Responsive Housing: Potential & Projected Impact

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ABSTRACT:

Currently, the made-to-last building techniques of American housing are incongruent with personal, family, energy, and technology evolution. Why aren't buildings designed to be flexible enough to respond to the fluctuating cadence of human inhabitance? This paper proposes a new design concept: responsive housing.

Responsive housing is a theoretical building system that can be continuously adjusted at the will of the home's occupants to provide the best living conditions possible. By componentizing the major elements of a home a responsive house can be built in stages, disassembled in stages, reconfigured internally and externally, and completely relocated to a different building site. Akin to providing homeowners with a set of life-sized building blocks, this system makes each home easily customizable. Ongoing occupant-executed customization has the potential to revolutionize the current state of residential building. This paper explains how responsive housing would work and the impact it would have socially, economically, and environmentally.

INTRODUCTION:

Structures are a fundamental part of our society; however, the connotation of rigidity that is associated with buildings evolved throughout history. Although shelters were originally ephemeral - moving and changing as our nomadic ancestors needed – longer lasting dwellings were constructed when societies settled and established communities (Friedman 2002; Kronenburg 2007). The buildings that created the legacy for our current inhabitation practices were the rigid, semi-permanent structures of the past starting with government buildings, banks, and religious facilities (Kronenburg 2007). The legacy excludes the flexible, transitory structures that were present at the same time in history. Eventually more and more landlords mimicked the characteristics of prominent buildings leading to the various regional typologies of today (Brand 1994; Kronenburg 2007). Brick and stone were chosen over timber and animal hides; mortar and nails were used instead of pegs and lashings – buildings became more indestructible, but also more static (Brand 1994; Kronenburg 2007). Unfortunately the easy-to-change nature of ephemeral dwellings gave way when permanent structures were required.

Buildings are not required to be and should not be static in order to be lasting (Brand 1994; Friedman 2002; Leupen 2006; Kronenburg 2007). This paper presents an overview of the potential for buildings to be less static, to become the opposite in fact – responsive.

WHAT ARE RESPONSIVE BUILDINGS?

The Merriam-Webster Dictionary (2012) defines the term "responsive" as *quick to respond or react appropriately*. *Response* implies that an initial action or change occurred. Therefore, responsive buildings are those that appropriately react to change.

What constitutes change?

Change as it relates to human nature and inhabitance is expansive. Change, something that is so integrated into our lives that it is often not noticed, is constant, unpredictable and can take many forms. As our buildings are an extension of us, they are subject to every change that we are; in fact, because buildings often serve more than one person, it is very likely that the climate of change surrounding a building is much more volatile than what the average individual experiences throughout their life. We may think that most of our buildings adequately suit our needs. We may believe that the vast amounts of time and money spent on planning and constructing a new building result in a product that will continue to repay us for generations. And of course we hope that our buildings will stand up to the volatility of Mother Nature. Most likely, we are wrong (Brand 1994).

Buildings are subject to two main types of change – internal and external (Brand 1994, Friedman 2002, Kronenburg 2007). Internal changes focus on the occupants of the building and may include anything from the daily turnover or accumulation of things spurred by changing occupant tastes, opinions and cash flow to the slow fluctuation of family composition as couples unite, children grow and the abilities of seniors diminish. Occupant turnover begins this cycle of change all over again. External changes may involve the immediate environment around a building such as the streetscape or the building site (Kronenburg 2007) or larger external forces such as demographics, cultural attitudes, economic climate, and/or environmental resource availability (Brand 1994, Friedman 2002, Kronenburg 2007, 2008, Leupen 2006).

How can buildings change?

When used as an adjective for buildings, the term responsive could take on several meanings. Past authors have focused on both physical and functional responses and have utilized various synonyms of *responsive* including *learning* (Brand 1994), *changing* (Duffy 1998), *adaptable* (Friedman 2002, 2010), *flexible* (Kronenburg 2007; Schneider, Till 2005), *polyvalent* (Leupen 2006), and *open* (Kendall, Teicher 2000). Physical responses can be described in various ways; material replacement (Brand 1994), interior wall reconfiguration (Friedman 2002), building relocation (Kronenburg 2002), or spatial additions and contractions (Brand 1994, Friedman 2002, Leupen 2006) are all examples. While buildings should be able to physically change

throughout their life, built-in responsiveness can also be achieved if the design and construction methods incorporate areas that have the ability to change function (Brand 1994, Friedman 2002, Kronenburg 2007, Till, Schneider 2005). Functional changes are characterized as happening automatically or with little monetary or physical effort (Brand 1994, Friedman 2002, Kronenburg 2007, Leupen 2006, Schneider, Till 2005). A change in use constitutes a functional change; for example a bedroom might have the ability to change functions to serve as a den.

When should buildings change?

Although flexibility during the design and construction of a building is desired, responsiveness is most important during the extended period after construction is complete (Brand 1994, Friedman 2002, Kronenburg 2007). The occupancy phase is the longest and most volatile; buildings must withstand the test of time, both in durability of materials and in usability (Brand 1994, Leupen 2006). Throughout this lifespan of continuous change, all buildings have constant requirements they must meet. Most notably they must be well built to keep the outside out and inside in (Brand 1994) and they must provide a spatially and aesthetically pleasant environment for occupants to be able to establish a sense of place (Heidegger 1971, Kronenburg 2007). As a building changes it must not lose these characteristics or else it becomes a wholly unsuccessful building (Brand 1994, Kronenburg 2007).

Goals of a responsive house:

In essence, a responsive building is one that is able to physically change or accommodate changing functions as required throughout the lifespan of the building. For this paper the targeted definition of the responsive house is as follows: *an easily adjustable dwelling that transforms based upon the needs of its occupants*. The overall goal of this exploration was to push design and construction techniques to their limits in hopes of devising an interchangeable housing system where homes can be assembled, disassembled, and re-assembled to enable a myriad of options for additions, divisions, spatial reconfigurations and even complete relocation. Therefore responsive housing should achieve four goals:

1. Able to be easily increased in size.
2. Able to be easily decreased in size.
3. Able to be spatially reconfigured both internally and externally.
4. Able to be completely relocated.

RESPONSIVE HOUSING: AN EXAMPLE

Perhaps the most straightforward way to exhibit the capabilities of a responsive housing system is through an example. The accompanying figures (Fig. 1 - Fig 4) and descriptions explain a theoretical narrative of the life of a typical North American family, the changes they experience and how a responsive house can adjust to be continually accommodating.

First imagine a young couple who has dreams of owning their own home. This couple is quite savvy; although they know that one day they want to have children, they decide to buy a smaller, more affordable home that can expand in the future as their spatial needs and bank accounts grow. They purchase a small kit of responsive house components and assemble them to form a one bedroom, one bath home that has a galley kitchen, a small utility room, and a combination living room/dining room (Fig. 1). Upon the arrival of their first child they reposition their bedroom, install a staircase and assemble two new floor plates and a few wall panels to create a living room downstairs and bedroom upstairs (Fig. 2). With the birth of a second child, the couple purchases a half bath and another bedroom and places both upstairs (Fig. 3). The couple also adds a large master bath and an office downstairs (Fig. 3).

Many years have now passed and the family begins to upgrade some parts of their home, first the kitchen, then the upstairs bathroom, making both larger (Fig. 4). But an interesting opportunity occurs during this upgrading process: because this responsive system can be disassembled, the previous kitchen and bath are not taken to a landfill, in fact they can be stored to be used again someday. Additions are traditionally easy, but the ability for disassembly

Figure 1. Initial House

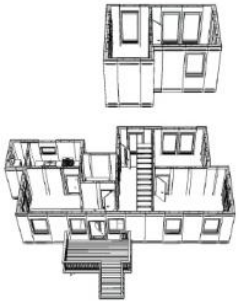

Figure 2. First Expansion

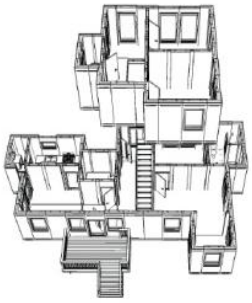

Figure 3. Second Expansion

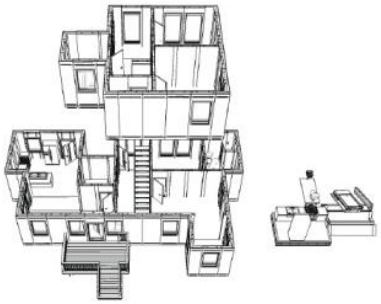

Figure 4. Replacement Phase

and reuse enables the system to achieve the other three goals: division, reconfiguration, and relocation.

Perhaps something monumental happens – a disaster, a population change, or an economic fluctuation creates a housing shortage. Because this family lives in a responsive home, they are able to pare down their dwelling to just what they need – two bedrooms, one bathroom, a kitchen, and a common space (Fig. 5, left). The leftovers include several components – a stair case, a kitchen, three bathrooms, a utility room, and multiple wall and floor panels – that can be reassembled to create a second independent home (Fig. 5, right). The family wants to loan out their extra parts to help satiate the community's need, so they call a trucking company and all of the components are loaded up and taken to help those who don't have homes.

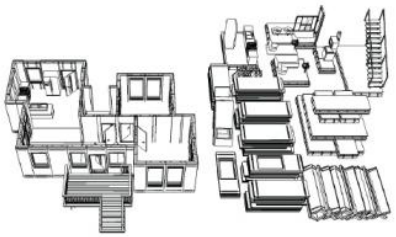

Figure 5. Partially Disassembled

DETAILS OF A RESPONSIVE HOUSING SYSTEM:

How is all of this possible? The four goals are achieved through the use of a 2'-0" design grid, temporary joints, and a separation of building layers. This erector-set mentality allows for initial and continued mass customization. Each house component is explained further below. These components have been grouped utilizing five of Stewart Brand's six shearing layers of change (Brand 1994).

Site:

Helical piers can be installed on gridlines to be used or lie dormant as the home's foot print fluctuates. Helical piers are driven into the ground using a torque motor operated by hand or by a small piece of machinery; small installation equipment allows the opportunity to avoid destroying existing site vegetation for the purpose of creating space for construction activities. If the house is ever to be relocated this foundation type can be completely removed, allowing the site to begin to return to its natural state.

Structure:

Floor plates are designed using light gage steel joists with rigid insulation installed between. These floor plates come in 4'-0" increments ranging from a 4'x4' up to a 16'x16'. The separation of structure from skin allows these components to be used as the first floor, intermediate floors, or the roof of the house. Wall panels are also made from steel studs and

rigid insulation. Each panel is 4'-0" wide by 10'-0" tall. Homeowners would be able to mix solid wall panels with panels that incorporate door and window openings to achieve a satisfactory enclosure both in terms of circulation and daylighting. Again, because of the separation of structure from skin, structural wall panels can be used to form exterior or interior walls.

Services:

The incorporation of a raised floor and dropped ceiling throughout the home provides ample flexible space for service lines to be run, rerouted, and replaced. Outlets can be placed where required through the use of baseboard electrical chases. The system incorporates pods for utility laden areas like the kitchen, bathroom, or mechanical room. These pods come as a room unit with the needed utility lines already installed.

Skin:

The interior and exterior skins of the building are provided by separate panels that attach to the walls. Exterior façade panels have two layers; the cladding material is attached to rigid insulation which upon installation forms a continuous layer around the home. The composition of interior façade panels changes with the desired material – some may need a backing material (hardwood floor panels) while some might just be a single material (finish grade plywood for walls). A library of materials would be provided to be easily selected, installed, and replaced at will.

Space Plan:

As explained above the responsive house system can accommodate whole house size changes (i.e. a change in the footprint of the home), in addition internal, non-structural spatial reconfigurations are also possible. Non-structural wall panels are identical to structural wall panels in everything but their height. These panels are designed to be placed between the raised floor and dropped ceiling systems. The difference in size and placement delineates these non-structural panels from the structural wall panels so the two types are not confused. The sole function of a non-structural wall is to delineate spaces; therefore, panel location can be altered at will.

RESPONSIVE HOUSING: EXAMPLE CONTINUED

Returning to the example, the disaster has passed and life is returning to normal. The components that the family donated are given back to them. But life is not the same so this family decides to assemble their panels in a different way and turn their single family house into a duplex (Fig. 6). As their children move away for school the couple is able to send the upstairs apartment along with them (Fig. 7). At some point the children only visit for special occasions; it is during these occasions that the couple decides to rent panels for a larger living space (Fig. 8). Eventually the couple reaches a point where independent living is no longer an option. There is no need to vacate their original home, they simply pare it down to an accessory dwelling unit to be transported and attached to one of their children's homes or incorporated into a senior living community (Fig.9).

Figure 6. Duplex

Figure 8. Special Occasions

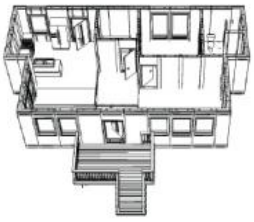

Figure 7. Empty Nest

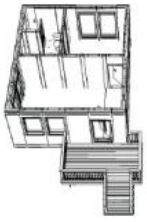

Figure 9. Accessory Dwelling Unit

ENABLED POTENTIAL:

The responsive housing system and the occupant-executed customization that it enables have the potential to revolutionize the current state of residential building. While continued customization might be seen as an attribute that only occupants will value, incorporating responsive houses into our typology enables the housing industry to achieve a more balanced triple bottom line. The triple bottom line, accounting for social, environmental, and economic vitality, can be used to evaluate the potential impact of the responsive house system. The following paragraphs summarize responsive housing's triple bottom line components in three separate scales of analysis: 1, 10, and 100. The 1 scale is singular; it represents a single family or a single house. This section details the relationship between home and occupant in terms of family structure (social), household income (economic), and availability of resources (environmental). The 10 scale represents a neighborhood. This section proposes what social, economic, and environmental opportunities can be achieved by making our neighborhoods more responsive. The 100 scale represents a society. Although societies will vary in size, this section imagines how societies might utilize the increased flexibility that a conglomeration of responsive neighborhoods would provide.

1 Scale:

Many of the social changes that commonly occur in a single household were exhibited in the example above. A responsive house allows families to grow, divide, age and evolve naturally; the home is no longer a hindrance, instead it is a facilitator. One economic advantage of a responsive house stems from the ability for segmented growth. Young families would be able to purchase homes in stages as their funds allow, eventually accumulating the needed or desired number of components to suit their preferences. The opportunity for affordable expansion is a characteristic that could bring buyers into the market earlier. Just as with size, quality of finishes can be procured over time. In conventionally built homes families may choose to replace a linoleum floor with ceramic tile, responsive house occupants have this same option along with the ability to easily upgrade all the other finishes of the house, both interior and exterior, whether the finish is on the floor, wall, ceiling or roof. Unlike a conventionally built home, if household income is ever to wane, responsive house occupants would be able to disassemble parts of their home to sell or trade in for less expensive options. Environmentally, a responsive house would be sensitive to its surroundings from the beginning of construction to the time of complete house disassembly. During construction the manageable sizes of the floor and wall panels require only human power for assembly instead of heavy machinery; without the need for large equipment, building sites would no longer need to be clear cut saving the site's natural vegetation. Throughout the occupation period of a responsive house, less energy is needed because the house can always be sized appropriately. Consuming extra electricity and gas to service a room that is only used one time a year would become a thing of the past. Finally, once there is no longer a need for a house at that location all components, including foundations, can be completely removed to allow the site to begin to return to its natural state.

10 Scale:

For this paper the definition of a responsive neighborhood is a group of homes that contains more than one responsive house. Communities do not need to be made up of only responsive houses to be considered responsive. However, the inclusion of responsive homes in a community would enable ongoing social flexibility. Because of their ability to easily change, responsive homes allow a diversity of people to live in the same area; neighborhoods with multiple responsive houses could easily include an assortment of family compositions, ages, and income levels. Multiple responsive houses assembled in the same area create the opportunity for a new material marketplace to be created. Because house components are interchangeable, this economic venture could provide a medium for neighbors to buy, sell, trade or even share their house components. Responsive neighborhoods would impose less of a burden on our landfills because components can be disassembled and reused instead of demolished and trashed.

100 Scale:

A network of responsive neighborhoods creates a responsive society. Although societies are usually slow to change, responsive societies would have the ability to quickly adjust to unexpected obstacles. Responsive societies would be less devastated when area demographics change; the housing stock could easily be adjusted as populations grow or shrink. When economic swings cause a switch in the job market of an area a responsive society would be poised to offer a medium of exchange as families relocate for work. And if a natural disaster wreaks havoc in an area, a responsive society would be able to rebuild quicker because of the interchangeability of the system.

CONCLUSION:

This paper first explained what *responsive* means as it relates to housing, then outlined the fundamental design and construction details of a proposed responsive system and lastly projected what opportunities would be enabled through the incorporation of responsiveness at three different scales. This paper has shown that responsive housing's potential is vast. Beyond the suggested possibilities outlined in the 1, 10 and 100 sections of this paper, imagine the capabilities if responsiveness is integrated at the 1,000 scale. As a global population, we would be able to react faster to future world problems. Of course globalization has both positive and negative connotations, which is why this paper is not suggesting that all future homes should be built in the manner described. A complete switch of design and construction techniques would lead to the loss of indispensable vernacular building practices. Similarly, a responsive housing system may take different forms, utilizing materials other than what was proposed above. No matter the details of a responsive system, this paper has shown that building technology has advanced to the point that ongoing, occupant-executed customization is possible and has the potential to solve several common social, economic, and environmental problems.

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