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Learning from Hurricane Katrina: The Case for Structural Insulated Panel Systems

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Abstract

In the face of growing public awareness and concern for global warming and climate change combined with new information regarding the detrimental impact of buildings on the environment, there is both a greater appreciation of the need for post-disaster reconstruction as well as a resurgence of interest in sustainability and green building. A relatively new building component system, Structural Insulated Panel systems (SIPs) have been identified as a 'green' environmentally sustainable product. They have proven particularly well suited to withstanding structural events such as earthquakes, hurricanes, or record snowfalls but also have the added potential for timely deployment and rapid reconstruction in the face of natural or civil disaster.

In many respects, SIPs appear to be the ideal solution for sustainable construction in New Zealand, a country prone to earthquakes, high wind and extreme weather conditions; one with a relatively unskilled construction labour force and a desire for more sustainable housing. Yet, SIPs currently do not exist in New Zealand. This paper reviews the performance characteristics of SIPs, then from a search of the literature, evaluates their performance most recently following Hurricane Katrina to identify challenges and opportunities as well as a framework and some options for further research and design for their application in New Zealand.

Keywords: SIPs, sustainability, disaster-recovery, temporary housing, New Zealand

Introduction

While virtually unknown in New Zealand, Structurally Insulated Panel systems (SIPs) have been in existence in some form or another since Frank Lloyd Wright used SIP-like panels in the 1930s[1]. A simple system of monolithic interlocking insulated panels, SIPs are composed of a sandwich assembly of wood and plastic, most typically engineered wood for the facing panels with a polyfoam core (see Fig 1). This composition is structurally analogous to a wide I-beam, providing structural strength and enabling load-bearing construction, so there is no need for conventional framing. While traditional panels have used oriented strand board, other facing materials such as fibre cement board, metal and treated plywoods have been used as are most suited to the local conditions and climate. Using computer aided design and manufacturing technologies, SIPs panels are cut to size for individually designed buildings with high levels of accuracy in the manufacturing plant, then most commonly are shipped to site for assembly. The fabrication process repositions much of the skill involved in conventional building to the factory, decreasing the reliance on skilled builders for quality construction and reducing the overall construction period.

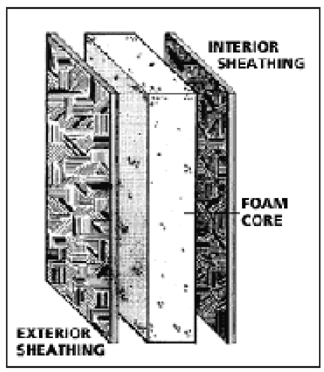

Fig 1: 3D sketch of SIP components. (SIPA, 2007)

Within North America, the UK and Europe, interest in SIPs has grown over the past decades due to: the introduction of more streamlined assembly technology; the reduction in construction time; and the subsequent reduction in labour costs and, most recently, the 'green building' attributes of the system. With respect to performance in disaster, SIPs buildings have performed well following the earthquakes in Japan (Kobe 1993) and Northridge California, recent hurricanes in southeastern USA (Hurricanes Andrew and Iniki) and following world record snowfalls in the Cascade and Rocky Mountains. The combination of sustainable building construction and high performance in hazard conditions are deemed well suited to the realities of our climatically challenged future, where a building is expected to last a minimum of 50 years.

With respect to the specific issues of post disaster recovery, the advantages of the reduced construction time for SIPs homes demonstrates their added value in the face of civil emergency. Most recently following Hurricane Katrina, the USA Federal Emergency

[1] though Alden B. Dow, son of the founder of Dow Chemical Co., is recognised as designing the first SIP homes in 1932 with plywood and Styrofoam.

Management Agency (FEMA) dispatched 25,000 Building America Structural Insulated Panel (BASIP) homes for temporary housing*).* Shortly thereafter, architects and planners retained by the state authorities to rebuild public housing also specified SIPs for their cottage designs. This paper briefly evaluates the sustainability qualities of SIPs as well as those aspects which make them so well suited to post-disaster situations, then using a case study approach assesses their use in the reconstruction following Hurricane Katrina, seeking lessons to be learned for SIPs deployment in other 'first world' recovery situations, namely New Zealand.

Structural Insulated Panel Systems and Sustainability

As we are increasingly confronted with evidence of climate change, and in particular, when seeking to recover from a climate-related disaster, we are conscious of the imperative to seek more environmentally friendly materials and processes. Any new construction must improve on what was there before and should not contribute to the problems that necessitated its use.

SIPs meet sustainability objectives in a number of ways. First, they are superior to conventional construction with respect to energy efficiency as they have continuous insulation throughout the panel, unbroken at any point. Thermal bridging only affects 3% of the panel where splines and electrical chases can affect the thickness of the foam insulation. In addition, the panel construction is more airtight, enabling the building envelope to regulate the heating, cooling and humidity using less energy to heat and cool. An added benefit of the continuous insulation is that it avoids cavity voids which are prone to mould—a leading contributor to respiratory problems and allergic reactions. Thermal and airtight qualities enhance the indoor environments by regulating the temperature close to that required by the occupants, eg. warm in winter and cool in summer, eliminating drafts.

Second, the sustainable objective of conserving materials and resources is accomplished in various ways with respect to SIPs. It can be achieved through using locally available materials, not requiring significant transportation to the project site. Alternatively, it can be achieved through the use of materials that have been harvested from sustainably managed sources. Other forms of resource efficiency are achieved through utilising materials that have a high level of identifiably recycled content or have been salvaged, refurbished or remanufactured or through manufacturing processes that are resource efficient (minimizing waste, energy efficient and reducing greenhouse gases). Finally, resource efficiency also relates to durability, where long lasting products require less frequent replacement or maintenance.

Third, they are very waste efficient. SIPs can be fully manufactured into homes in a factory setting, but are more commonly cut to a specific design, and are delivered to the site ready to assemble without further modification and with the timber block in-fills and splines ready to fit. As a consequence there is very little on-site waste.

While not directly a sustainability asset, the flexibility of SIPs use in a building allows for even greater economies in situations where considerable construction is taking place. While the majority of buildings constructed from SIPs to date have been built new, SIPs are compatible with other building systems, including conventional stick framing. They can be used for floors, walls and roofs in residential and commercial buildings to a height of several storeys. Wall panels can sit on a variety of foundation materials including a poured concrete slab, SIPs floor panels or reinforced concrete masonry blocks. Builders can mix and match SIPs elements with other construction forms, such as a conventionally framed wall with a SIPs roof, or SIPs walls with a truss roof. SIPs construction also has the benefit of not requiring any specialty equipment--conventional building tools suffice. The flexibility ensuing from SIPs construction means that it is well suited to use for new construction as well as remodelling/renovation. It is equally well suited to residential, school, commercial and industrial construction. With respect to disaster recovery response, this means that not only can SIPs respond quickly to complete building replacement, but it can also respond to incidences of substantial as well as minor structural damage.

Hurricane Katrina

Hurricane Katrina devastated the US Gulf Coast in August 2005. The storm inflicted major damage to housing, commercial property and infrastructure. While the US has had previous experience with hurricanes Hurricane Katrina was the first to impact the central urban area of a major city. Prior to Katrina, the housing stock consisted of a mix of single family dwellings, multi dwelling units and mobile homes, the majority of which were owner occupied. Following Katrina, the research of the RAND institute which analysed building permit data to understand the characteristics of the recovery revealed some important features of the process. The rate of recovery appears to have moved more rapidly for single family dwellings than for multifamily units and was higher for moderately damaged buildings than for severely damaged units. The costs for repair appeared high relative to market values and that at the current rate; recovery was expected to take several years longer than initially expected. Three issues were deemed to be most critical to short-term recovery efforts: capacity of the construction sector, availability of funding and providing an adequate supply of housing for those displaced.

While the availability of funding is not central to this paper, it is important to note that despite the availability of funding through insurance, government grants and loans etc. the rapid increase in housing values and building costs left financing gaps for most home owners. This was especially true for properties most severely damaged, un/under insured home owners and landlords (for example those with multiunit rental properties). Landlords with severely damaged buildings, faced with overheated construction costs and financing shortfalls had the ability to ‘take their investment money elsewhere’, delaying rebuilding until the market cooled off. (This was deemed to have been particularly true for the ‘mom and pop’ landlords who depend heavily on the cash flow from rents.) In addition to those homeowners seeking to restore their housing, some homeowners were not happy with the direction that their former neighbourhood was taking in the rebuilding process and took the cash from their insurance to rebuild elsewhere, out of state. The proportion of owners to renters changed as a result, as did the type of housing landlord (RAND) shifting responsibility from the private landlord to the public/state landlord.

Poorly constructed housing was found more likely to sustain greater damage. Lower income families more commonly occupied poorly constructed housing. Rental housing was often discovered to be more poorly constructed than owner occupied housing. As a result of all of these factors, combined with the influx of construction workers, the requirement for affordable housing grew exponentially. In sum, the number of private landlords dropped significantly following the hurricane, the number of renters (compared to owners) increased, the demand for affordable housing increased (also inflated by the influx of low paid construction workers—many of which were migrants) and the 'market' showed signs of not recovering fast enough to meet demand, putting added pressure on the state to provide affordable housing—fast. These pressures, relatively unique to disaster recovery can be managed with SIPs construction.

Much has been written both explaining and critiquing the stages of post-disaster housing (Quarantelli, 1995). From the first emergency shelter, where a family can stay at the height of the emergency such as a public facilities or a home of friend or family (also characterised by the lack of food preparation areas or other services), to a temporary shelter intended for a short stay, through to temporary housing and finally permanent housing. Permanent housing refers to the family returning to their rebuilt home or moving into new permanent housing in the community. These stages are apparent in the response to Hurricane Katrina as are other alternatives to these stages, the both of which are useful for understanding how the nature of the emergency provider affects the housing outcome.

Shortly after Hurricane Katrina struck, FEMA provided temporary emergency housing, both drawing from their existing inventory of temporary trailers (most recently following Hurricane Andrew in the neighbouring sate of Florida), but also purchasing 102,000 travel trailers to house those who had been displaced by the storm. The FEMA trailers used following Katrina were a mix of new and used small trailers (18.5 m^2) larger travel trailers (37 m^2) and larger still mobile homes (see figs 2 and 3).

Fig 2: FEMA travel trailer types (Richard Alan Hannon /Mark Wolfe)

Designed for mobility and rapid deployment, the trailers were provided on wheels for ease of deployment in both trailer park settings as well as on individual lots. Much like holiday caravans, all of the FEMA travel trailers were made of similar construction. Factory manufactured buildings with steel framing, a building envelope of metal sided foam-insulated panels with manufactured wood interiors. To meet the massive demand, the new trailers were manufactured using least expensive and most readily available materials and methods, then constructed in haste with little time spent drying out in the factory. This means of manufacture combined with deployment in high humidity locations and limited ventilation resulted in the off-gassing of formaldehydes from some of the materials. Independent experts have said they think the problem is due to manufacturers using cheap materials purchased from countries where formaldehyde regulations are lax (House of Representatives, 2007).

In addition to the FEMA trailers, FEMA had also ordered 25,000 Building America Structural Insulated Panel (BASIP) homes (see Figs 3 and 4). The program for the house design was developed in the 1970's and like the travel trailers; they were designed for temporary shelter, not to exceed 18 months. These houses differ from the travel trailers both in terms of size and construction. Seeking a more sustainable housing option, the proposed BASIP home design utilises SIPs for walls and the roof, resulting in greater energy efficiency as well as improved durability. The units all have 3 bedrooms and 2 bathrooms and have been designed for expansion through the joining of a second unit to create a 'double wide'. Other proposed features include special shutters to provide future hurricane protection and solar shading, a retractable awning for solar shading and additional square area.

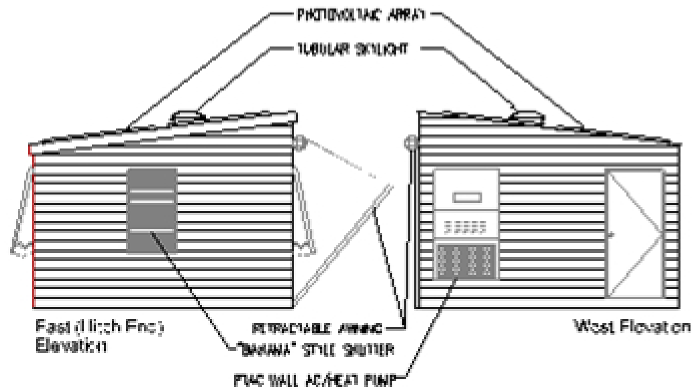

Fig 3: BASIP Homes: (a.)FEMA: Robert Kaufmann b.) Thomas-Rees, S., et al. (2006))

Some of the other sustainable features include the potential for integration of photovoltaics to generate peak power requirements for situations where utilities have not been restored or during times when service is interrupted (Thomas-Rees, 2006). In terms of external appearance however, the BASIP's homes look very much like a larger version of the FEMA trailer only with a pitched roof.

Fig 4: 140 unit BASIPS park in LaPlace, St John Parish, LA. 3-15-06 (FEMA/Marvin Nauman)

Seeking to provide more permanent housing, the state (MISS) then issued bonds to construct 3,400 new affordable units and sought funding from FEMA for a pilot program to demonstrate the feasibility of a model cottage house as a longer term solution for the FEMA trailers. Unfortunately the initial bond for the 3,400 houses was insufficient to replace the number of units damaged and as it was geared to traditional construction models would not be ready far into the future. As a result, while their intended use was just for the immediate period following disaster, in the case of Katrina, the state appealed to FEMA for an extension to August 2007. As of mid August 2007—two years after the hurricane, 60,000 people were still living in the Stage 2--temporary shelter FEMA trailers in Louisiana and Mississippi (Blueprint for Gulf Renewal, Institute for Southern Studies)

The FEMA travel trailers were widely criticized for providing less than desirable temporary housing. The web is filled with personal accounts of unhappy occupants, reports of unhealthy living conditions and overall dissatisfaction. However, FEMA sought to provide large numbers of emergency housing fast, to move the huge numbers of people in Stage 1 emergency shelters into a Stage 2 temporary shelter. The travel trailers were purpose designed to this end. Never intended to be used long term, the program under which they were obtained limited their use to 18 months. Despite these restrictions however, the extended use of travel trailers following disasters of this nature were well documented in the southern US, with people continuing to live in them for many years.

With respect to temporary housing for those displaced from public housing units, almost immediately following the hurricane the Governor for the State of Mississippi met with architect/planners Andre Duany and Steve Muson on Sept 6, 2005 to discuss potential models to solve the housing crisis. Duany and his colleagues had been approached based on their past experiences and expertise rebuilding from the aftermath of Hurricane Andrew in Florida as well as their holistic approach, encompassing urban/community design to revitalise the areas. Initially seeking an alternative to the FEMA trailers, Duany organised a design charette, by the end of which dozens of designs had been generated and the 'Katrina cottage' was born. The designers had fast realised that the so-called temporary shelters had out-of-necessity become more permanent fixtures. With their interest in affordable housing models, they sought to go beyond the bandaid solutions previously utilised for disaster recovery, utilizing prefabricated construction methods that could match the speed of the FEMA trailers. They realised that shelter is not enough, that a sustainable model had to be fast, flexible and able to transition from stage 2 temporary shelter to temporary housing through to permanent housing. Only through this transition capability were they able to keep costs reasonable and only using SIPs could they respond with a Stage 3 solution in Stage 2.

Fig 5: The original Katrina cottage designed by Marianne Cusanto
(Jeffrey K. Bounds photo/ URL: http://www.cusatocottages.com/photogallery.php?photo=4)

The Katrina cottages were developed first as Stage 2 temporary shelter but were designed to evolve into the beginnings of either new communities in the case of green field development or alternatively, in the case of buildings sited at the back of an existing property, as additional dwelling spaces for guests or aging relatives. Duany combined his vision for emergency housing with beliefs in the importance of community as evidenced in the development of the

New Urban Guild, the charter for which states its dedication to the promotion of the creation of better places through the traditional patterns and languages of architecture and urbanism. 'We view the pervasiveness of disposable buildings, placeless buildings, forgettable buildings and unlovable buildings as the natural end product of any theory of architecture that is not based primarily on human beings." Initial affordability was achieved largely through size (and durability)—seeking a bridge between the 18.5 m^2 and 27.8 m^2 trailers, the first cottage was designed to 27.8 m^2. To satisfy requirements for rapid construction and deployment, the cottages were kitset, using prefabricated SIPs panels specially designed for hurricane conditions, able to withstand high wind load conditions and excessive moisture without incurring damage or destruction. In sum, to meet with his objectives, the cottages had to be sustainable, to be able to mitigate damage from future storms, to be appropriate to regional condition, culture and climate and deliverable by all major delivery methods. This vision extended beyond simple cottage design to an all encompassing community design (see Fig 6), avoiding the less than desirable temporary community plans formerly employed (see Fig 4).

Fig 6: New Urbanist images of community settlement
(http://www.katrinacottages.com/home/mission.html)

The permanence of the Katrina cottage solution challenged existing federal models for disaster recovery, as responsibility shifted from one government agency to the individual states and even private home owners. Rather than accepting the FEMA trailers, the state sought to accept the money in lieu. FEMA officials are assumed to have seen the logic in this initiative as they established the Alternative Housing Pilot Program to which they allocated $400M. They then invited the Gulf Coast states to compete for money to run pilot projects aimed at providing emergency or interim housing for hurricane victims. The Katrina cottage designers were one of the recipients of this funding.

Duany and his team continued to develop their ideas, expanding the original Katrina cottage idea to 20 different cottage models, including among them the Kernel House, which is specially designed to grow from an initial 46.4 m^2 module to a 120.7 m^2 home with added wings. (see Fig 7). Meanwhile the prototype Katrina cottage had caught the imagination of designers throughout the southern US, eliciting a host of Katrina copies. The new models did not all encompass prefabrication in the same manner—encompassing four different methods of construction: on-site construction using traditional construction; panelisation--where the house is made in parts in the factory, then assembled on site; manufactured--where the entire house is produced in a factory then shipped to the site; modular housing--where partially assembled parts of the house (eg. In halves) are shipped and assembled on site, and finally the kitset house. While each of these methods has resulted in housing ‘marketing types’, there is a blurring of definitions in that some prefabricated housing types fit into more than one category. To make matters even more confusing, all of these models have been marketed under the Katrina cottage banner.

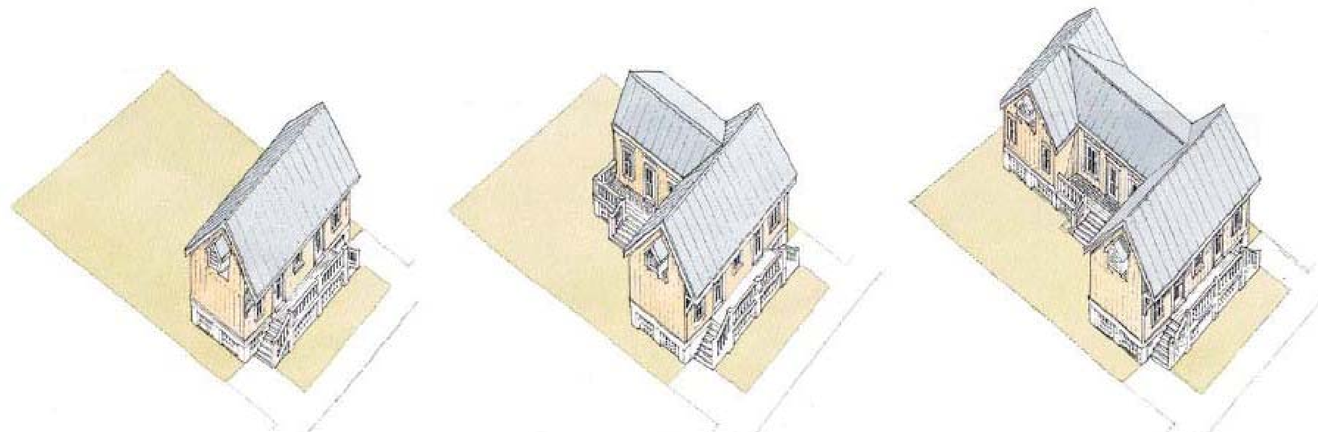

Fig 7: Kernel cottages designed for expansion (Katrinacottages.com)

The challenge for many of the different housing types is the requirement for rapid deployment. The key to the choice of the FEMA trailer for previous disaster recovery was its ability to be rapidly constructed and deployed. This was achieved through both the creation of existing stockpiles from previous disasters that could be redeployed, as well as the fast processes for constructing new trailers. The trailers arrived on site ready to inhabit, flexible for use in a variety of situations and as temporary dwellings, they did not require building consent. While the original Katrina cottage could be manufactured completely within the plant and delivered ready for occupancy, it was still challenged by unprepared regulatory authorities and the SIPs advantage of self-build suitability was not being fully exploited.

On Aug 23, 2006, Lowes, the second-largest home improvement retailer in the world, announced a licenced agreement to be the exclusive retailer of the Cusanto Katrina cottage housing plans and the associated building materials needed to construct 4 different models of the Katrina cottage. Using traditional building materials already being sold by Lowes, the cottage design was modified for traditional ‘stick built’ construction and requires a professional builder. An estimated 6 weeks are required for construction. At the time of writing, sales figures for these packages are unknown to the writer. Why Lowes changed from the original SIPs construction to traditional stick framing is uncertain, particularly in the face of the John C Stennis Institute of Government report proposing large scale construction of SIPs homes to meet Katrina’s rebuilding needs. We do know however, that the SIPs used would require factory custom cutting—requiring Lowes to make changes to their supply chain; that by the time the Lowes packages were available for sale (more than a year following the hurricane) the urgency of deployment was much diminished (hence the cost savings of avoiding Stage 2 housing would not have been achieved); and that the package offered by Lowes simply allows improved marketing of existing materials. Finally we would note that at the time of writing, SIPs are still novel for most homeowners. It is possible to speculate that large commercial suppliers are likely to stick to conventional solutions to serve the largest private home owner market.

Learning from Hurricane Katrina

While there are many lessons to be learned from Hurricane Katrina, this paper has confined its lessons to those directly related to SIPs construction with a view to the New Zealand context.

Lesson #1: SIPs construction is well suited to situations where speed of construction and quality are the first determinants of an immediate shelter option, be it temporary or permanent. The danger in a disaster recovery situation is that efforts to expedite short term recovery can result in insufficient attention being paid to longer term goals such as mitigating damage from future events or sustainable construction and even cost. The test BASIPs temporary home was built inside a factory in 9 days including all interior fitout and a 300-mile road test. The completed home was estimated to reduce energy consumption by 50% and to have twice the structural strength required by code for manufactured homes. Similar energy consumption and sustainable benefits were achieved in the Katrina cottages. The demonstration also proved that a manufactured home production line could support SIPs production simultaneously with traditional construction and without major modifications. The use of SIPs were pivotal to achieving the sustainable building features while accelerating the speed of construction.

Lesson #2: One size (one type of SIPs) does not fit all. The type of SIPs panel selected and the housing components most suited for SIPs vary both by climate, most likely hazard(s) and region. For example, the type of SIPs best suited to warm humid hurricane conditions, may not necessarily be the same for an earthquake hazard area or a location prone to dryness, fire and to insect invasion. The ‘standard’ temporary BASIPs housing was constructed from oriented strandboard and polystyrene SIPs, however, following Katrina, the SIPs selected for the Katrina cottage were not the typical OSB faced panel. To meet requirements of water immersion or invasion, fibre cement boards were selected as facing panels.

The combination of building design and requirements for heating and cooling will determine which building components (eg. walls, roofs or floors) are best suited for SIPs construction. In addition, climate will determine the R-values sought from SIPs construction combined with design to determine the thickness of the SIPs. Finally, the architectural response by region will dictate different housing designs and different materials choices. The first Katrina cottage design was selected for its familiarity as a Gulf coast historic prototype.

Lesson #3: Sustainable housing goals and better quality building options (such as through the use of SIPs) are achievable in post-disaster housing but are generally only cost-effective if life cycle costing benefits are considered or if the costs of disposable/temporary Stage 2 housing is eliminated. This requires considerable preplanning and forethought both at the level of the dwelling as well as that of the community. In the short term, traditional construction may be less expensive; however, over the life of the disaster recovery response as well as the life of the individual building, more sustainable construction pays off. (Savings were also achieved when monies for Stage 2 trailers were redirected to the permanent cottages.) SIPs construction is superior in terms of sustainability (and constructability) to traditional construction but is still marginally more expensive than traditional construction methods. This is evidenced by both the FEMA BASIPs temporary shelters as well as the short term and longer term Katrina cottages. The BASIPs housing utilised SIPs for speed of construction but achieved sustainability and durability advantages. This was done without sacrificing mobility/portability of the dwellings—allowing longer occupancy and utility (longer lasting trailers). The Katrina cottages used the same SIPs technologies, but with the objective of achieving in-situ permanence. The key difference between these two examples is the performance requirements of the funding agencies. While, the FEMA buildings have been designed to satisfy the owner (FEMA), a federal agency responsible for national disaster recovery having the ability to move accommodation from one location to another depending on disaster needs--the Katrina cottages have been designed for the end user, incorporating New Urbanist ideals of community and sustainability and with the ability to grow and change to meet end user requirements.

Lesson #4: New technologies (such as SIPs housing) will develop from government leadership rather than market forces following a disaster as government has the greatest 'need'. "A housing disaster results when there is no reasonable alternative housing available for victims, and/or there is no capacity to finance within a reasonable time frame the repair or reconstruction of units lost" (Comerio 1998). A disproportionate responsibility for rental housing reconstruction will fall to the state following disaster recovery leaving little time for planning and limited market support. Rental housing is typically the least well constructed and suffers the most damage. The first response to the Katrina disaster was for the market to 'move on' to safer investments where possible. For many of those owning rental property, insurance money was redirected into other investments--waiting for market recovery and normalised construction costs before rebuilding. This was evidenced by the change in proportions between rental and owned housing in the two years following Katrina. Simple supply and demand economics were evidenced in massive inflation of temporary housing costs. (The same principles did not stimulate rebuilding of rental housing due to issues of timing combined with inflated construction costs). The onus for providing affordable housing fell to the state, which was struggling to restore its own supply and was unprepared for the increased demand. The replacement of rental housing was much slower to be replaced than owned housing and the numbers of renters overall increased with the influx of construction workers, aid workers and those displaced from their homes but not seeking to rebuild immediately, as did the numbers seeking affordable options as employment was lost and overall incomes dropped.

With reference to SIPs this has implications for both leadership and research, both with respect to the development of new prefabricated systems but also with respect to the housing outcomes that will be developed as a result. In both situations of housing response, the BASIP homes and the Katrina cottages, SIPs were used in the construction, yet the outcomes were vastly different. In both situations, the government took initiative to obtain SIPs housing.

Discussion and conclusions

Following an emergency, response time demands restrict planning time. Working through the recovery following Katrina, the US developed a workable housing prototype in the Katrina model, but not soon enough to address their immediate housing needs. Inadvertently, they also found a successful model for affordable housing. Since the original Katrina cottage, multiple 'clones' have been developed all across the US, many using SIPs. Currently there are dozens of listings on the internet for Katrina cottages available for rent. They are being used for long-term housing and for uses including vacation homes, Granny cottages and home offices (Green, 2008). SIPs cottages have found favour by owners who are reporting on the relative ease of self-build with SIPs technologies. These benefits were not fully exploited in the SIPs housing developed following Katrina.

Katrina showed us the importance of; advance design, at both the scale of the individual dwelling as well as the community; advance testing of that design and; advance planning in terms of technologies to be used; as well as the importance of leadership from government. Working backwards from a sustainable housing model that is suited to the needs for current rental housing but adaptable for situations of disaster, then developing the technologies to manufacture and deliver in large numbers in short time frames are initiatives that are best resolved prior to emergency. While conventional construction technologies may satisfy current affordable housing requirements, they are unable to respond with sufficient timeliness following a large scale disaster. The government cannot rely on the 'market' to initiate new technologies. As demonstrated in the aftermath of Katrina, the 'market' is economically driven and will respond to demand, but not in advance of it. These lessons have bearing on disaster recovery planning in New Zealand.

The leading form of investment in New Zealand is rental property. A recent Treasury working Paper (2007) established that one in six households own residential investment property; and one in twelve households own a rental property. As of the 2006 census, 53% of the NZ population owned their usual residence[2] (Statistics New Zealand) compared to 70% in the Gulf Coast (McCarthy 2007). This equates to proportionately far higher levels of rental in New Zealand compared to the affected areas of the Gulf Coast. In addition, the 2006 census revealed that 82% of the rental housing in New Zealand is currently owned privately. The Department of building and housing notes that 'small time DIY landlords are common among private landlords and that corporate landlords are very rare. That most landlords do not have a budget for property maintenance and that most expenditure on maintenance is unplanned and that a large proportion (over one third) of landlords do not make routine property inspections (DBH website). Combining these facts with the well documented overall poor quality of rental housing construction, lead to an expectation that with respect to disaster recovery in New Zealand it is to be expected that following any significant disaster, government will be faced with a disproportionate demand for immediate affordable rental housing. It therefore stands to reason that research into the SIPs technologies, so critical to recovery following Katrina and non existent in New Zealand, are of national urgency.

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