

wasted opportunities

developing resiliency in architecture through ecosystem biomimicry

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ABSTRACT: Surplus buildings are frequently demolished and replaced under the assumption that it is cheaper to replace than adapt. The demolished building becomes waste material, usually ending up in landfills. Yet in nature discarded waste does not exist – it instead becomes ‘food’ for other flora and fauna. So too can surplus artificial waste become ‘food’ for new construction, thereby prolonging the life-cycle of materials by seeking new opportunities for their reinvestment in a building. We can thus rethink a building as a long duration work-in-progress, constantly developing and changing incrementally under changing conditions of context; designed to be readily susceptible – not resistant – to adaptation and growth. The energy-conservative re-use of an existing building and materials represents a positive response to the environmental sustainability imperative. Yet, whilst gently adding layers and texture over time through gradual, incremental growth, this re-use paradigm also ensures a continuing social familiarity with the urban landscape and the sustainability of associated memory. This paper critically examines the reuse paradigm and appraises the application of re-use strategies, taking as its case study a post-graduate architectural research project based in the adaptive re-use of an electricity substation building and site in the city-fringe suburb of Kingsland in Auckland, New Zealand.

Keywords: resiliency, ecosystem, biomimicry

1.0 INTRODUCTION

The effects of Man’s existence on Earth are more evident today than ever. Of all living things on Earth, we have the largest impact on our environment, constantly modifying it to suit our social and economic desires. We mine and harvest our planet for its precious resources, we use them, and then we waste them. We leave our planet, in many cases, scarred from our activities. Once limited to the raw materials of nature’s palette, we now know how to manipulate nature’s bounty and manufacture foreign materials, most of which are not easily absorbed back into natural systems and can be detrimental when disposed of. Since the advent of mass-production society has succumbed to the insatiable desire to own, use and retire products. This phenomenon, known as ‘Consumerism’, is encouraged by constantly changing fashions and planned obsolescence, where products are designed to be out-of-date or useless within a defined period of time. In turn, this leads to growing amounts of waste and increased use of virgin materials.

In New Zealand construction and demolition waste, for example, accounts for fifty percent of total waste entering our landfills – ten percent higher than the global average (Pedersen Zari, 2009a). Waste materials for recycling are more often transported overseas closer to where most manufacturing takes place, such as plastics and steel that are exported to Asia and parts of Australia. Our waste situation needs re-evaluating. We should be striving to reduce our building-related waste in the first instance, and complement this by developing a *reuse* and *recycling* industry similar to that operating in The Netherlands.

That country is at the forefront of reuse and recycling, with more than ninety-five percent of construction and demolition waste reused or recycled (Willoughby, 2009). There are currently over two-hundred thriving companies there that deal with the collection of waste material and their reuse or recycling. We should be using our waste as a resource to locally manufacture new goods, rather than sending it to landfill, or shipping it overseas for recycling. This would help address waste problems, create employment, demonstrate a commitment to achieving Zero Waste to landfill by 2015 (a policy adopted in principle by many of New Zealand’s territorial authorities) and reinforce our tourism marketing of a “100% Pure New Zealand.”

1.1. Key Definitions. (Sassi, 2002)

downcycling. the complete reprocessing of a building element producing a different and lower grade building element

reuse. when elements are minimally reprocessed and reinstalled in a building without having to be remanufactured.

recycling. the complete remanufacturing of a used building element to produce the same type of building element (or one of equal quality).

1.2. Outline – MArch (Prof.) Research Project

What began as simply an investigation into the adaptive reuse of a building quickly escalated into something very challenging, and much more complex, after this question was asked: “How can a building adapt to a new use not just once, but many times over?” The question led to the research of existing systems that are dynamic and display resiliency; and so nature, ecosystems and biomimicry became the main focus of study. Kibert, Sendzimir, & Guy (2002:7), in *Construction Ecology*, state:

Ecosystems are the source of important lessons and models for transitioning human activities onto a sustainable path. Natural processes are predominantly cyclic rather than linear; operate off solar energy flux and organic storages; promote resilience within each range of scales by diversifying the execution of functions redundantly over different range of scale; promote efficient use of materials by developing cooperative webs of interactions between members of complex communities; and sustain sufficient diversity of information and function to adapt and evolve in response to changes in their external environments.

In a paper titled “An ecosystem-based biomimetic theory for a regenerative built environment” Storey & Pedersen Zari (2007) distilled these ideas into a set of six key attributes common to all ecosystems:

- ecosystems are attuned to and dependent on local conditions
- ecosystems are diverse in components, relationships and information
- ecosystems optimize the system rather than its components
- ecosystems adapt and evolve at different levels and at different rates and
- ecosystems create conditions favorable to sustained life
- ecosystems are dependent on contemporary sunlight

The mimicry of ecosystems has little, if any, architectural precedent, but is outlined by Storey & Pedersen Zari (2007) as an important area of research. They assert that the application of the fundamentals of ecosystems to architecture could drastically alter the way humans live, allowing us to become reconnected with nature and live more responsibly on Earth. Biomimicry is the investigation of nature’s methods of solving common problems, then mimicking and applying these methods to solve human-related problems. The scale and level of mimicking can vary from the characteristics of a single organism to the mimicking of a collective of organisms acting as an ecosystem.

Developing building resilience can be regarded as fundamental to reducing construction waste. The Research Project investigated how the key attributes listed above could be mimicked and applied in architecture to develop more resilient constructions. The first three listed – and their architectural applications – are discussed in detail below.

1.3. Site Description – MArch (Prof.) Research Project

The Research Project was based in the adaptive re-use of an electricity substation building (which would remain active) and site in the small, bohemian, city-fringe suburb of Kingsland in Auckland, New Zealand. The site is contains ‘character defining’ buildings that should remain embedded within Kingsland and adapted for continued use (Boffa Miskell, Matthew + Matthew Architects, R.A. Skidmore Urban Design Ltd. & Salmond Reed Architects, 2004)

The substation consists of two buildings housing switchgear, open spaces acting as transformer bays, and a service lane running through the site. The older of the two buildings, dating from the 1930s, is a concrete monolithic structure, with all walls, columns, beams and floor cast in-situ. It was remodelled in 1948 in an Art Deco style. The second building, dating from the 1960s, consists of a steel portal frame, non-loadbearing concrete and brick walls, profiled steel roof and concrete floor.

Professional indications were that, with new digital equipment, space occupied by existing switchgear and ripple-plant could be decreased by as much as ninety percent, and with transformers stacked into a tower, much of the ground plane would be freed-up – thus permitting other, and optimal, use of the site.

2.0 ECOSYSTEMS ARE ATTUNED TO AND DEPENDANT ON LOCAL CONDITIONS

Pedersen Zari (2009b:6) states: “The immediate or local context an organism lives in, generally provides the resources and information it needs”. Braungart and McDonough (2009) agree, suggesting that some organisms within an ecosystem are more attuned to their environment than others. These are thriving species, and are considered those that are the most ‘fitting-est’ for their environment due to their strong “energetic and material engagement with place, and an interdependent relationship to it.” (Braungart and McDonough, 2009: 120)

2.1. Architectural Application

For a building to be the most fitting-est for its environment Storey & Pedersen Zari (2007:5) suggest that “a thorough understanding of a particular place would be required of the design team.” With this understanding a design solution can be developed that does not fight its surroundings, but instead complements and enhances it. A building should be environmentally, economically and culturally connected with its surroundings. It should become one of many nodes within a system of material and energy exchanges that are beneficial to all involved parties. Construction materials should be sourced as locally as possible and local energy sources should be explored. In return for the

materials and energy it receives, the building should offer products and services that benefit others within the area. The building's programme should capitalise on the characteristics of its surroundings, complementing other local businesses rather than directly competing with them.

This can be likened to the 'niche-finding' of biological organisms competing within the same area. Organisms will often limit competition with others for resources by defining territories, or staggering feeding times (Storey & Pedersen Zari, 2007). 'Niche-finding' seems to allow those competing to coexist. Although in the built environment it does involve a degree of foresight, prior research allows the designer or developer to make more informed decisions regarding matching building programme to site.

2.2. Urban Scan – MArch (Prof.) Research Project

The Kingsland area was 'scanned' for information to develop a building programme and aesthetic consistent with its identity. This was executed by analysing the existing buildings, their uses and the people living in the area. The suburb is sandwiched between two semi-industrial areas and hence contains a mix of industrial, commercial and residential buildings. Its main shopping strip consists of buildings of different eras, styles, colours and proportions that contribute to its eclectic "vibe". Over half of these buildings were built between 1890 and 1950 and very few new buildings have been built in the last thirty years. Many have instead been subject to a change in use – including an old petrol station now occupied by 'Handmade Burgers'; a Bar in what was a mechanics workshop, and the 'AW Page General Store' buildings, which are now mixed retail, bars and cafés.

The people living and working in Kingsland form its creative culture, as is evident in the twenty arts and design-oriented businesses present, many of whose owners live locally. These businesses include architects, graphic designers, jewellery designers and fashion retailers. Yet despite this creative culture, Kingsland seems to lack a formal gallery space for designers and artists to display and sell their work.

2.3. Site Scan – MArch (Prof.) Research Project

The site was also 'micro-scanned' to obtain an in-depth understanding of the site's history, construction and workings that would inform future design decisions. The site contained some immensely unusual and tectonically striking features, most of which could be useful in the new construction – for example, the concrete isolator columns, concrete transformer bays, steel tracks within the building, switchgear lockers, the network of service tunnels within the site and the decommissioned sprinkler system.

These were identified as features, other than the buildings themselves, that made the site distinctive and should therefore play a part in the redevelopment by being reused and integrated as useful components of the proposed construction, as well as acting as relics of its previous use. And so, these propositions were formulated:

- remove as little as possible to minimise the creation of waste
- when items are removed, try to reinvest them elsewhere on site rather than let them enter the waste stream.

2.4. Harvest Mapping

The sourcing of local materials is seen as one of many sustainable design initiatives that can be employed in construction, due to the reduced energy and carbon emissions involved in transporting them from source to site. *2012 Architecten* developed what they refer to as a 'harvest map' as a means of locating and mapping potential sources of waste or surplus materials from within a given area around a building site (van Hinte, Peeren & Jongert, 2007).

These materials are sourced due to their abundance, variation and local availability. Before any design work begins, the architects scout the area to find sources of waste or surplus materials to integrate into, and inform the design. The location of each material is then plotted on the map, along with a description of each material and quantities. The map acts as a design tool to help generate ideas based on the materials found, as well as inform the architects of the materials transport requirements. The use of locally sourced surplus materials minimises the distance of materials flow from one place to the next. It is usually beneficial to both the provider and recipient of materials, as the provider saves on the cost of disposal, while the recipient is supplied with free or discounted materials.

Harvest maps seem to be most useful in densely built areas such as cities and around city fringes where there is generally a large variety of development and industry occurring. Suburban areas therefore pose a more difficult task in terms of locating materials useful for construction.

2.5. Harvest Mapping – MArch (Prof.) Research Project

Prior to any design work a harvest map was prepared. Materials and componentry identified included those removed from the buildings on the substation site as part of their reuse (including crushed concrete and brick, profiled sheet aluminium, steel switch-gear housing); those found at three local demolition sites (including concrete rubble and structural steel); and surplus, dead stock and generic waste materials from varied sources in the Kingsland and adjacent semi-industrial areas.

3.0 ECOSYSTEMS ARE DIVERSE IN COMPONENTS, RELATIONSHIPS AND INFORMATION

Ecosystems are sustained by a diversity of organisms, their varied functions and the multiple relationships existing between one another (Kibert, Sendzimir & Guy, 2002). Each organism has a specific role to play in the processing of energy, matter and information. Odum, Brewer & Barrett (2004) point out that the more diverse an ecosystem, the more intricate the food webs among species and greater chance for mutual relationships to develop. Storey & Pedersen Zari (2007) further suggest that it is not specifically the *number* of species that contributes to the stability of an ecosystem, but rather the strength and number of the *relationships* between them. They assert that "through this kind of cooperative networking, one organism can fail without disrupting the whole system." (Storey & Pedersen Zari 2007:7)

'Niche-finding' (ref. Section 2.1) is in direct correlation to the diversity of functions in organisms. Organisms rely on differing resources from multiple locations, in order to avoid direct competition with others (Kibert, Sendzimir & Guy, 2002). In most cases this is the result of specific characteristics that allow an organism to occupy a niche. For example, there are a number of food niches present in a grove of trees, with a variety of bird, mammal and insect life that focus on different food sources. Different birds focus on food sources at different levels between the canopy and forest floor. These include a range of fruits, seeds and insects within each level. Evolution has allowed them to develop their functions to better suit their source, such as the New Zealand Kiwi, with its long bill and sensitive smell that allows it to find insects deeper beneath leaf litter than most other birds in the same area.

3.1. Architectural Application

In nature there is biodiversity – diversity of species, each with a different role in the working of the system. In the built environment, diversity can be represented by a wide range of built structures housing different functions. Mixed-use developments consist of a diversity of compatible building functions grouped within one building, or multiple buildings in close proximity (NSCC, 2005). This helps foster relationships among local businesses, and creates vibrancy and variation within an area due to the diverse range of activities taking place.

Although diverse relationships might be considered more important than the diversity of the buildings themselves, a consistent yet varied streetscape is still considered vital to the vibrancy of an area (NSCC, 2005). As mixed-use developments typically amalgamate multiple functions into one or two buildings it could be argued that there is a loss in what would have otherwise been a collection of varied building types, and subsequently a loss in diversity within the street. This, however, can be somewhat balanced by integrating existing character buildings into a mixed-use development. Developments should therefore seek to find a balance between building diversity and the diversity of relationships among their users. Moudon (quoted in Brand, 1995:18) suggests diversity can be established simply by dividing a site into many small lots:

Small lots will support resilience because they allow many people to attend directly to their needs by designing, building, and maintaining their own environment. By ensuring that property remains in many hands, small lots bring important results: many people make many different decisions, thereby ensuring variety in the resulting environment.

Interdependence among local business and industry should be encouraged in order to maximise efficient material and energy use, and minimise waste. In Kalundborg, Denmark there are a group of companies working together as an 'Industrial Ecosystem', where resources and energy are shared in an interdependent network (Benyus, 2002). A coal-fired power station, oil refinery, pharmaceutical plant, plasterboard manufacturer, and fish and pig farms all operate within a local area. Waste steam and materials such as sulphur, fly ash and sludge are exchanged from one business to another, where they become fuel or raw material for use in another production process. Such relationships include the use of waste steam produced by the power plant to power the oil refinery, the pharmaceutical plant and heat thirty-five hundred local homes. The Kalundborg industrial, commercial and residential areas are thus connected in an ecosystem 'food web' involving business relationships, and material and energy exchanges.

Similar initiatives could also exist on a much smaller scale simply by collecting and exchanging waste heat and rooftop-collected water between neighbouring buildings. Repeated within a neighbourhood, this would see each building become one of many nodes, connected with other local buildings within a system of exchanged resources (Storey & Pedersen Zari, 2007).

3.2. Programme – MArch (Prof.) Research Project

The site was split to accommodate a dominant programme with smaller sub-programmes in close proximity, to encourage relationships to develop. To reinforce the idea of a building in 'a state of flux', it seemed appropriate that its occupants might also be 'in flux', constantly changing. This was achieved by proposing a programme which would encourage a high 'turnover' of use, providing for both daytime and evening functions and including public amenities to ensure public interaction. From the Urban Scan (ref. 2.2), the following conclusions were drawn:

- Kingsland has a number of designers and artists living and working in the local area.
- there is a strong industrial presence.
- there is an existing material reuse culture

- there is locally available waste, surplus and second-hand goods.

Based on these factors, it was determined that the site would suit a mixed-use space that promotes product and material reuse through creative activities. The site would become a creative quarter – *Wasted Opportunities* – that incubates New Zealand artists and designers, while encouraging them to reuse materials in their work to reduce local waste. *Wasted Opportunities* would consist of the following features:

- subsidised studio and workshop space for artists and designers who use discarded, second-hand and waste products in their work.
- provision for two designer/artist-in-residence positions
- a separate studio space to host evening classes for the public
- retail gallery and exhibition space for users to promote and sell their work to the public with
- café and relocated substation

The reasonable proposition was that the facility would be subsidised by the territorial authority, with additional funding provided by the 'Zero Waste New Zealand Trust' – a funding, advocacy, support and information group fostering community development projects for minimising waste. It would take as its functional model *Toi Poneke*, a facility in Wellington that offers low rent studios to developing young artists. *Toi Poneke* gives each user three years access before they are expected to move on, thus making way for new applicants.

Users of *Wasted Opportunities* would explore the integration of waste in art and design in a variety of fields and scales, including architecture, product and object design, furniture design, fashion design and jewellery design. The low or free rent space offered would become an attractive incentive for people to work with waste materials. With both young artists and designers changing triennially a flux of occupants is ensured, keeping the facility fresh, and work in the retail gallery changing.

Occupancy and adaptive re-use ideology would work hand-in-hand, as many artist colonies and designers studios will have started in ex-industrial buildings due to the low cost, flexible-use space that these buildings usually provide. Building reuse would lower the start-up costs of the facility and provide a unique and inspirational environment for its users.

4.0 ECOSYSTEMS OPTIMIZE THE SYSTEM RATHER THAN ITS COMPONENTS

In nature waste does not exist. Organisms in an ecosystem acquire matter and energy from their local surroundings as nourishment for growth. They use only what they require then discard the excess back into their immediate environment. The discarded waste of one organism then becomes nourishment for the growth of another, cycling perpetually through connected food webs of many different species (Odum et al, 2004). The exchange of this material and energy is what establishes interdependence among species, where coexistence becomes beneficial to all parties within the system. This is fundamental to the working of an ecosystem (Braungart & McDonough, 2009).

The releasing of excess material and energy would be considered inefficient on the organism's behalf if it were not reliant on the excess or waste of another. As humans we rely little on the waste of others to provide for us and the waste we produce is non-beneficial to other species; in fact, it is increasingly detrimental to them. Essentially, we fail to participate as a part of an ecosystem.

4.1. Architectural Application

The chemist and architect authors of *Cradle to Cradle – remaking the way we make things* (Braungart & McDonough 2009) believe we do not have to cease producing waste to reconnect ourselves with active ecosystems. Instead, they suggest we need to imitate nature's cradle-to-cradle metabolism, where detritus becomes the food for the growth of another and essentially eliminate the very concept of 'waste' altogether. They believe that man-made materials, similarly to biological materials, can be seen as nutrients able to feed new growth as they become surplus. While some will aid natural growth, others can be broken down and used as nutrient for artificial growth: the growth of industry. Hence, they separate the material stream into two distinct categories, biological nutrients and technical nutrients.

Biological nutrients are materials that can be returned to the earth to become part of a biological cycle, where micro-organisms and other animals can safely consume them. Braungart & McDonough (2009) use the example of a compostable fabric they were asked to develop for the textile company *DesignTex*. This fabric uses no harmful substances in its creation, allowing it to be tossed onto the garden at the end of its useful life where it safely breaks down. It is, in fact, so safe that it is claimed to be edible by humans. As the process of making it involves no carcinogens, mutagens or pesticides, the water coming out of the factory that produces the textile was found to be cleaner than the water entering it. This example suggests that re-evaluating the way things are made could not only lead to safer, healthier products that can be disposed of in a manner beneficial to the environment, but the processes that make them could also become beneficial.

Technical nutrients are described as materials or products that can be returned to an industrial metabolism, where they become the nourishment for artificial growth. Through the act of recycling, material flows can become closed

loop systems, with technical nutrients reused perpetually. This would entail the disassembly of products or components to break them down into a more usable state so that they can be easily absorbed into different technical processes, similar to the metabolism of an organism.

Nature has the advantage of a vast multitude of organisms working locally disassembling her biological products with the motive of turning them into their own food. However, the application of Braungart & McDonough's theory of recycling 'technical nutrients' is problematic as it must take account of the location of reprocessing in relation to the material's origin, the energy required for transport and reprocessing, and the limited range and availability of materials that are infinitely recyclable. The reality of 'technical nutrients' is that they are not all recycled, even if they are intended to be. Impurities, coatings and alloys are common barriers that complicate even the most recyclable materials, aluminium and steel (Sassi, 2008).

Developing products and materials as biological nutrients could radically change the global industry, as industrial growth would have the potential to improve the quality of its environment, rather than damage it. However, as manufactured products fitting into the 'biological nutrient' category are still in their infancy, the reuse and recycling of non-biodegradable materials – 'technical nutrients' – is *the* pressing problem globally that needs to be addressed. Reuse is a commonly confused and overlooked approach to dealing with waste, yet as a strategy is superior to recycling in that there is little or no loss in quality and minimal reprocessing involved, which in turn means less energy is used and fewer emissions are made (Sassi, 2002).

Many of today's buildings have the capacity to exist in a usable state for as long as fifty to one hundred years, but few reach this age before they enter the waste stream (Brand, 1995). Put simply, our buildings and their components do not last long enough in one given state before they are torn down. Each time we recycle a material or product rather than reuse it, it is subject to additional energy, material and chemical inputs (Addis, 2006). These inputs are usually less than what is required to produce it from virgin materials, but are still considerably more than reusing it in its existing state. The other consequence is that often materials cannot be recycled to create a product equal in quality to the original. This loss of quality is referred to as "down-cycling." (Sassi, 2002)

4.2. Adaptive Reuse

Adaptive Reuse is commonly defined as the reuse of a building or buildings involving a level of adaptation or change in character of the building fabric and its spaces, to suit a new program. Luis Fernandez-Galiano (2000) helps us to see an existing building from an unusual point of view. He suggests that a building essentially represents a bank of stored material and energy already expended. Therefore the greater the amount of an existing building retained and reused, the more that energy remains locked in its most useful state (van Hinte, Peeren & Jongert, 2007). A revised definition of Adaptive Reuse could therefore be: "the prolonging of the cradle-to-grave lifecycle of the building (O'Rourke & Norris, 2002), its associated materials and the energy costs involved in the materials manufacture and the buildings construction."

Demolition requires additional energy to break the building into smaller, less useful pieces. As a high proportion of this demolished building becomes waste, the stored material and energy is essentially dissipated and lost. By limiting or avoiding demolition or disassembly in the first instance, there are monetary and energy savings to be made through a reduced dismantling process and the reduced transport, sorting and disposal of the resultant wastes (O'Rourke & Norris, 2002). To replace the building also entails additional energy and the use of virgin materials inherent in new construction. It is for these reasons that in situ adaptive reuse of buildings can be seen as the most efficient form of reuse (Storey, Gjerde, Charleson & Pedersen Zari, 2003).

Lynch & Southworth (1991) believe that the change in program of a building is a "significant test of its quality" and could be argued as fundamental to its survival and continued evolution, as it demonstrates the building has the capacity to perform a function other than that for which it may have been specifically designed. It is not uncommon in adaptive reuse for the building to be reformatted to perform a less specific function or set of functions, and as a result becomes 'loose-fitting'. The alterations that adaptive reuse involves bring spaces to an acceptable state of useability, but by no means makes them the most efficient for a particular use. Some ambiguity remains. This ambiguity adds a certain idiosyncrasy to the building and often can become a feature. It is also what makes future reuse easier, as less effort is required to reformat the building and its spaces for a new function.

Fernandez-Galiano (2000) also suggests that buildings not only retain material and energy, but also valuable information worth conserving. This information includes the continued familiarity and identity of the urban environment, the conservation of the history associated with the building's inhabitancy and the retained knowledge of past construction methods. He suggests that a building becomes a complex story of recorded events and traces of human inhabitation, with information stored through matter in the same way as in nature.

The earth's layers remember geological ages, the rings of a tree recall past springs and autumns, and the archaeological mound is a reminder of the passage of cultures. The built structure remembers living habits and processes, contains information about historic vicissitudes, and forms the material basis of collective memory. (Fernandez-Galiano, 2000:66)

Brand (1995) agrees and suggests the complexity that develops through this succession of interventions makes a building more interesting. He writes: "the continuing changes in function turn into a colourful story, which becomes valued in its own right." (Brand, 1995:104) Through sequential changes in use and their subsequent alterations the

building's collective memory becomes an intricate tapestry of information. This information is recorded at a variety of scales, from an evolving building form, down to the developing patina on some materials as a result of wear and weathering.

4.3. Superuse – Waste Material reuse

Superuse can be defined as the action of removing materials from a scenario where their maximum value is dissipated through storage, potential 'down-cycling' or dumping, and reusing them in a similar state for a purpose of equal or greater value than its original use (van Hinte, Peeren & Jongert, 2007). The term was coined by *2012 Architecten*, a small architecture practice in The Netherlands that frequently makes use of second-hand and waste materials in the buildings they design. It is an efficient and creative way of dealing with a number of waste products and materials, as often little additional energy is required to make them useful again. The superuse of a product or material demonstrates resiliency through its capacity to be *repurposed*. Its life is prolonged; it also promotes awareness of waste materials and their creative applications in architecture and other design fields.

4.4. Reuse and Superuse – MArch (Prof.) Research Project

Materials and componentry documented in the Harvest Map became 'food' for the growth and development of *Wasted Opportunities*, informing its design at both a conceptual and detail level. In summary, significant items included the following:

4.4.1. Road Signs

Road signs are commonly made from 3mm sheet aluminium with two layers of PVC vinyl coating, one the reflective background and the other the graphic of the sign. According to a New Zealand road sign supplier, the typical road sign has a lifespan of between ten to fifteen years, determined by the reflectivity of the vinyl, which diminishes with age. Although the aluminium body is highly recyclable, the vinyl layers are difficult to remove. Old signs make an interesting building material – they are very durable yet easily cut and bent. Despite having diminished reflective qualities, most signs are still very reflective in the presence of direct light. To take advantage of this characteristic the signs would be cut into quarters, bent on the diagonal and fixed to galvanised steel frames to create an inventive screen that filters sunlight into the room behind. Positioned above the 1960s building façade, the screen doubles as a 'beacon'.

4.4.2 Rackable Plastic Shipping Pallets

These (usually) polypropylene pallets are used for transporting goods nationally and internationally, and can be slotted into a rack with no need for shelving. While varying in size, they have two common dimensions: 145mm depth and 1200mm width. Lifespan varies depending on pallet type and use, but averages at seven years. Once damaged, they are left unused in stockpiles – although considered recyclable, a local supplier confirmed that they are not recycled at all in New Zealand. The pallets are strong and lightweight due to their intricate and skeletal 3D structural patterning. The pallets are proposed as (vertical) external screens, allowing filtered light penetration.

4.4.3 Toughened Glass Panes

Stacks of dead-stock toughened glass have been stored at a local supplier for five years due to an over-order of product. As glass is toughened it cannot be recut. The glass is of varying size and tint.

4.4.4 Eden Park South Stand Structure

The South Stand has been replaced by a much larger capacity stand, as part of the Park upgrade for the 2011 Rugby World Cup. If the Stand had been dismantled rather than demolished, the raking steel frames that supported the terraced seating would have been recoverable and capable of being used in a new construction. The research project design proposes their re-use, kept in their original shape but 'flipped on-end' as tall, tapering portal frames. The resultant, distinctive form houses a studio/workshop on two levels.

4.4.5 Petrol Station Canopy

The canopy from this ex-petrol station was originally bolted in-place, making it easy to recover and reuse in new construction. The cantilever structure of the canopy makes it ideal for the proposed vehicle-access workshop in the (north-eastern) corner of the project site.

4.4.6 Concrete Rubble

Concrete rubble from demolition projects, if reused, is typically down-cycled as hard fill (although overseas, in places where aggregates are scarce, it is crushed and the aggregates extracted and reused in new concrete). The research project design includes the reuse of on-site demolition rubble, which would be crushed on-site with a mobile crusher, and used as fill for gabion walls.

5.0 CONCLUSION

The expansion of this Research Project from the topic of adaptive reuse to the wider topic of Ecosystem Biomimicry revealed adaptive reuse as just one of many collated sustainability strategies that encourage the prolonging of buildings and their components. Together, the strategies consider a building's whole life cycle: what it is made of, how it is made, how it is maintained, and what happens to it when it ceases to work. The strategies not only encourage buildings to be resilient, but also their materials and components, through reuse rather than recycling.

The strategies are by no means a perfect translation of a biological ecosystem's workings, but can be used as a starting point for designers to apply similar principles in their work using existing building practices. Applying the fundamentals of an ecosystem to architecture to develop more resilient constructions may only mean the resulting building is *capable* of being more resilient, as ultimately, support for these strategies will need to come from society, and its local and central government. We need to shift our concerns from the 'short-term', and make 'long-term' thinking our habit.

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