competitions such as field operations Fresh Kills Lifescape project that converts the Staten Island landfill into a new public park, and the current Downsview Park proposal by Rem Koolhaas of OMA and Bruce Mau in Toronto. Koolhaas speaks of these spaces in his publication *S, M, L, XL*, as:

not be based on the twin fantasies of order and omnipotence; it will be the staging of uncertainty; it will no longer be concerned with arrangement of more or less permanent objects but with the irrigation of territories with potential; it will no longer aim for stable

configurations but for the creation of enabling fields that accommodate processes that refuse to be crystallized into definitive form; it will no longer be about meticulous definition, ... but about expanding notions, ... it will no longer be obsessed with the city but with the manipulation of infrastructure for endless intensifications and diversifications (Koolhaas, 1999, p.969)

It is hard to tell whether these examples will be successful and embraced by their communities, as they have not been completed. While these projects are exciting, performative spaces have primarily been addressed in designs at a master planning city or park scale, and rarely do they consider how these types of spaces could work at a more architectural level.

The Souks of Beirut competition entry presented by Stan Allen in his publication "Points and Lines" begins to show how an architecture project can address a changing site. Part of the proposal is to implement an architectural solution that would connect the souk through a series of roof modules that would help to create a unity among the elements. The importance of this roof module is that not only does it define the current program of the site, but that it could then expand and encompass future programs within the same architectural language. A question posed by Allen within this text is: "How can one impose a measure of unity while respecting the essential diversity of the city to come (Allen, 1999, p.59)?" This project and statement poses the fundamental question: How can you create something that has an identity of its own, while still allowing it to be changed, and not lose that identity?

Foreign Office Architects speak of identity in their book *Phylogenesis* in relation to mass consumption in our quickly evolving world. Within the text it states that "location and matter are the critical factors in the synthesis of identity (FOA, 2004, p.7)." This is in response to a suggestion that an architect must have a "style" or an identifiable quality within their work. But this statement suggests that this is not the case in their work, and that a design must respond to its environment and the forces acting upon it. But this raises the question of "what if the conditions of the site were to change?" Would the design remain unchanged or would it evolve into something different?

These texts begin to explore how design can interact and respond to the needs of different programs, but they have not addressed this at a smaller scale. My thesis research document will explore and investigate how to formulate and synthesize an architectural design that can better connect to its site and prepare for its yet-to-be-determined needs in order to achieve a more holistic and appropriate response.

2.3 Performative Architecture vs. Functionalism

Functionalism is most easily defined by the much used expression by Louis Sullivan: "form follows function." That is to say that any feature within a building should serve a function for it to be a legitimate part of the design, and those functions should then decide what the form of the building should be. Furthermore, functionalism concerns itself with the efficiency of the program within the building, and any ornamentation whether cultural, iconic, or otherwise would largely be frowned upon.

One of the issues that has arisen because of functionalism is that many functionalist buildings have been found to have a lack of cultural identity. This is particularly evident in the international style of functionalism, where many of the buildings completed in this style look like they can be placed anywhere in the world. This is because they have failed to address the local context of the surrounding area, and have been primarily concerned with the economics of the building, and if designated a skyscraper, have relied on its sheer size and volume to account for its iconic recognition.

In contrast to functionalist architecture, performative architecture requires that the architectural design response is inherently flexible, so that it can respond to its changing context, and its user's needs. It requires that the design to be open to change, both in use, and through its form, so that it can best reflect what is going on within the building, and reflect the people using it. This differs from a functionalist's point of view, in that a performative architectural approach realizes that the functions within a building may change, or want to be changed by its users, and that ornamentation may have intrinsic qualities that are important to the users and is not tied to one particular program.

Imbedded within the definition of Performative architecture is its interaction with its context, creating a relationship within its environment to coexist with its surroundings, natural or otherwise. This is directly related to its users, as they specify the final program of the design, and input their own cultural influences into the form.

2.4 User-Changed Forms

Inherent to performative architecture is the idea of allowing for user-driven program and user-influenced forms. The most notable and recognizable example of user driven forms in North America are housing types typically found in low density residential sectors. That is because this type of structure allows for growth and change by owners who have an invested level of financial interest in it. It is not necessarily seen in a home's initial structure, but as the number of residents or the age of the residents within a home change, their needs may change as well. This then may require that the program areas within the home may change, either through additions or through a redistribution of areas within a house. This is where the user-driven forms really start to appear, and can be studied as a process over time.

User-driven forms bring about questions of programming and what is really needed from it. Creating a program for a socially adaptive architectural project requires that one must be open to new modes of arrangements and is able to rethink the preconceived notion about what a space is, how it works, and what is required of it. Hashim Sharkis describes programming as:

Programming is thus not only a process of receiving already formulated ideas and information; it is an interactive and educational process through which communities of users are empowered to ask questions about what they need, to answer them, and to seek new spatial arrangements that will best suit their already formulated social solutions" (Sharkis, 2001, pg. 82)

Programming for future projects requires an approach for anticipating programs within the designed space itself. By anticipating future programs in the design that need to be created through either expansion or retraction of that space, it allows us to start to synthesize approaches that allow the user to achieve their desired function.

An example of user-driven and changed forms and program is the community of Levittown on Long Island, New York. These changes are easily seen because this community began as a series of mass-produced homes in 1947, using a limited number of house-type variations. As the resident's needs over time have changed, so has the built form (This example is explored in more detail within the case studies section within this thesis). Levittown, credited with being the typological example of the modern North American suburb has changed immensely since its inception. Almost all (but one) of the houses located in Levittown have undergone some sort of change, and the change implemented in each home is unique. Some of the homes have

changed little, with only a small carport or mudroom added, while some have added entire second stories, and mass additions to their rears.

Another example of user-changed forms is in Pessac, France. It is there that Le Corbusier developed a community that has changed because its users have decided to alter it. This was not Corbusier's intention when he had first designed and built Pessac, his goal for this project was to produce low-cost modern style homes that people could live in, and adapt to. He also wanted to create a functional design that took advantage of new technological procedures. However by creating these modular houses he unknowing created a system that its residents changed and adaptive to their needs over time. Philippe Boudon describes the residents' actions as:

Instead of installing themselves in their containers, instead of adapting to them and living in them 'passively', they decided that as far as possible they were going to live 'actively'. In doing so they showed what living in a house really is: an activity. They took what had been offered to them and worked on it, added to it. What did they add? Their needs. They created distinctions..., They introduced personal qualities. They built a differentiated social cluster. (Boudon, 1972, preface)

Figure 2.1 - Le Corbusier, Pessac

Figure 2.2 - Le Corbusier, Pessac

What is it in Le Corbusier's Pessac community that has allowed its residents to take such control over the basic architectural forms, and what is it within his design that has allowed its residents to begin to alter its form? The elements that are common in all of the similar structures are the roof garden, the free plan and the strip window. The roof gardens were installed for aesthetic, economic, and comfort reasons on the cube form, but it is the changes in the free plan and in the strip windows that show where a majority of the differences occur between the structures. All the interior walls of the structures are non-load bearing which allowed the user to easily change and create variations within. The strip windows run from one side of the structure

to the other which allows for multiple combinations of treatments and let the user customize the façade to their own desires.

An issue that has arisen from the North American residential sector is that they have been primarily built in a suburban low-density setting. This has caused problems because they are relatively low density in nature and are a major drain on infrastructural, and environmental resources. This is because of the amount of space required to house these areas, the amount of materials for the homes, as well as the area required for all of the support spaces (shopping, schools, hospitals, etc.), and the required transportation infrastructure associated with these communities as well. The goal of performative architecture in this context is then to implement these user-driven types of structures into a higher density environment, where the infrastructure, can be used to a better level of efficiency.

Understanding user-driven forms are important because they allow us to view our final design response as architecture that is no longer ours. What does this mean for our role as designers then? This means that we need to be better facilitators for change, and create a response that allows the users to better generate their own forms and programs

2.5 Mat Buildings

Theories concerning mat buildings suggest that this type of structure creates an interesting approach to designing flexible buildings and spaces because they are said to accommodate a greater freedom for users to make choices about their own space. Mat buildings also called carpet buildings or field buildings are defined somewhat differently by various authors. At this time there is no specified checklist that indicates what is, and what is not a “mat building” but what is known about mat buildings continues to draw both practitioners and theorists to its inherent qualities of growth and change. For the sake of discussion, this building type is defined as having qualities such as repetitive elements, like modules or columns, and is a rule based organizational principle.

Le Corbusier is not the first person we normally think of when looking at examples of a flexible space, as we often think of him as the architect and urbanist that wanted to take control of the city and prescribe a formal design to it. However towards the later part of his career he admitted that:

"He no longer felt we could be confident about the way men should live in the changing world. He no longer felt he himself knew what 'a town' should be... and that "habitat," understood as the "setting of daily human life," was "clearly an element of living space (Sharkis, 2001, p. 52).

This line of thinking from Le Corbusier becomes even more evident when looking at his proposal for the Venice Hospital in 1964 (this project is explored in more depth in the case study section of this report). This building is often thought of an icon when speaking of mat-buildings, and even though it has many elements of a mat building and has been influenced by its theories, the Venice hospital project still appears to be an extension of a premanufactured building systems approach.

The Venice Hospital proposal is credited with being an iconic example of a mat building, even though Le Corbusier did not design it with that concept in mind. Le Corbusier worked on this proposal with his apprentice Guillermo Jullian de la Fuente, who is thought to have had a large influence on this design because of his involvement with a group of architects called Team X which were proponents of a mat building theory approach.

Team X (Team Ten) was a group of architects that started meeting in the 1950's within CIAM, and later broke away because of differences with the group. A mat buildings approach to design was developed out of their discussions and was built around the idea that a building should be able to grow, or change over its lifespan. A prominent member within Team X. Alison Smithson writes:

"Mat-building can be said to epitomize the anonymous collective; where the functions come to enrich the fabric, and the individual gains new freedoms of action through a new and shuffled order, based on interconnection, close-knit patterns of association, and possibilities for growth, diminution, and change." (Sharkis, 2001, pg. 91)

An example of this is the Berlin Free University, where the campus was designed within a repeating grid system. This system was used to organize the interior and exterior space of the campus, and it can be seen within the buildings and on the campus itself. This infrastructural system allowed for the campus to be able to continue to grow and replicate the existing rhythm as it is expanded.

Figure 2.3 - Free Berlin University

Studying mat buildings helps to understand how a building typology allows for growth within its own organizing principals. Resulting information can be used as a base in which to plan and design performative architecture. Examples such as Free Berlin University demonstrate that with geometric and modular planning a building can be made that is able to expand its structural system to encompass future required programs. However, mat buildings can be limited to their strict modular origins and often can only repeat their inherent geometry. For a mat building approach to work within performative architecture, it would have to break from this limitation and allow for different repetitions and patterns to occur, in order to allow for greater flexibility.

2.6 Mass Customization

Mass customization has not been fully explored in the architectural field despite some advances in other fields. There have been some notable works and studies conducted in this field, but we as architects and designers have not used this notion to its full potential. Commercial mass customization can be easily exemplified in the Starbucks franchise, where products are highly "customized" and catered to the individuals needs and wants. By being able to pick from a multitude of options, both in substance and in detail, users are able to get exactly what they

want. In the work "*Refabricating Architecture*" by Stephen Kieran and James Timberlake they define mass customization as:

a Hybrid. It proposes new processes to build using automated production, but with the ability to differentiate each artifact from those that are fabricated before and after. The ability to differentiate, to distinguish architecture based upon site, use, and desire, is a prerequisite to success that has eluded our predecessors. (Kieran, Timberlake, 2004, p. xii-xiii)

This method is inspired by the Ford model, but unlike Ford, where efficiency was about producing one single element over and over, mass customization requires that many elements are able to be produced at the same time to give choices to the consumer. Allowing construction elements to be produced as a type of "blank" or "slug" that could be transformed to meet a specific requirement; either technical or aesthetic.

Kieran Timberlake's Loblolly house serves as an example of what a mass produced home could be like. A highly engineered construction method that has been broken down into parts in order to increase the efficiency of the assembly and disassembly of the structure. They describe their project as:

The idea of an elemental architecture extends to the method of assembly. The house is composed entirely of off-site fabricated elements and ready-made components, assembled from the platform up in less than six weeks. Specification is no longer conceived and structured about the sixteen divisions of the CSI that organizes thousands of parts that make up even a small house. Instead, the conception and detailing are formed about four new elements of architecture: the scaffold, the cartridge, the block and equipment. (Kieran Timberlake, 2009)

The development of these elements is an exciting and interesting proposal as it begins to break down the construction and fabrication methods. This is important because I believe that part of the issue of why mass customization in the architectural sector has not been achieved is because clients and architects are still approaching prefabricated designs as if it they are the final product, rather than items from a catalogue. For mass customization in architecture to become financially competitive it should not be about supplying a final product to a client, but about creating a product that is available to a client. This is in a response to the lack of standardization in the fabrication and construction approach in the building industry. For a mass customizable product to be viable it would need to standardize itself in terms of dimensions and connections, so that different options could be made while remaining the same. Much like LEGO that has hundreds of different pieces, the majority of them all follow a certain ratio, and all

pieces have either a male or female connection. In this way mass customization in the construction industry can become mainstream.

Mass Customization could become an integral link within a design response by allowing the users to order their own items to create their own spaces. This would require that performative architecture allow for a system (that may be structural) that allows for its parts to be interchangeable.

Mass Customization could become an integral link within performative architecture, by allowing the users to order their own items to create their own spaces. This would require that performative architecture allow for a system (that may be structural) that allows for its parts to be interchangeable.

Chapter 3: Case Studies

3.1 Case Study: Venice Hospital (never completed)

Proposed location: Venice, Italy

Client: The City of Venice

Architect(s): Le Corbusier + Jullian de la Fuente

Design Phases:	Phase 1 (Plans)	1964
	Phase 2 (Rapport)	1965
	Phase 3 (Site plan + detail plan)	1966

Introduction

Le Corbusier and Guillermo Jullian de la Fuente's Venice Hospital is a project that was never completed even though it has had many years of design history behind it. It has become a project that has inspired many people to think about the relationships between city and building, as well as programming and building. The Venice hospital has been seen as a project which shows the possibility of a mat-building like approach, and is usually at the centre of discussion when explaining mat buildings.

The programmatic organization of the Venice Hospital project had the main level as being primarily for the general public, the second level for the staff of the hospital, and the third level was for the patients. The hospital was organized so that the corridors and the courtyards in the hospital extended to connect with the alleyways, walkways, and courtyards of the city at large, which lead to how it was to be organized horizontally. These levels are then linked together vertically through a series of circulation cores and ramps, as well as the building's "*campielli*" (little square/plaza) which allow two or more of the layers of program to be connected to one another.

3.1.2 Venice Hospital Drawings

Figure 3.1 - First project – Level 1

An important aspect of the Venice Hospital project is that its form is developed from a series of networks that are related to its surrounding external forces rather than its inner programmatic spaces. This allows it to grow in increments related to the city rather than in increments related to an internal module. This works particularly well for this project as its horizontal growth is directed toward the open water and does not have to compete with surrounding building infrastructures.

Level 1 of the building was meant to extend the public space of the city and encourage the public to interact with the building by extending the main roadways and alleys. All of the main public spaces for the hospital were placed on this level, acting as the transition level between the city and the rest of the structure.

Figure 3.2 - First project – Level 2a acts as a transition and buffer area to the higher staff and more serious hospitalization areas. The second level's primary function is to act as the preventative care level.

Figure 3.3 - First Project - Level 2b acts as a circulation level to connect level 2 and 3 through a series of ramps and corridors. It also serves as the service level of the hospital, which primarily deals with sanitation issues.

Figure 3.4 - First Project - Level 3- acts as the patient ward of the building

Figure 3.5 - First Project - Level 3 – Modules In the third level Le Corbusier used a set of three different modules when composing the layout. He used these modules by arranging them as he deemed appropriate to create different variations within the structure, much like how tatami mats work in the Japanese home. By placing the different modules together, there sometimes existed a blank or leftover space. It is within these leftover spaces that the outdoor and corridor functions are created within the building. These 3 elements are the main organizing principles for the building, and are what help it to be able to grow. This is because the edges or façades of the structure are left with connections, and through the implementation of additional modules the structure would be open to growth and change.

Figure 3 - Modules

Figure 4 - Project 3 - Sections + Elevations

Venice Hospital Conclusions

The Venice Hospital is an example of a building that is able to grow and expand with the city in a horizontal format. However when it comes to flexibility of the program and space, each area was designed to be program specific and did not allow for changes to their function over any period of time. If changes were to be made to the hospitals function, a serious reconsideration of the use of space would need to happen, and any change to the repeating form of the design would require a reconstruction of the design that would function with the vertical and repeating system or a demolition of the building.

What is important to note about this project is its use of a system that allows for the growth that the Venice project displays. It was able to do this through its modular repeating system that allowed for additional program spaces to be added as needed. The system introduced in this project is too rigid in its design that only allows for the prescribed functions to take place. But by taken this approach and introducing variations in generation to the system, it could be possible to have a design that is more responsive and less susceptible to a single outcome

3.2 Case Study: Levitt Town Suburb

Location: Levitt Town, New York (Long Island), Nassau County

Construction Date: Built Between 1947 – 1951

Built By: Levitt & Sons, Inc

Population: 51,899

Total area of community: 17.8 km²

Estimated median household income in 2007: \$87,200

Density: 2981/km²

3.2.1 Introduction

Levittown was one of the first mass-produced suburbs and is widely regarded as the birthplace for the archetype of postwar suburbs throughout the United States of America. It started out as a small development but because of demand and affordability, approximately 17,000 homes were eventually built in the community. It was originally targeted towards returning GI's after World War II, but it also included families and others in its demographics. What started as a community of small mass-produced homes soon became a master plan with a number of variations upon the original house.

The community was also designed to include small supportive spaces spaced across the town called "greens." These "greens" were small strips for stores and small recreation areas including delis, dry cleaners, hardware, stores, and even community pools. But as time and the main arterial roads have changed in Levittown, so has the nature of its community. It used to be that the patrons of Levittown would have to commute to nearby Hempstead to get their larger goods, but Levittown has been invaded by big box and chain stores, and their smaller, mom and pop type of local stores have been reduced to the sideline.

3.2.2 Housing Types

The Cape Cod was the original Levittown house, and is the most abundant housing type in the community. It was a small almost square plan that encompassed two bedrooms, a living room, kitchen, and bathroom. The Cape Cod is easily identifiable by (even after modification) its chimney that is located on the right side of the building.

Figure 5 - Original Cape Cod Plan

(a)

Figure 3.8 - Original Cape Cod Elevation

The "Ranch" design was added to the Levitt's repertoire as well as car ports, garages, and combinations of all of the above. This case study will look at the variations within these housing types and how they have been implemented as well as how they have evolved over the years. The Ranch's easiest identifiable feature (even after modification) is its chimney that is located on the left hand side of the building.

Figure 3.9- Original Ranch Plan

Figure 3.10 - Original Ranch Elevation

3.2.3 Housing Analysis

When looking at the different permutations that have occurred to the Cape Cod and Ranch style houses, one cannot help but be fascinated in how many different outcomes have developed from the same starting point. It is a challenge to determine what decisions were made in each particular circumstance.

These additive diagrams are the result of a typomorphological approach. The diagrams first indicate the buildings original form, and then identify the elements that have been added, and end by showing its current form. This study was done in an effort to identify elements added to the houses, and to investigate how mass produced structures can be changed over time.

Cape Cod House Permittations

(A)

+

=

This cape has been only slightly modified with the addition of a car port.

Figure 3.11 – Cape Cod House modifications

Cape Cod House Permutations

Figure 6 - Cape Cod House modifications

Cape Cod House Permutations

Figure 3.13 - Cape Cod House modifications

Ranch House Permutations

+

+

=

Figure 3.14 - Ranch House modifications

Ranch House Permutations

+

+

=

Figure 3.15 - Ranch House modifications

+

+

=

Figure 3.16 - Ranch House modifications

3.2.4 Conclusions

The lessons that can be learned from Levittown focus on the factors related to the growth of the homes themselves. Each home in essence was a single module that was able to expand and grow over time. Each home was able to do this because of its surroundings, enabling expandability and allowing buildings to learn. It is important to note that their users also changed (either by moving, or through age, or a change in the number of family members), which forced their users to expand the homes to better suit their needs. In addition these homes became an investment to their inhabitants, and in response their invested emotional interest in the form allowed them to invest in its expansion and improvements. Changes in technology also had an impact on the homes in Levittown and as technologies changed over the years, so did the internal and external workings in the homes for better or for worse.

Chapter 4: Response

4.1 Research Conclusions

A performative type of architecture is not necessarily new, but is a combination of ideas that have come from successful parts of projects both real and proposed. In the next chapter of this thesis I will explore an architecture that is flexible in its program, space, and form. It will be a design that looks at a modifiable modular designs that may take their cues from mass customization, as well it will have to explore a structure that will allow for this modular input, but is still open to modifications so it does not necessarily have to stay static. The response will also use some of the principals invoked through adaptive reuse, in that it will be prepared for future changes, and make it easier to be modified rather than being forced into something that it does not want to become. It will continue to explore what performative architecture can be.

4.1 Design Goals

The design stage of this thesis this study will explore a response that is flexible in its program, space, and form.

It will look at modifiable modular elements that may take their cues from mass customization, and will explore how to enable this input.

The response will use principals implemented in adaptive reuse projects so that it can anticipate future changes.

The structure must make sure that it is open to modifications that allows for a variety of permutations and additions. In this way the building will be flexible, easily modified, and adapted.

Chapter 5: Design Response

5.1 Initial Diagrams

As part of the initial research presentation I developed a series of diagrams to study and understand how buildings change. They looked at adaptive or flexible interiors, adaptive reuse projects, mat buildings, and modular designs. At this time I also created a diagram of what I wanted to create; I called this a performative architecture. The design response was imagined to have a starting point, but was able to change and rearrange itself in both its form and program. It was imagined romantically, able to be everything, yet nothing at the same time. It was from these initial diagrams that I began to define my design response.

ONE WAY LINEAR.

TWO WAY

TWO WAY ADDITIVE.

INTERIOR RECONFIGURATION

Adaptive. → feature repositioned partitions or are changeable to user/occupant
- Japanese house
Shneider house.

Mat Buildings

Transformable/Changeable.

→ modular design.
(adding/removing)
can change form,
open/close,
rotate.

Adaptive Reuse.

PERFORMATIVE

Figure 5.1 - How buildings change diagrams

5.2 Process Images

The design process started as an investigation into module configurations, which took cues from Le Corbusier's Venice hospital project. However, as time progressed, I found that the modules were becoming too rigid and could limit the number of formal opportunities. This led into a study of grid permutations and how they affected formal arrangements. This study also led to the integration of component type inserts, and eventually influenced the final design response.

Figure 5.2 - Process Images

5.3 Systems Approach

The design response utilizes a prefabricated system that is comprised of 5 main elements. These elements include a primary structural system, a slug wall system, a spanning slug system, a sealing unit system, and a partition and storage unit system. Combined, these elements produce multiple design opportunities that allow for future changes through the standardization of fabrication and construction techniques. The system is designed for future modifications by allowing changes to its modular and structural elements. This allows for additions, alterations, and upgrades to any part of the design to change its program or form as required by its users.

5.4 Primary Structural System

The primary structure for the system consists of 3 main elements. A standard wide flange for horizontal spanning, A modified HSS column as the main support structure, and a connection piece that allows for the insertion of additional elements and the expansion of the system.

Once constructed, the structural system allows for the insertion of the panel and spanning systems through connection points. It also works as a utilidor to house and deliver the systems electrical, water, and waste water systems. This allows for the wall and spanning panel slugs to be inserted easily into the system and be instantly energized.

The system has opportunities for different foundation options depending on the situation. It can be placed on new site using a concrete pile system, or place on top of an existing structure through the use of a transfer floor assembly. This is made possible though the systems connector piece because it is used as transitional receptacle for the expansion of the system through a standardized connection.

Figure 5.3 - Main Structural Elements

Figure 5.4 - Main Structural Elements Combined

Figure 5.6 - Pile Foundation Detail

Figure 5.5 - Column Section

5.5 Panel Slug System

The panels come in 3 standardize sizes of 3.6m, 4.8m, and 6.0m, all 3.6m tall. Their dimensions are based on metric building standards in order to increase efficiency in the manufacturing process. This will increase the efficiency in which the panels are fabricated by minimizing associated labour costs, and by reducing the waste created as a by-product of these dimensions.

Each panel has built-in electrical and wet wall options that connect to the primary structural system. Panels also have the option for built in magic packs, radiant heat, and exhaust options. The panels are made to connect to the primary structural system through connection points along the panel which attach to points along the column.

Exterior and interior panel options are available with different R values, as well as fire resistant panels for unit separations. Panels are viewed as templates for the designer to be used as an open source element of the system so that designers can create new options.

Figure 5.11 - Wall Slug Perspectives

5.6 Spanning Slug System

The floor and ceiling components utilize a stressed skin panel system (s.s.p.s.) as its primary structural spanning element. Its dimensions are based on metric building standards to reduce waste in both its construction and manufacturing process. Each slug is 1.2m wide and up to 6.0m long, after which it begins to push the spanning limits of the s.s.p.s.. The spanning system integrates built-in electrical systems, radiant heating/cooling systems, and waste water channels to deal with user needs as required. Finishes can be applied to both the top or bottom of the panel system. Hardware can also be installed with the system to allow for integration of storage and partition modules.

The s.s.p.s. can also be used as the base for a roof system that can accommodate either a traditional flat roof system or sloped roof (with insert). The spanning slugs can also be modified to allow for different stair systems, interconnected floor openings, or an outdoor patio.

Figure 5.12 - Typical Spanning Slug System Detail

Figure 5.13 - Spanning Slug Dimensions

5.6.1 Spanning System: Stairs

Stairs are treated as another component of the system, and attach directly to a modified spanning system element. This modified spanning element attaches directly to the primary structural system, but differs from a normal spanning element because of the opening that it allows. The stair element uses this opening as its main vertical connection point, and attaches to the lower panel via a floor plate connection. Fastening opportunities for railing options are also included in the elements, and are installed on site.

5.6.2 Spanning System: Roof Slugs

Flat roof units utilize the same s.s.p.s as the spanning system. However as roofs require additional finishes, the system is significantly thicker. This roof system works in conjunction with the sealing units in order to define a parapet, and complete the air, vapour, and thermal breaks. The roof system also incorporates roof drains to deal with any access water that may be accumulated.

The flat roof structure can also be converted into a rooftop patio system that allows for occupation of the roof space. It can also be modified to include different opportunities for skylight option.

With the use of sloped roof connections and a specified insert panel, the system can accommodate sloped roof designs into the system. In this situation the panels should be stacked horizontally to maximize efficiency, and minimize cuts.

the slope of the roof will always be in one direction towards one side, so that waterflow be not interrupted from skylight inserts

Figure 5.18 - Slope Direction

Figure 5.19 - Skylight Axonometric

Figure 5.20 - Sloped Roof Assembly

Figure 5.21 - Sloped Roof Connection Inserts

when more than on flat roof plane is created, a sealing unit is installed to complete barriers, and slope for additional roof structures

Figure 5.22 - Flat Roof Slope Directions

5.7 Sealing Unit System

The sealing units work as a vital element of the system, especially in a cold climate. They are used to complete the panel and spanning systems to deal with air/vapour barrier completion and to deal with thermal break issues. They work by overlapping and completing the thermal and vapour barrier breaks that are created by the separation of the panel and spanning systems.

The sealing units work as finishing caps for the primary structural system, and can come in a variety of different finishes to offer a variety of aesthetic opportunities.

The sealing units also combine with the spanning system to work as a parapet unit to complete a sealed flat roof system, and as a flashing unit to complete a sloped roof system.

Figure 5.23 - Wide Flange and Column Sealing Unit Options

5.8 Partition + Storage System

Storage and partition units are used in conjunction with the panel and spanning system to further divide spaces within the system, as well these modules introduce storage and service elements into the system. These include (but are not limited to): kitchen units, washer/dryer units, multiple dimensioned storage units, wet/mechanical units,, and stair units.

The storage and partition modules work like “ikea” type module units that are assembled together partly on site. These modules use connection pieces to fasten with the panel and spanning systems to place them accordingly, this connection also helps create rigidity in the module and partition structures.

Figure 5.24 - Partition, Stair, and Storage Units

5.9 Permutation Study

Alongside the development of the systems approach to the design proposal, a permutation study visualize possible outcomes. It started with a simple 1 room proposal with a sloped roof, and ended with a tower form. From this initial beginning a series of additions were made to view formal possibilities. This was done by adding either one addition in front or behind the initial structure, and up to 3 levels high. From its beginnings over 167 formal options were created and studied. This helped to show the versatility of the system and just some of the possible outcomes that this strategy would be able to produce.

Figure 5.25 - System Permutations

Figure 5.26 - System Permutations

5.10 Starter House

The starter house is envisioned as being a simple model for the system and is viewed as the first step of a home that would grow with user needs. While smaller units are available this design example shows a small two bedroom unit, where a spare room could be used for a second bedroom or a home office. This design is imagined as having no site and is viewed as being generic. Like the cap cod or ranch homes of Levittown it is a starting point which allows for future opportunities for change.

Figure 5.27 - Starter House: Level 1 Plan

Figure 5.28 - Starter House: Section A

Figure 5.29 - Starter House: Exterior Perspective

Figure 5.30 - Starter House: Interior Perspective

5.11 Starter House + Rental Suite

Future needs of the starter home client would be subject to change. This design demonstrates an option where the user wishes to build a rental unit attached to his home. This proposal requires only a slight modification to the starter home. Fire wall slugs be purchased to create the required fire separation between the units. The existing exterior wall panels would be reused and moved to the new exterior location, and two additional slugs would have to be purchased to finish construction.

Figure 5.31 - Starter House + Rental Suite: Level 1 Plan

Figure Figure 5.32 - Starter House + Rental Suite: Section

Figure 5.33 - Starter House + Rental Suite: Exterior Perspective

Figure 5.34 - Starter House + Rental Suite: Interior Perspective

5.12 Starter House + Small Addition

A starter home user has gained more capital and wishes to create a simple modification to the form. They wish the addition of a singular room. For this modification, 2 pile foundations would be set, and the order of two exterior panels and 1 interior wall slug would be required. The existing exterior panel can be reused in the new required location.

Figure 5.35 - Starter House + Small Addition: Level 1 Plan

Figure 5.36 - Starter House + Small Addition: Section A

5.13 Starter House + Second Level

A starter homes family has grown and requires more space. A second level addition has been constructed to deal with changing user needs. This design response takes advantage of the both the flat roof system and the sloped roof system. It also incorporates a rooftop patio, skylight, and stair and storage module unit.

Figure 5.37 - Starter House + Second Level: Level 1 Plan

Figure 5.38 - Starter House + Second Level: Level 2 Plan

Figure 5.39 - Starter House + Second Level: Section A

Figure 5.40 - Starter House + Second Level: Section B

Figure 5.41 - Starter House + Second Level: Exterior Perspective

Figure 5.42 - Starter House + Second Level: Exterior Perspective

Figure 5.43 - Starter House + Second Level: Interior Perspective

Figure 5.44 - Starter House + Second Level: Interior Perspective

5.14 Skinny House

The skinny house is located between two 4 story walkups in downtown Toronto, and takes advantage of the small 14ft laneway created by their separation. This location was chosen due to its constraints, and to show the versatility of the system being implemented into a fairly common urban condition. This project creates a three level 130sq. m. 2 bedroom home, with a large home office, library, upper level living area, and an outdoor patio. The proposal has no parking to promote other means of transportation, but has provided an enclosed entry space for the storage of bicycles, and other equipment.

Figure 5.45 - Skinny House: Site

Figure 5.46 - Skinny House: Site Photos

Figure 5.47 - Skinny House: Level 1 Plan

Figure 5.48 - Skinny House: Level 2 Plan

Figure 5.49 - Skinny House: Level 3 Plan

Figure 5.50 - Skinny House: Section A

Figure 5.51 - Skinny House: Section B

Figure 5.52 - Skinny House: Exterior Perspective

Figure 5.53 - Skinny House: Exterior Perspective

Figure 5.54 - Skinny House: Interior Perspective

Chapter 6: Speculations

6.1 Looking Toward the Future

To be truly viable this system would need the support of investors to create the necessary manufacturing infrastructure.

Cities produce many different situations, requiring different responses. Issues such as building code, zoning, and respecting the urban environment are all factors that may need to be addressed in the design process. That said, the ever-changing program requirements by users also require different responses at different times and locations. The system outlined above can be used in different combinations to be able to deal with these situations accordingly. Dealing with zoning issues the system can be used to create the necessary setback conditions through terracing or by installing a sloped roof system. Building code issues such as limiting distances can be dealt with the choice of panel slug chosen and the percentage of glazing used in said panel.

An interactive software program could be developed to assist designers in interacting with clients to help design their own homes. The program would be set up by laying out the base dimensions from previously or pre designed models to show clients possible options. Once the base dimensions have been set up, the client and designer can then start customizing the design by playing with different panel configurations. In this design process the designer can then organize the response to deal with optimal situations for solar gain, interior day lighting and other situations. It would also be able to determine if panel slugs, spanning slugs, sealing units and modifications to these units would be compatible with each other the software would notify the designer, and be able to provide alternative options for the replacement of the unit.

Possible stages to be involved in the design and construction process would be for a client to set up a design consultation to discuss preliminary design options outlined above. The client would work with the designer to pick and choose from a variety of different aesthetic, technical, and environmental options to create a design that best suited their needs. Once finished, the design order would be sent to a depot for processing, and be coordinated with the construction team for delivery. If the depot does not have the required elements in stock, the depot would order the required pieces from the manufacturer. Anytime after construction, the user / future user can change their design by contacting their design consultant. They would be able to change their buildings form or aesthetics through additional elements, or by upgrading existing components. During this process the user would gain a nominal sum for any components replaced or sent back to the depot. This would be encouraged all situations in an effort to create a more responsible attitude to how we build, and create as much as a cradle to cradle situation as possible.

Design and Supply Chain Diagram

Figure 6.1 - Design and Supply Chain Diagram

Chapter 7: Conclusions

This process started by reflecting on the qualities of a performative space, and how those ideals could be transferred into architecture. A performative architecture would allow for users to make decisions about a site's program and form over a span of time that could change use and form. The architecture would ideally be made with an infrastructure suited to accommodate such changes. This thesis investigated how buildings have change over time and analyzed what was successful or unsuccessful about those processes. The analysis led to the design response which included a systems approach to architecture to deal with user issues involving change to program and form over time. This system is able to create initial design responses, while allowing for future modifications and alterations. By standardizing the system to a limited number of connections and working with metric building standards, it created a system with multiple economic and environmental benefits. These benefits will help to reduce waste and labour costs associated with the manufacturing and construction processes by reducing the overall amount of embodied energy. The systems approach created is a design tool that acts as an imaginary infrastructure across a site, being nothing and anything at the same time.

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