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The design of a rural house in Bushbuckridge, South Africa: An Open Building interpretation

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Abstract

This qualitative study argues that ongoing occupant involvement in housing design, construction, and maintenance processes leads to more appropriate buildings that can sustain their usefulness while undergoing change over time to adapt to dynamic user needs. This is demonstrated by the documentation of the design of a house in Bushbuckridge, Mpumalanga, South Africa that uses Open Building (OB) principles so that the house adapts to the changing needs of the family and maintains its intergenerational value.

This project centres on the occupant, not only at the outset with initial consultation but also throughout the lifetime of the project, as the house design is deliberately flexible and aims to allow many authors to participate in its future adaptations. Based on this worldview, we use the following tools: a literature review on OB, an OB analysis of low-cost housing in general, and an analysis of the proposed design project.

We compare low-cost housing projects using four OB principles: 1. how the project involves the occupant's agency to build; 2. how the project separates its elements to facilitate this agency; 3. whether the project focuses on providing a housing product, or a housing process; and 4. how sustainably the delivered structure can accommodate the occupant's current and future needs.

The paper illustrates these OB principles in the design of a low-cost, rural house project in Bushbuckridge to show that they also have value for the architecture at a small scale, and how a house can be designed to ensure that it adapts to the changing needs and creativity of the occupant.

The paper concludes with the implications that OB principles have for the design process. The process no longer consists of a simple sequence that separated design and construction and ends with a housing product. Rather, the design and construction focus on delivering a building process that the occupant can take ownership of, and sustain over the lifetime of the building.

Keywords

Open Building; Architecture; rural house; Bushbuckridge, South Africa;

1. Introduction

South Africans associate mass housing projects with the houses delivered through the post-Apartheid outputs of the 1994 Reconstruction and Development Programme (RDP) (Moolla, Kotze, & Block, 2011). Although these projects aim to house the homeless, they falter at addressing a fundamental divide in society: dignity (they are poor in quality and poorly located) and ownership (title deeds are often delayed and the method of delivery is exclusionary

leading to reduced sense of participation and involvement). Their greatest failure is their design. The houses are too rigid to evolve with the occupant's needs and too poorly constructed to ensure intergenerational value. Low-cost housing projects such as Elemental's Half a good house (Moore, 2016) and Urban Think Tank's Empower Shack (Block, 2017) aim to involve the occupants in the completion of the unit. This goes some way to acknowledge the occupant's agency to build and recognises at least some of the principles of Open Building (OB).

OB principles were developed in response to the rigid, post-war housing developments that could not evolve to meet the changing needs of the occupants and their community. These principles focus on the occupant's agency to build. Central to these principles is separating the building into a long-term, infrastructural portion, and a short-term, flexible portion. If we design houses with sufficient flexibility for the occupant to construct and change them to their future needs, we can sustain their usefulness and reduce the social and environmental impact of demolishing much-needed housing.

To further clarify OB principles, we analyse three low-cost housing developments, each believed to be stepping closer to realising these principles. We then illustrate the use of OB principles in a single-house project for a family in rural Bushbuckridge, Mpumalanga, South Africa and draw relevant implications for the design and construction process in the broader architectural context.

2. Methodology

This qualitative study documents a house design that uses OB principles to centre the current known and future unknown aspirations of the occupant in its design. It considers the house malleable and conceived by many makers, evolving to the changing needs of the users. We use a literature review on OB and low-cost housing projects, an analysis of the project site and its socio-economic context, developing a brief of the current and potential future needs of the family as possible scenarios, and a breakdown of the building elements based on OB.

3. Open Building:

Mass housing in post-war Europe delivered the number of residential units needed but was considered too rigid to evolve with the needs of the occupants. These estates provided a series of typologies: an unmarried person, a small family, or the elderly. Once the occupant's situation changes by getting married or growing old, they had to move out of their current residence into a new type (Habraken, 1972, p. 45). These units also failed to consider changing market demand and lifestyles. Inevitably, as the needs of the occupants and communities changed, the rigidity of these buildings made them too costly for remodelling and developers had to demolish them to make room for new developments that met the new needs. All this is at a great environmental and social cost.

In 1961, John Habraken articulated a set of building principles for mass housing in Dutch in *de Dragers en de Mensen* (1961), which was officially published in English in 1972 under the title *Supports* (1972). His response to these monoliths gave rise to what we now call Open Building (OB) principles. His central argument is that mass housing disrupts the natural relationship between the occupant and their home. Houses should be flexible enough to accommodate the occupant's need to build to meet their current and future needs. Many architects and theorists adopted and further developed these principles. We can summarise four key principles of OB as follows:

1. **The occupant should build their space**. To truly live in a place is to make it. OB affirms the occupant's agency to build and rebuild their dwelling. Habraken points out that we have a natural desire and a natural capacity to build. He advocated for occupants to take ownership of the houses and change them to reflect their individuality and needs. One of our strongest urges of is our desire for possession, a personal environment where we can do as we like (Habraken, 1972, p. 15). Possession is how we take our environment into ourselves and make it part of our identity. It is also how we project our identity on our environments and how we express ourselves through them. It is important that buildings respond to our need to build and rebuild our space. This is not

only true because different people might live in a place over its lifespan, but also because our needs change over the course of our lives.

2. **OB separates building elements into levels depending on their lifespan and the competencies needed to work on each level** (Habraken, 1998, p. 22). We call this process *disentanglement* (Kendall, 2016). Long-term elements form part of the primary level that we construct from durable materials. Short-term elements form part of the secondary level that requires less durability and technical competency. This separation allows different authors with different identities, needs, and economic situations to affect various levels of change throughout the building's life.
3. **The building is a process rather than an end-product.** A building is not a product that the developer delivers to the occupant. We should see the building continually evolve as it engages with new occupants. Rather than trying to predict all potential future forms that might suit its occupants, OB provides the occupant with a building framework. Its focus shifts from providing a house product to providing a process by which a house can emerge and re-emerge (Habraken, 1972). It develops an infrastructure around which it accommodates unpredictable and continuous rebuilding.
4. **OB builds for the present and the future.** OB provides infrastructure that is sufficiently flexible for present and future occupants. It should accommodate the lifestyles of households and the future form of households that occupy it without significant restructuring (Kendall, 1999). Constructing the primary structures with long-term flexibility reduces the need to demolish them when the economic and socio-economic climate of the occupant and community changes.

4. RDP, Half a House, and the Empowerment Shack

In this section, we draw on precedents to discuss the presence or absence of the above OB principles in low-cost housing projects. These projects are typical units delivered through South Africa's RDP housing, Elemental's Half a House, and Urban-Think Tank's Empower Shack. Each of these projects recognises the first OB principle by aiming to accommodate the occupant's building agency at some point or another, typically after constructing of a core structure. They rely on the occupant completing the construction of the house to increase the quality of the houses or serve a greater number of people. As expressed by Elemental in Chile, instead of producing a few complete houses, they build many half-houses.

We will introduce each case study with its context and a short description of the building typology. In terms of the second OB principle, we discuss how each project organises the occupant's territory between a primary (delivered) structure and a secondary structure (occupant's construction) and how their design choices facilitate or limit the occupant's building activity. The third principle focuses on the extent that the occupant is involved in the design process. This involvement contributes to focusing the project on being a housing process that the occupant can take ownership of and sustain versus focusing simply on providing a housing product. For the fourth principle, measuring the sustainability of an OB project lies in how well the delivered structure allows the occupant to develop and redefine their home before it must be adapted or demolished. We will discuss the extent of each project's internal flexibility, the potential for expansion, and the extent to which the occupant can reuse the delivered materials.

5. RDP Housing by the Department of Human Settlement, Braamfischerville, Soweto, South Africa, 1996.

The South African government has implemented the Reconstruction and Development Programme (RDP) since 1994. The programme deals with a matrix of infrastructural projects for human settlement such as water, electricity, sanitation, and housing developments, as well as financial subsidies for housing. For South Africans, the most well-known aspect of the programme is the RDP housing projects that deliver low-cost houses to people. RDP housing aims to bridge the property ownership gap left behind by the dispossession policies of colonialism and Apartheid. Local authorities appoint local contractors through a tendering process to construct the houses. RDP housing

focuses on providing a core structure that the occupant can expand on. The programme has delivered almost four million houses to people in its first twenty years (1994-2014) (Nokulunga, Didi, & Clinton, 2018).

The programme's mandate is to provide as many houses as possible to fill the country's housing shortage. To that end, its design strategy is to provide each household with a minimum structure that is inexpensive and easy to construct.

5.1. Typology

In the case of Braamfischerville, typical of RDP houses elsewhere, the detached houses stand free on a plot of land which allows the occupant to expand their structure as they need, as well as grow crops or raise livestock.

6. Delivered Structure and Occupant Construction

The delivered structure is a one-room house with a sink and an enclosed toilet (Moolla, Kotze, & Block, 2011). There is no clear distinction between long-term and short-term spaces or elements. The project seems to operate on an internal, delivered structure and the surrounding plot for development. Since these projects have had time to develop, we can study how occupants have made use of the project.

Figure 1 is a partial figure-ground of the Braamfischerville project with 62 plots of land (each originally supplied with an RDP house) that indicates the delivered structure on its plot with iterations of attached and detached additions as well as new buildings built in their place. We can see that occupants build onto the delivered structure as well as boundary walls. Most occupants (24) decided to build their additions completely detached from their RDP. Occupants of only 16 RDP houses opted to build their additions attached to their RDP house (this number includes further additions detached from the RDP). In the cases where the occupants built new structures over their RDP house (as 15 occupants had), they do not seem to retain any traces of the delivered structure or its spatial logic. This seems to suggest that they reject, and perhaps demolish, the delivered structure when they can afford to upgrade the house. The remaining 7 occupants had made no additions or alterations to their RDP houses.

Figure 1: Figure-ground of Braamfischerville illustrating occupant construction. By author, 2022.

7. Occupant's Opportunities and Limitations

There is little design or construction guidance for the occupant. The initial/starter unit, its shape and size as well as its placement on the site, does not offer any clues as to how the future additions or expansions could be. They may design and construct whatever spaces they need with whatever means they have available. The above figure-ground illustrates this diversity in the responses by owners and thus diversity in the form of the occupant-built structures. The fact that most built structures are detached from the core units probably implies complexity in connecting the

units either due to the limited skills of the occupants or due to some restrictions posed by the design of the core units and their placement on the sites.

As successful as the RDP projects are in providing houses, there are significant issues with the quality and design of these houses. Although it is important to know that the quality of the houses varies widely inside a community and between communities, the following two studies capture similar findings in two different communities, the first, in Gauteng and the second in the Eastern Cape. In a study evaluating the residents' satisfaction with their homes, 43.5% were dissatisfied with the delivered structure, which the researchers attributed to poor design and contractors attempting to minimise construction costs (Moolla, Kotze, & Block, 2011). Another study conducted in 2012 also revealed that approximately 95% of responding residents use their personal income to maintain the quality of their houses (Zunguzane, Smallwood, & Emuze, 2012). This again points to poor construction that leads to the delivered structures rapidly deteriorating.

Occupants want to build, but they struggle to change these rigid houses and must use their resources to maintain a house that cannot respond to their needs. Instead of being able to rely on the durability of the house, occupants must either build outside the provided structure or, if they have the means, demolish it to build a new house in its place.

8. Occupant Involvement in the Design Process

There are no documented community engagement or participatory processes for housing development. Local authorities construct the houses and allocate them to an occupant afterward. As such, the occupant is not involved in the design process of the delivered structure.

9. Extent of Flexibility

The occupant can use the interior of their delivered house as they see fit. However, the size of the room limits to what extent it can be redefined or subdivided. All the walls that define the envelope are structural. This is the most obvious design problem that limits the occupant from effectively expanding their residential units. For the occupant to expand the house, they require additional support measures to make new openings that connect the original structure to a new addition or risk damaging the existing building. This presents an unnecessary obstacle to occupants. The walls of the RDP house are built of clay or cement bricks that are then plastered and painted. Any changes to the delivered structure would lead to rubble that would be difficult to integrate into new additions, except for filling and levelling the ground to build over.

As we see from the figure-ground above, most occupants built detached units on their plots and many occupants demolished their delivered house to build a new home. The design of the RDP restricts the possible expansion and redefinition of the delivered house. Any expansion onto the delivered house requires adapting it and thus we should consider the RDP house as having a low level of sustainability.

9.1. Half a House by Elemental, Iquique, Chile, 2003.

The project housed one hundred families who have been living on the site in informal structures for thirty years. The budget per unit was $7500 and afforded 30 square metres of living space (Moore, 2016). Elemental's approach was to provide each family with "half a good house" to maximise the impact of the funding and expensive land costs.

Figure 2: Elemental's Iquique development, Chile. Archdaily.com, 2016.

9.2. Typology

The project is a series of attached triple-storey houses. Each house has one completed half and the rest of its space is primed for expansion. The completed half consists of a complete envelope, kitchen, and circulation to the entrance on the first floor. The overall structure of the houses guides the occupant to fill the gap between the houses.

9.3. Delivered Structure and occupant construction

The delivered structure of the house consists of a three-storey block completed with plumbing and electricity. Figure 3 illustrates the separation between the delivered structure (in blue) and where the occupant can expand into or adapt (in orange). The block consists of a cast concrete frame with concrete block infill to establish the envelope along with windows and doors. The concrete block infill allows the occupant to redefine their envelope with more or fewer apertures. The entrance to the unit is on the first floor with the ground floor unfinished. In between the units is a floor on the first storey that functions as a platform for expansion**.**

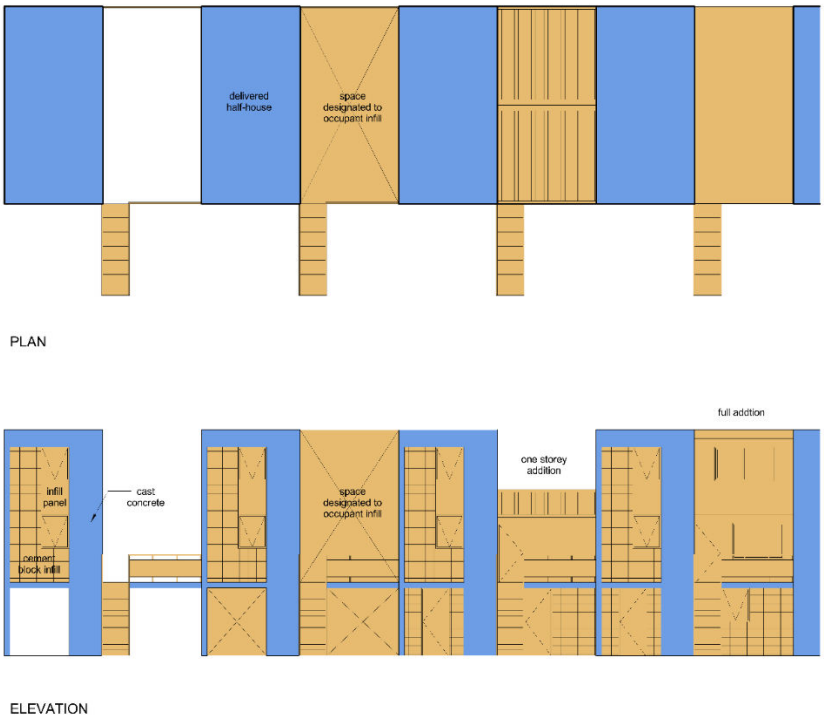

Figure 3: Plan and elevation of Half a House illustrating the delivered structure in blue and the intended additions and adaptations in orange. By author, 2022.

Along with the shared walls between the units, these elements form an indicative envelope and infrastructure that the occupant can fill in to expand their house. The occupant can immediately move into the delivered structure and in time develop the secondary structure as they need.

From Figures 3 and 4, we can see that the secondary structure is completely up to the occupant to design and construct. They may use whatever materials and technologies they have at their disposal. The simple geometry and uniformity of the delivered structure highlight each nuanced addition the occupant makes.

Figure 4: Occupant infill construction at Iquique. Theguardian.com, 2016.

9.4. Occupant Opportunities and Limitations

The configuration of the delivered structure as a triple-storey building affords the units more living space on the expensive land. The void infill space between the units gives the occupant a clear guide on expanding their unit, especially as they can span structural elements between the units.

The triple-storey layout of the units limits the occupant's definition of internal spaces. For example, an elderly person must either climb the stairs to enter the house or move to the isolated ground floor. As much as the delivered structure guides the occupant in constructing the secondary structure, it also functions as a boundary that stops further expansion. This being an urban site allows for the definition of external space and the creation of an urban block that has a strong urban presence. The residential unit becomes a part of a whole configuration, a building block of the city rather than an isolated element on the periphery of the city.

Concerning how flexible the delivered structure is to the occupant's needs, Iquique presents an improvement over RDP housing both in the quality of the construction as well as its guidance on expanding the house. Occupants do not have to break through structural elements to expand their houses. The separation between the delivered and occupant structure is more three-dimensional than with RDP houses. However, when considering the whole house, the delivered structure is contained to one half, relying on the occupant to construct new structural elements to use the infill half.

Elemental's Villa Verde project in Constitución, Chile, addresses the latter concern by including a roof and floor support beams in the incomplete portion of the house. This means that the occupant can simply complete the floor and fill in the envelope to define the spaces they need.

Figure 5: Elemental's Villa Verde project, Chile, with additional infrastructure over the incomplete half of the house. Archdaily, 2016.

10. Occupant involvement in the Design Process

The distinct decision makers in the design of the house create distinct elements in the structure – a separation of levels (Osman, 2022). One group of decision-makers, such as the architects and contractors, deliver the primary structure. The occupant along with local contractors form the second group of decision-makers who design and construct the secondary structure.

Extent of Flexibility

The occupant has the freedom to conceptualise the configuration and use of the interior spaces. The size of the houses makes them flexible for interior subdivision. The 'half a house' approach to the project gives the occupant sizable space to expand into. Placing the entrance to the delivered structure on the side where the occupant would expand, ensures that there is already a connection between the original structure and its additions. However, this connection only exists on the first floor. Should the occupant want to connect the original and new structure on other floors, or simply enlarge the original door-sized connection on the first floor, they must break through the delivered structure. The architect seems to have appreciated this eventuality as they constructed these walls from concrete infill blocks. If properly planned and executed, the occupant can reuse the removed concrete blocks in the additions or elsewhere to limit the construction waste.

Empower Shack by Urban-Think Tank, Khayelitsha, Cape Town, South Africa, 2013.

The Empower Shack aims to develop a methodology for upgrading informal settlement dwellings without the need to displace the residents. The house provides a core building with plumbing, electricity, and other regulatory features like firewalls. These walls help contain the spread of fires in settlements where the building density helps them spread and lead to large-scale devastation. Local NGOs fund the project with each Empower Shack running an average construction cost of R160 000 (Block, 2017). The project is currently in its third phase with talks to include city funding in future phases of the development.

Typology

The housing project aims to upgrade the existing footprint of the densely populated community. It also needs to provide economical means to distribute resources and mitigate the ever-present fire hazards of informal settlements. As such, Urban Think Tank designed the units as double-storey rowhouses that shrink the layout needed for services compared to stand-alone units that are typical for the area. A firewall separates each unit to prevent the spread of fire.

Figure 6: Phase three of Urban Think Tank's Empower Shack prototype in Khayelitsha, South Africa. Dezeen.com, 2017.

Delivered Structure and occupant construction

The Empower Shack delivers an immediately occupiable house to the residents. Thus, the envelope and interior structure is already defined when the occupant arrives. The project allows the occupant flexibility by using soft materials (timber and sheet metal) and construction methods that are established in the community. It takes Half a House's approach with the infill cement blocks further into every element that defines the spaces. Since all the elements are already delivered in the strict sense, Figure 7 illustrates how the project separates the delivered structure into what the occupant would feasibly change (in orange) and the structure that limits change (in blue).

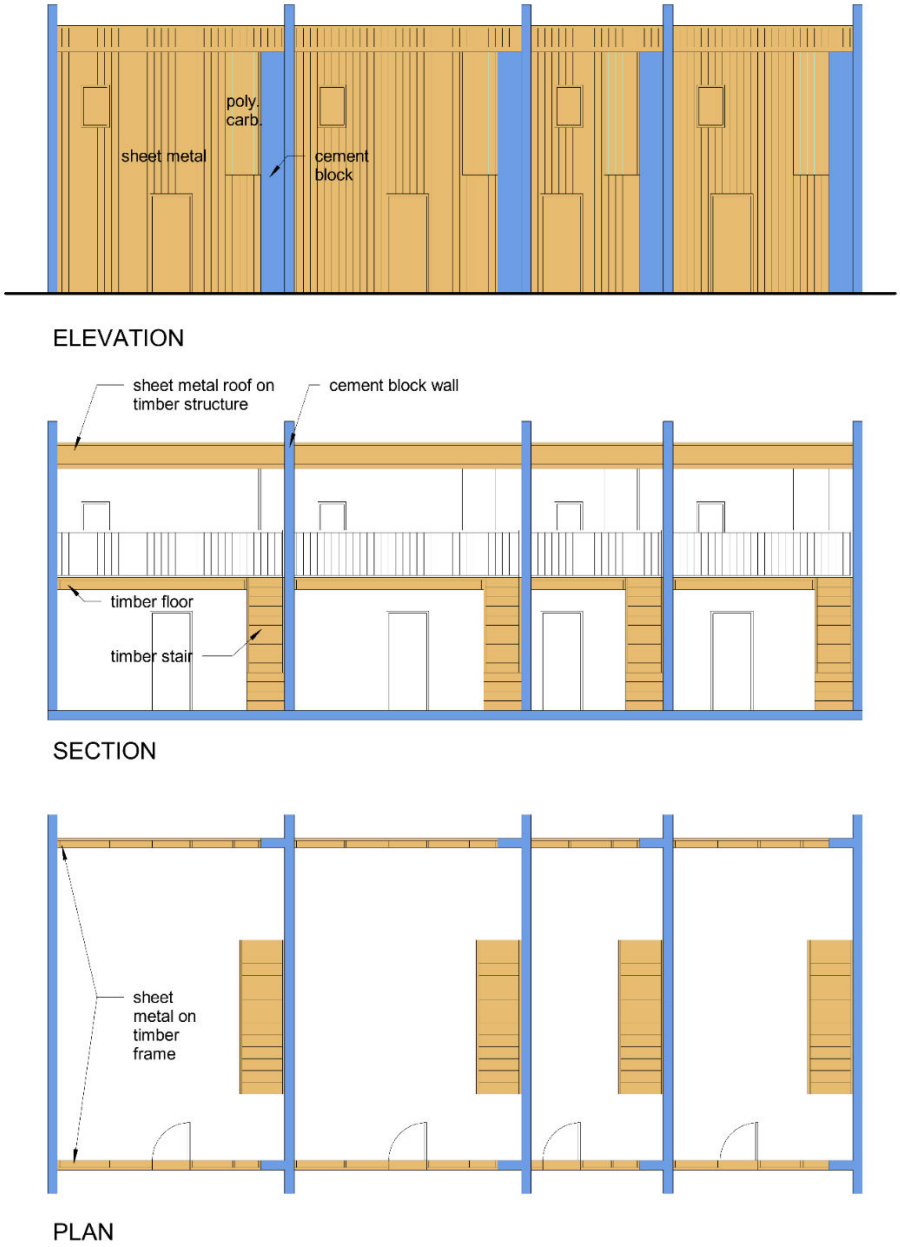

Figure 7: Elevation, section, and plan of the Empower Shack illustrating the hard structure in blue and the softer structure the occupant can readily adapt. By author, 2022.

The delivered structure includes the foundations, the ground floor surfaced, firewalls made from concrete blocks, and the roof. Along with these rigid elements, is also the internal first floor with a staircase made from timber. The construction also includes an initial secondary structure to fill in the envelope. These infill walls are made from a timber frame structure with sheet metal and polycarbonate cladding and include an entrance door and an openable window on the first floor.

The occupant can further develop the interior of the unit with the materials and technologies at their disposal. Timber construction is easier to manipulate compared to concrete or brick structures. Occupants can redefine and build onto the envelope's infill walls.


Figure 8: Ground floor interior of the Empower Shack. Dezeen.com, 2017, Figure 9: First floor interior of Empower Shack. Architizer.com, 2017.

Occupant Opportunities and Limitations

The infill and floor materials are within the construction culture of the area. These material choices make it easier for the occupant to redevelop the interior construction and envelope to suit their needs. The technical performance of the firewalls presents a clear boundary that the occupant should not interfere with, otherwise they would jeopardise its function.

Occupant involvement in the Design Process

The project entered its third phase in 2018 and had gone through extensive prototyping and community engagement process in the form of traditional consultations and computer-based exercises to develop a three-dimensional integration strategy for space, resources, and micro-funding (Low, 2018).

Extent of Flexibility

The Empower shack allows the occupant to redefine the interior and façade of the building to a great extent because of the softness of the material and how these materials are already within the building culture of the community. The Empower Shack does not allow the occupant to expand the footprint of their house, even though the lightweight façade seems to be an obvious route to do so. Expanding outward beyond the protection of the firewalls would risk their function and South Africa's fire safety regulations would not allow it (to the extent local authorities enforce them). Similar to Elemental's approach, this also allows the houses in unison to have an urban presence and street edge. There would be no foreseeable expansion sideways either as the concrete block walls divide the units and their ownership. The softness of the materials and their presence in the building culture ensures that the occupant can reuse the timber and corrugated sheet metal without much effort.

Reflecting on the case studies presented

In RDP housing, the occupant is provided with a core structure on a plot of land. They can build onto the provided structure or freely on their plot. There seems to be no separation in the building spaces or elements. The project is focusses on providing a housing product upon which the occupant can improve. However, occupants seem to struggle with the rigidity of the core structure as most additions are detached from the core structure.

Half a House provides the occupant with one-half of a rowhouse with the infrastructure to fill in the other half. The configuration of the houses gives the occupant clear guidance in expanding their houses. Although the separation seems more three-dimensional, by including the ground floor as an in-fill space, it still separates spaces rather than separating building elements. The project provides a finished product to the occupant that they can then build onto.

The Empower Shack provides a similar row-house approach as Half a House, however, the envelope is fully defined. The project separates building elements by using soft materials (timber and sheet metal) for internal floors and envelope walls. There seems to be greater flexibility for the occupant to redefine the interior spaces and exterior envelope. Through its community workshops, use of local construction culture, and disentangling the building elements, the project seems to provide a building process, rather than a building product. Empower Shack seems to align closest with the identified OB principles.

Towards OB in low-cost housing

Each of these examples gives the occupant agency in building their spaces to a greater or lesser extent. In doing so, they respond to the rigid nature of mass housing projects that are used as emergency measures to house people. When considering the houses themselves, the projects divide the house into a delivered structure that is provided as a product to the occupant and the secondary structure that the occupant defines from scratch or builds into the delivered structure. In OB, the separation of a delivered (primary) structure and an occupant (secondary) structure is more fine-grained than what we have observed from the precedents. The disentanglement is more three-dimensional and separates building elements and services.

Another observation from these low-cost projects is that for buildings to respond to the occupant's agency, the occupant must be able to adapt them with whatever means they have available. In urban, industrialised communities, we have a diverse selection of materials and elements to choose from. We can exercise discretion to ensure their sourcing and production mitigate the building's strain on our environment. As these elements need maintenance or we develop better ones, we have the expertise on hand to fix or upgrade them. In a rural setting, we have a limited selection of building elements and materials. There must be a relationship between the materials and technologies used to construct the primary and secondary levels of the house and the materials and technologies available in the local area. This factor limits the potential use of prefabricated building elements to whatever is already within the local construction culture.

Sustainable building culture in rural OB projects relies on responding to existing building practices and materials. In principle, OB attends first to how we coordinate building elements and is less prescriptive of how we make these elements or how we source them. The occupant needs flexibility in what elements and materials they can use to accommodate varying availability.

Bushbuckridge House, Bushbuckridge, South Africa

Bushbuckridge is an experimental project designed by Amira Osman at the Tshwane University of Technology as part of a Community Engagement Project, that aims to develop low-cost housing at a small-scale using OB principles. Although the project is for a low-cost, standalone house, the family asked that it must steer away from the image of conventional low-cost designs such as RDP housing. The project uses the four OB principles as design strategies. First, it centres the occupant in the design and construction process. Secondly, it disentangles the house at the building element level to increase its flexibility of the house and allow different authors to work on separate elements of the house. This strategy also ensures the house's durability by spending enough resources on important structural elements and services. The third principle ensures that the occupant's involvement in its design and construction provides the occupant with a housing process. The last principle ensures that the occupant can use the flexibility of the house to continually sustain their needs.

Bushbuckridge and Family

Bushbuckridge is a rural community situated in Mpumalanga, South Africa. It is a low-income community where 46% of its citizens are unemployed and nearly half of its population dependent on the government for grant support (Bushbuckridge Local Municipality, 2021, pp. 33-34). Bushbuckridge has distinct developments along its ridges, each with a different socio-economic architecture, ranging from middle-income brick houses, lower-income cement block houses, corrugated metal houses, and traditional houses. The project is situated in a lower-income section of the community. The family requires a house that accommodates all its current members, but it will soon change as some younger members move out. The house must be flexible to allow future changes in the family structure.

Typology

The Bushbuckridge project is a standalone house, like RDP housing developments, except it has only one iteration. It also differs from most OB projects by being a single, standalone house whereas most of OB's principles were developed for large-scale, attached, multi-unit housing. The aim of this design is to ensure that the occupants have a great level of agency in constructing and reconstructing the house.

Delivered Structure and occupant construction

The design employs two levels of competency, the primary and secondary levels, whose design and construction will be dealt with independently. The primary structure (figures 10 and 11) supports the house and supplies its basic infrastructure. An institution funds the primary structure while professionals build it to ensure quality workmanship. The secondary structure is easier for the occupant to construct and manipulate as their needs and economic circumstances change.

The load-bearing structure of the house has the greatest lifespan and requires the greatest technical competency, whereas the envelope and other space-defining elements need shorter lifespans as we can foresee them changing with time (Kendall, 1996). They need less technical competency from the occupant and allow for greater creativity in definition, materiality, and construction.

The building elements in the primary level include the foundations; floors; structural walls – including their doors and windows; the roof; and basic plumbing – such as toilets, basins, and showers; as well as the infrastructure needed to run these facilities, such the solar geysers. The plumbing forms part of the primary level for this project as having it completed to high technical standard benefits the longer lifespan of the house.

The materials in the primary level include concrete for the foundations and floors; cement blocks, plaster, and paint for the walls; timber, sheet metal, and insulation for the roof; as well as building elements like doors and windows. Along with these, services such as plumbing and water reticulation, electricity reticulation, and water heating are also part of the primary structure. These services must be easily accessible yet positioned to not prohibit foreseeable changes in the house.

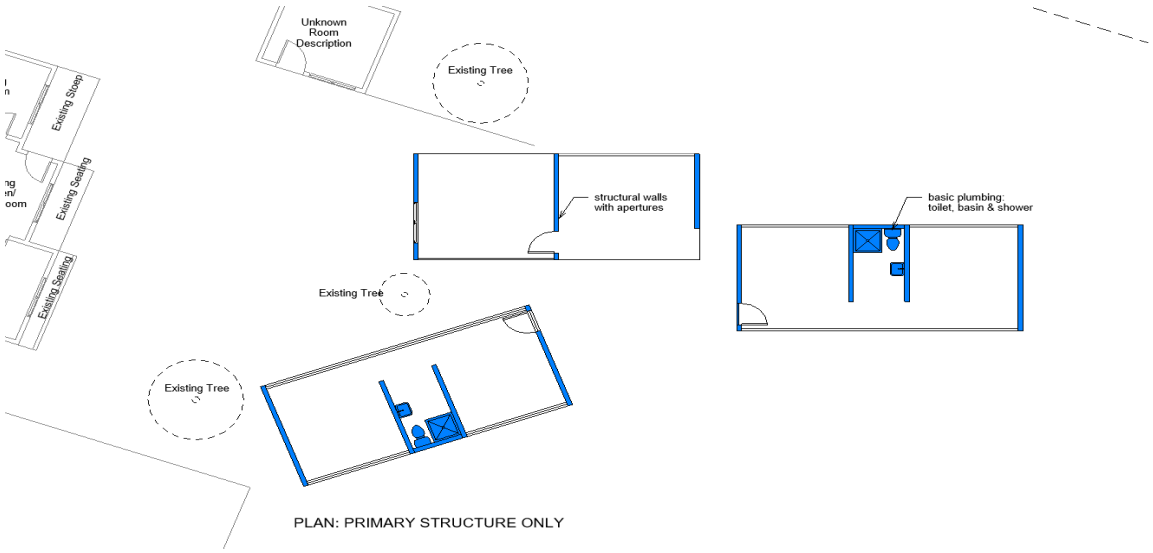

Figure 10: Primary level (blue) completed. By author, 2022.

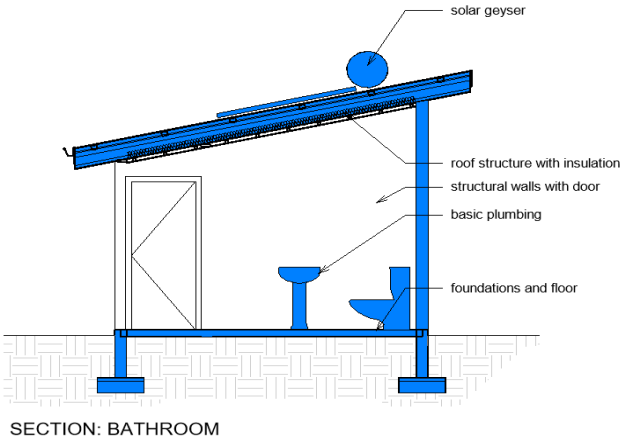

Figure 11: Primary level: Section through the bathroom. By author, 2022.

The secondary level (Figure 12) deals with the rest of the space-defining elements of the architecture that the family and local builders will design and construct with assistance from the architect. These are the room-defining elements of the building that were not part of the primary phase including the non-structural walls and their doors and windows; the connecting passages – that unify the three buildings into what can function as one house; the privacy screens; and the necessary landscape infrastructure. The materiality of the secondary level can be more diverse as they do not serve structural purposes. It can more closely reflect the local materiality and include creative uses of natural and inexpensive materials.

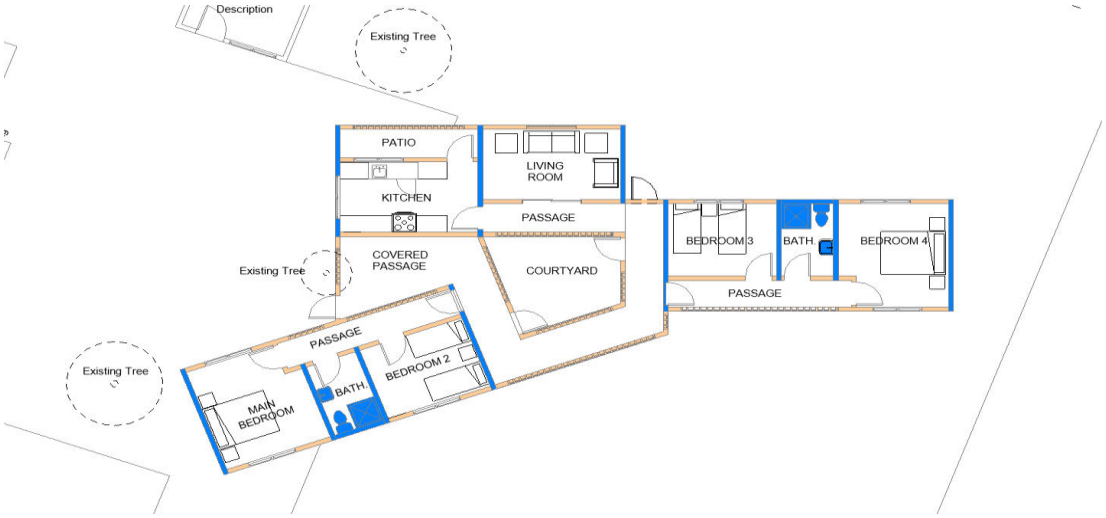

Figure 12: Secondary level (orange) completed. By author, 2022.

Occupant Opportunities and Limitations:

The layout of the house is detached into three buildings that are connected by an inner courtyard. This configuration allows the occupant to define multiple internal layouts to suit their needs as they are and as they change. The first iteration is a single-family home with four bedrooms (figure 13). The second iteration is a family home with two bedrooms and a separate structure with one bedroom for a tenant (figure 14). The third iteration has three separate dwellings which may function independently (figure 15). The family can reconfigure the house to suit their needs to a great extent before needing to extend the footprint of the house.

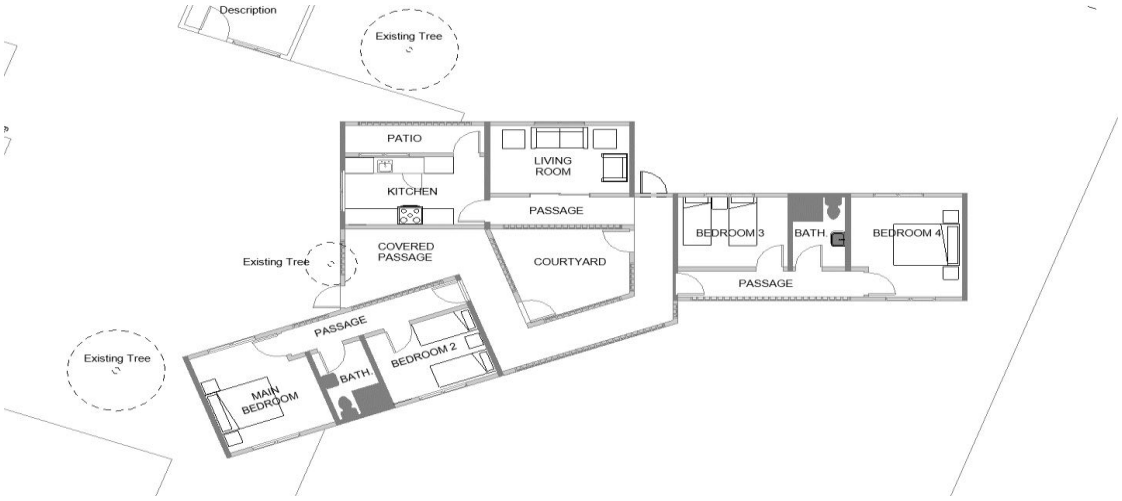

Figure 13: Scenario 1: One house with four bedrooms. By author, 2022.

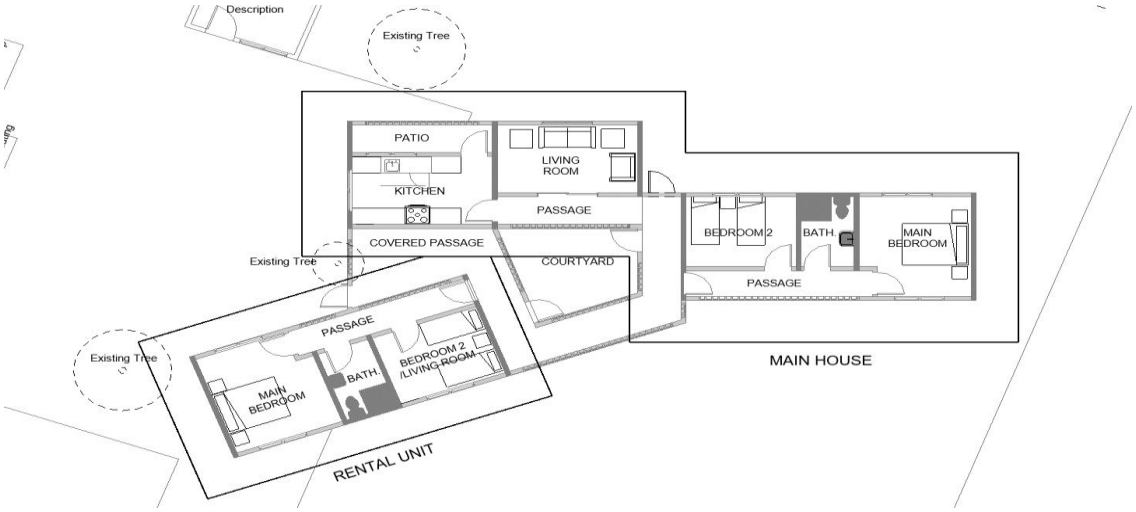

Figure 14: Scenario 2: One main house with two bedrooms and one rental unit. By author, 2022.

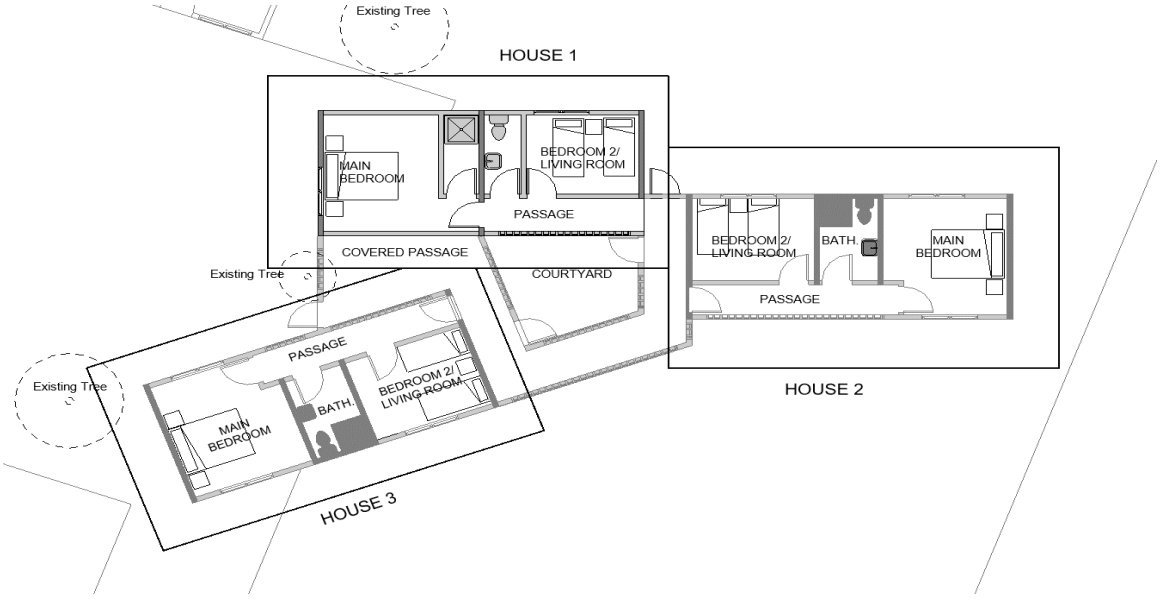

Figure 15: Scenario 3: Three independent houses. By author, 2022.

Should the occupant need to expand the footprint of the house, its detached layout gives them space to do so. Defining the outer long walls as a secondary structure means that the occupant needs not to work through structural walls as is the case with RDP houses.

Occupant involvement in the Design Process

The Bushbuckridge project differs from most housing developments in that the project has an intended occupant. The family is involved in a typical client-architect consultation process as with most architectural projects. This consultation process helps the architect develop a brief of what the occupant's current needs are and how these needs could foreseeably change. Along with professional experience and insight, the architect develops the primary structure. The primary structure should provide a decent infrastructure that would serve the family as well as allow for a great deal of flexibility to the secondary structure. After building the primary structure, the occupant cannot yet occupy the house as it lacks a complete envelope and space-defining elements. The occupant leads the design process in completing the house, where the architect takes on a facilitating and consulting role. Completing the secondary structure is the first milestone in a liveable home.

Including the occupant at the primary level and handing over the design lead to them during the design and construction of the secondary level, helps the occupant take possession of the house as they have been involved in key decisions from its inception. The house is not a product they receive, but a familiar process they have helped initiate.

Extent of Flexibility

The Bushbuckridge project allows the occupant to redefine the use of the house to a lesser extent by allocating certain uses to different spaces, and to a greater extent by reworking the secondary structure. The secondary structure allows the occupant to replace the material of the façade walls, its detailing, and its apertures. They can make the screen walls solid and remove internal walls to redefine the sizes of the rooms. The exterior walls that define the secondary structure allow for outward expansion of the house, whereas the detached configuration of the buildings ensures sufficient room for expansion while maintaining open spaces in between. Separating the primary and secondary structures along building elements, rather than spaces, gives the occupant greater flexibility in how they want to define their spaces with materials, detailing, and openings.

However, there are still a few limitations to the design. The primary structure serves as a limitation to the expansion in two cases. First, the roof height and angle, which stem from cost limitations, require consideration if there is extensive expansion against its lower end. The second case regards east and west expansion through the primary structure if this becomes necessary. This issue can be addressed in a similar way that Elemental had in Half a House by providing portions of secondary structure that the occupant can replace with doors or openings.

Although the project does not specify materials for the secondary structure, as the occupant would lead this design process, we can learn from the Empower Shack, in how it develops building elements from materials within the existing construction culture and in a manner that these materials can be disassembled and redefined for future uses.

Design Process Implications:

The design process of an OB project differs from a typical design process as there can be multiple, sequential design-construction cycles in making the building.

A typical, entangled, design process includes an occupant that the architect may consult. It usually involves a long design process where the architect determines the occupant's needs, funding, and regulatory constraints and designs the building layout, spatial design for each room, material detailing, and furnishing. The design process concludes with the occupant's approval of the design and the start of construction. During construction, there may be minor adjustments to the design, but the architect has made all the important design decisions. The occupant receives the building as a finished product.

As the typical process relies on giving form to the occupant's needs (Habraken, 1972), it becomes increasingly challenging to design good housing in developments where there is no occupant. The architect has no one to consult to determine their needs and must rely on an abstracted version of 'the occupant' and define a reasonable form that 'the occupant' can inhabit. This abstracted process is what gave rise to unsustainable mass housing.

OB provides a differentiation and disentanglement of levels of the built environment as a solution addressing the absence of an occupant from the initial design decision-making process. Its aim is not in providing a complete product, but an infrastructure within which, the occupant, when they arrive on the scene, may design and construct their space as they see fit – or alternatively, to provide elements and building components that may be adapted and changed at occupation.

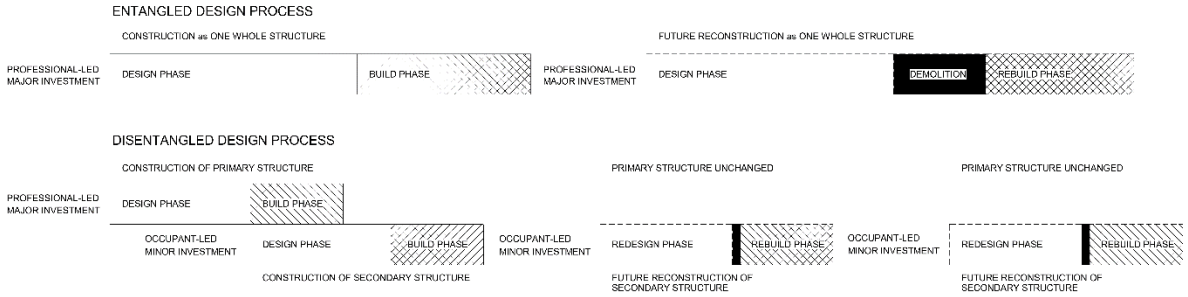

Figure 16: Comparison between entangled and disentangled design processes. By author, 2022.

In Bushbuckridge, the design process occurs on each level. The architect adopts OB principles along with the family's input to design the primary level. This ensures that the building is suitable for the family but also flexible for the next level. Once we have built this level, the architect and the family embark on another, the more detailed design process for the secondary level. By disentangling the building into levels, we can distribute the design process over a longer time. We can defer important design decisions to a later level. This can be useful where the architect does not have a full image of the occupant's needs and it would be better to make these decisions when the occupant is on site. Not only does this process allow the family to give more creative design input, they can also inhabit the primary level to make more meaningful design decisions in the space, as opposed to making all the decisions on paper, before construction. Drawing out the design process and involving the occupant as a leading decision-maker improves the design decisions made in ensuring the building is suitable, flexible, and sustainable by the occupant.

Conclusions

This paper argues that we can use OB principles to improve the sustainability of low-cost housing projects by ensuring they maintain their usefulness as the family's context and needs change. We set out four relevant OB principles: the occupant should build their space; we should separate building elements into levels based on their lifespans and needed competencies; the building should be a process, rather than an end-product; and buildings should be sustainable by responding to future, unknowable needs. These aspects all contribute to the occupant taking ownership of the house as a process (versus a product) and being able to adapt it to their changing needs.

In the three low-cost housing case studies we found that the RDP housing aligned the least with the OB principles. Occupants seem to find it difficult to work with the rigid delivered structure and as such, is the least sustainable approach. Half a House took a more three-dimensional approach to disentangle the spaces for occupants to build into. This aligns closer to OB principles and would seem to improve the extent to which the occupant can sustain the delivered structure as their need for different spaces changes. Empower Shack aligned the closest to OB principles. It separated the building elements into a rigid structure and space-defining elements the occupant can readily change. The project focuses on providing a building process that the occupant can sustain.

We illustrated the use of the four OB principles in the Bushbuckridge project to illustrate that they are not only applicable to large-scale, low-cost developments. It showed how we can disentangle a standalone house to ensure

that it can adapt to the changing needs of the family. The primary structure of the house receives the necessary investment to ensure a long-lasting structure and well-functioning services.

OB disentanglement is beneficial to the design process, which is no longer a simple, linear sequence leading to construction and concluding in an architectural product. This is typically an issue in mass housing projects where the architect cannot consult an occupant to understand their needs. In OB, we can defer critical design decisions that require consulting a user/occupant/owner to when they arrive on the scene. The architect can develop the primary elements for the housing and the occupant can design and construct the infill based on their current needs on occupation and reconstruct and adapt this as their needs change.

By using OB principles, we can develop housing projects as sustainable processes as opposed to static products. We can develop a framework for the building that is flexible and disentangled enough to accommodate the unknowable needs of the occupant. The occupant's later involvement in the design and construction of the space-defining structure embeds their thinking and practices into the house. They take ownership of a familiar home.

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Figures

Figure 1: Figure-ground of Braamfischerville illustrating occupant construction. By author, 2022.

Figure 2: *Elemental's Iquique development, Chile.* Archdaily.com, 2016. Available from: https://www.archdaily.com/797779/half-a-house-builds-a-whole-community-elementals-controversial-social-housing/580897bbe58ece3c6600018e-half-a-house-builds-a-whole-community-elementals-controversial-social-housing-image Accessed on: 2022/08/25.

Figure 3: Plan and elevation of Half a House illustrating the delivered structure in blue and the intended additions and adaptations in orange. By author, 2022.

Figure 4: *Occupant infill construction at Iquique*. Theguardian.com, 2016. Available from: https://www.theguardian.com/artanddesign/2016/apr/10/architect-alejandro-aravena-pritzker-prize-elemental-housing-iquique-constitucion-tsunami-defences Accessed on: 2022/08/25.

Figure 5*: Elemental's Villa Verde project, Chile, with additional infrastructure over the incomplete half of the house.* Archdaily, 2016. Available from: https://www.archdaily.com/797779/half-a-house-builds-a-whole-community-elementals-controversial-social-housing/580897e4e58ece68aa0002dd-half-a-house-builds-a-whole-community-elementals-controversial-social-housing-image Accessed on: 2022/08/25.

Figure 6: *Phase three of Urban Think Tank's Empower Shack prototype in Khayelitsha, South Africa.* Dezeen.com, 2017. Available from: https://www.dezeen.com/2017/12/28/empower-shack-urban-think-tank-low-cost-housing-khayelitsha-south-africa/ Accessed on: 2022/08/25.

Figure 7: Elevation, section and plan of the Empower Shack illustrating the hard structure in blue and the softer structure the occupant can readily adapt. By author, 2022.

Figure 8: *Ground floor interior of the Empower Shack.* Dezeen.com, 2017. Available from: https://www.dezeen.com/2017/12/28/empower-shack-urban-think-tank-low-cost-housing-khayelitsha-south-africa/ Accessed on: 2022/08/26.

Figure 9: *First floor interior of Empower Shack.* Architizer.com, 2017. Available from: https://architizer.com/projects/empower-shack/ Accessed on: 2022/08/26.

Figure 10: Primary level (blue) completed. By author, 2022.

Figure 11: Primary level: Section through the bathroom. By author, 2022.

Figure 12: Secondary level (orange) completed. By author, 2022.

Figure 13: Scenario 1: One house with four bedrooms. By author, 2022.

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