OCCUPYING THE EDGE
CHRISTCHURCH URBAN HOUSING
Masters Thesis Explanatory Document

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ABSTRACT

The February 2011 Christchurch earthquake caused loss of life and widespread damage, especially in the central city and poorer eastern suburbs. Architects and urban planners have been working with the council over the following two years and have produced various planning documents to guide the rebuild. Throughout this process housing, one of the main components in the original plans has become increasingly excluded from the central city plans with every revision. Satellite suburbs and the relocation of families from the eastern suburbs to the periphery of Christchurch is already underway. The sidelining of housing and introduction of commercial zones raise questions about the feasibility and importance of housing within the city center.

This research project is an urban housing scheme for central city Christchurch that combines the disciplines of Urban Planning and Architecture in an attempt to build on and improve the “100-day Blueprint plan” released in 2012. This project explores housing through an analysis of site specific environmental, economic and social factors. Urban housing can be a solution when used as a tool to improve pre-quake conditions and to bring life and people back into the city. Specifically this design research examines the people and places affected by the proposed the “eastern frame”. This research revealed the need for a new typology of urban housing to mitigate the prevailing east–northeasternly winds, with the long term objective of creating an improved urban environment for pedestrians and residents.

From this research it became clear that New Zealand urban housing shortages could be approached in a different way, perhaps using satellite suburbs or small apartment complexes in a larger comprehensive development that included other uses. This discovery has resulted in a project that calls for both the public and private sectors to work together on a 50 year long term plan, with staged design and build processes to enhance community engagement, and with the objective of re-establishing a connection and sense of community ownership through design.
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1 INTRODUCTION

1.1 RESEARCH QUESTION

Housing is extremely important. It makes up the majority of most architects work and is what we inhabit during our lives. Housing is strongly associated with health and wellbeing and for New Zealanders our homes are often the biggest investment we will make in our lives. However, and much to the detriment of our urban landscape and the quality life in our largest cities, housing is often given less attention than it deserves by developers; and Christchurch is no exception to this rule. Christchurch is the largest city in the South Island and is currently undergoing a period of change due to the magnitude 6.3 earthquake that hit on February 11, 2011, and the subsequent aftershocks. These seismic events resulted in the loss of 185 lives and also created a large stock of damaged buildings that needs to be demolished and replaced.

This project will examine the definition of urban sustainability indicated through the New Christchurch Center City Plans. The research will investigate how the current plan has developed from historic theory, and what planning mechanisms and guidelines have been employed to direct the rebuild of the Center City, with an emphasis on housing and the quality of the pedestrian environment.

This project is an Urban Housing Scheme for Central City Christchurch that combines the disciplines of Urban Planning and Architecture in an attempt to build on and improve the quality of the urban pedestrian environment. I aim to demonstrate how, through an investigation into climatic factors such as wind, the typology of a new urban housing can emerge, to mitigate the effects of the prevailing east–northeasterly winds, and to improve the urban environment for all of Christchurch’s community.
QUESTIONS:

What role does housing play within the Christchurch rebuild and is it a sustainable and feasible option to rebuild housing within the city’s center?

Original Title: Defining Sustainability: An analysis of Christchurch post-earthquake management of urban housing.

Hypothesis: The post-quake urban guidelines for center city Christchurch are not ‘sustainable’ as defined by the New Center City plan.

Revised Title: Occupying the Edge: Christchurch Urban Housing

How can the new development Blueprint Plan be an effective tool for the re-integration of quality housing back into the Christchurch’s central city?

1.2 OBJECTIVES

Objective One: To develop an innovative housing project which improves the quality of the Christchurch center city environment and provides another option for housing.

Objective Two: To design a housing project and framework that is comprehensive in its long term development and involving a high level of participation from the local community, government and private entities.

Objective Three: To reclaim the street and improve the urban pedestrian environment, by prioritizing the needs of pedestrians and public transport over private car users.
1.3 DEFINITIONS

Urban Density: There are two main measurements of urban density used in this study; the first being People Per Hectare (pph) as this unit is widely used in New Zealand urban planning documentation to categorize residential zones. A second unit of measurement is Units/Dwellings per Hectare (dph). “The average Christchurch household had 2.5 people per dwelling pre quake 2010\(^1\) which will serve as an occupation rate for the purposes of this study.

Residential Density: the number of dwelling units in any given area, used to measure neighbourhood population density.

Urbanism: Much urban planning has been tied to recent theories particularly in North America and the UK, premised on raising urban densities, in particular, “New Urbanism”, with parallel and complimentary theory in “Transit-oriented development”, “Smart growth”, and others. These theories are influential, have been visible in pre-quake Christchurch (for example the Pegasus project), and are characterised by a neo-traditional approach to design.

Urban Sprawl or Suburban Sprawl: Is a multifaceted concept centered on the expansion of auto-oriented, low-density development. In this research, the term will refer to the outward spreading of a city and its suburbs by uncontrolled growth.

Sustainability: A sustainable city is often limited to the concept of a city designed with consideration of environmental impact, inhabited by people dedicated to minimization of required inputs of energy, water and food, and waste output of heat, air pollution and water pollution. For the purposes of this study, architecturally sustainable design also attempts to respond to social and economic factors along with environmental ones.

1.4 SCOPE AND LIMITATIONS

Although there exist many planning documents and tools that have been used by Christchurch City Council to control urban development, due to the dynamic and changing nature of the present situation, I have narrowed the scope to study the three key documents: the Greater Christchurch Urban Development Strategy and Action Plan 2007, the Draft Central City Plan 2011, and the Christchurch Central Recovery Plan 2012. This will result in a design that responds to the situation as of the end of 2012, not including further events after that time.

This research has evolved from an analysis of the definition of sustainability for urban housing in Christchurch City, with regard to the Draft Central City Plan 2011, combined with an analysis of the habitability of the urban environment. It is also a response to the Christchurch Central Recovery Plan released in 2012, and is specifically concerned with the Blueprint Plan mentioned within that document.

The design process resulted from a site investigation into pre-earthquake climatic, social and economic conditions as well as the future application of city planning documentation such as the Blueprint Plan\(^2\).

Environmental design factors such as controlling prevailing winds have emerged as key to achieving a successful urban intervention scheme for the rest of the new city centre. The primary aim of the design is to improve the urban environment at pedestrian level.

Sustainable housing can be roughly divided into economic, social, and environmental elements. As the scope is a large urban housing scheme, this project does not seek to solve all of the problems associated with urban housing, but it will suggest possible solutions for the specific site, based on site and case study analysis and applications of emerging technologies. This project seeks to identify the elements of the scheme that will have the most impact on improving the streetscape environment to encourage pedestrian movement in and through the site.

This project does not set out to criticize the feasibility of the Council plans for the central city; instead it examines the role housing could perform within that plan. The research seeks to enhance the proposed design and improve the quality of the urban environment to demonstrate a feasible solution that reinstates housing in the city, and community ownership of the space.

\(^2\) Christchurch City Council, Christchurch Central Recovery Plan, 2012, 33-34
2 METHODOLOGY

2.1 OVERVIEW

The project’s methodological approach is developed from the combination of the two research fields of Architecture and Urban Planning. The focus of the research was determined by key attributes of the scheme: Urban Housing and the environmental, economic and social sustainability opportunities that result from the circumstances created from the Christchurch earthquake. Combining investigations into literature and current practice with the process of generating design solutions the project was then able develop in complexity to generate ideas and solutions that could have a direct effect on the rebuild of the Christchurch Central City and the way designers approach and research urban housing schemes in the future.

2.2 URBANISM & ARCHITECTURAL THEORY

The quickly changing environment of post-quake Christchurch resulted in many adaptations of the brief including an entire revision of the scale and aim of the brief at the end of 2011 due to the release of new planning documentation by the local government. A decision was made to use the new planning documentation as a guide/base document and to disregard any further changes in order to reach a definitive answer and design outcome responding to the research question. Throughout the project, research was constantly revised, re-visited and integrated with my master planning and design process, taking elements from conventional research and research by design.
2.3 DESIGN CRITERIA

Due to the large area of inner city land designated for reconstruction it was necessary to reference a number of important national and international housing developments that analyse housing in terms of its long term success. Key principals that guided design were based on evaluating the three areas of sustainability, in conjunction with the central city development plan released by the local council September 2012. Site analysis research further identified specific design elements and factors that influenced and reshaped the direction of design.

2.4 CASE STUDY SELECTION & ANALYSIS

An overview of case studies was an important step in analyzing and understanding how to go about designing a Sustainable Urban Housing project. After analysing many projects, I have chosen to cover three examples in depth, discussing their strengths and weaknesses in terms of sustainability. These schemes were chosen most notably because all of them have been regarded as successful in creating quality housing and each exhibit key traits that are well documented and analyzed post construction and reveal the level of success from the inhabitant’s perspective and their acceptance into the wider community.

The examples include two European projects, Dutch and English, and one from New Zealand:

THE EASTERN HARBOUR DISTRICT, Amsterdam, The Netherlands

ACCORDIA, Cambridge, United Kingdom

BEAUMONT QUARTER, Auckland, New Zealand
2.5 SITE SELECTION & ANALYSIS

Christchurch is a unique city in New Zealand as unlike the two other largest cities, Auckland and Wellington, Christchurch is not strongly defined by its coastline or hills and its streets are planned in a grid formation. The combination of these two elements, flat terrain and a grid street plan make it a potential ‘model city’, and facilitate its comparison with other cities internationally.

Christchurch is also unique for being a city with a well-documented ‘dying’ city center. The earthquakes and widespread damage to the urban fabric created huge potential to re-design a new way for Cantabrians to live and re-engage with the city center. The final site, to the east of the Cathedral Square in an area referred to as the ‘east frame’ by the Blueprint Plan, was chosen due to its proximity to the heart of the city, and public transport hubs. The site is also one of only two areas within the Blueprint Plan selected for residential development within the four avenues and being situated to the East offers one of the closest options for re-locating residents from the eastern suburbs.

I visited Christchurch three times during the research period and lived there for one month while participating in the Studio Christchurch Summer School in January 2011, which was conjointly run by Auckland, Victoria University and UNITEC and hosted by Christchurch (CPIT) Architecture school. This visit was a transformative experience not only due to the ability to walk through my site every day on my way to and from CPIT, but also through exposure to local residents and experts living there. It transformed the focus of my research from an environmentally focused sustainable design to acknowledge that to design a project of this large scale required also examining the social and economic factors as they all impact on the success of the development.
2.6 DESIGN PROCESS

Master planning and design work were on-going throughout the process of initial research and were considerably influenced by the site research, especially climatic factors such as prevailing winds that required for large changes to be made to building form, density and configurations throughout the design process.

The site analysis was central to my design and I soon discovered that context was important. The design process was in interesting exercise in working with scale, working back and forth between master planning and localized zones to smaller built elements and then repeating this process. Due to the fact that the future of almost all the buildings on the site was under dispute, the decision was made to keep and include only the three existing buildings that were detailed in the Blueprint Plan. The same logic has been applied to the surrounding buildings: in principle, where any building is still standing but is under dispute, it is assumed that it will eventually be replaced with a building of approximately the same height and scale as that indicated in the Blueprint Plan.

Throughout the design process changes to the building height and population density required constant revision and a variety of design tools. Physical and virtual 3d models of site were utilized throughout the design process along with 2d drawings of plans and sections. In particular wind tunnel tests of the site model to establish pre- and post-earthquake pedestrian wind conditions and potential design outcomes were a key design tool assisting with an architectural solution to the question proposed.
3 CURRENT STATE OF KNOWLEDGE

3.1 URBANISM THEORY

The art of town planning has developed from a need to provide comfortable and healthy living quarters and enhanced trading and goods production, along with aesthetic beauty in built environments. The Vitruvian synopsis on city planning, of which architecture is an integral part, implies the presence of a plan, a physical layout that enhances the functional capacity and purpose of the city, most commonly influenced by the existing geographic terrain and population parameters. In his work “Ten Books on Architecture” written around 15 BC, Vitruvius defines several principles associated with choosing appropriate sites for Roman buildings and for the habitation of cities. However, these were not rules for everyone to follow, but rather a record of particular Roman guidelines that were being applied at the time corresponding with his role as an architectural historian. These principles give the first recorded insight into the methodology of planning, how it was employed, and the thought behind it. Vitruvius’s commentary on construction continued from fortifications, to street planning and establishing the internal divisions of a city, through the incorporation of housing plots and street design. It also took note of climate control. Vitruvius stated with absolute conviction that the orientation of a city must be planned in accordance with the movement of the winds so that these may keep inhabitants of the city healthy.

The Garden City movement was a method of urban planning which emerged in Europe around the end of the 19th century. It was devised by Sir Ebenezer Howard, who in 1899 founded the Garden Cities Association, known today as the Town and Country Planning Association. Howard criticized the way modern cities were being developed and thought people should live in places that would combine the best aspects of both country and town living.

The movement was intended to combat the overcrowded and unhealthy living conditions in European cities, which had resulted from industrialization. The movement proposed a combination of town and country through the introduction of green belts to the city and the clear zoning of activities, separating residences, industry and agriculture. These communities were envisioned to be small, environmentally and economically self-sustaining capsules with a population limited to 32,000 people. This movement should not be confused with that of “garden suburbs”, which defines a large number of New Zealand suburbs.


4 Hall, P, Cities of Tomorrow (3rd ed.), 2002
built on the outskirts of cities many miles from employment centres. Thus these suburbs have become heavily dependent on transport to allow workers to commute into the city.

In the 1920s the ideal of ‘living in a park’ was advocated by Le Corbusier, an architect from the modernist movement who was dedicated to improving living conditions for residents in crowded cities. Corbusier was also an enthusiast for modern technologies, particularly motor cars, which now have a huge influence on our city forms, and are consequently somewhat responsible for the currently prolific urban sprawl.

The definition of social, economic and environmental sustainability has become a prominent topic over the last sixty years. Jane Jacobs\(^5\) analysed the social and economic impacts of the built environment on American life, and was a critic of the suburban sprawl that occurred around the 1950s as a result of rising rates of car ownership. Jacobs observed the connection between the larger urban context and the social conditions of the neighbourhoods within them right down to individual buildings and the people inhabiting them. At the same time Peter Clark\(^6\) was observing similar trends in the New Zealand urban environment, predominantly the effect the private automobile had on facilitating unchecked suburban sprawl. He proposed similar solutions to Jacobs’, such as higher density housing and improved public transport, including electrified railways.

A movement called New Urbanism drew on earlier works (for example, Jane Jacobs The Death and Life of Great American Cities; Christopher Alexander, A Pattern Language) and emerged in the 1980s with a populist agenda, advocating neo-traditional development. Wheeler describes the main urban characteristics of New Urbanism as focusing on compact, efficient land use, less automobile use, but improved pedestrian access and flexibility, efficient use of resources, minimised pollution and waste, good housing and living environments, a healthy social ecology, a sustainable economy, community participation and involvement, and preservation of local culture and wisdom.

Alexander’s later book, A New Theory of Urban Design (1987), coincided with a renewal of interest in Urbanism among architects, but stood apart from most other expressions of this by assuming a distinctly anti-master planning stance. Instead, it emphasizes the richness and quality of spatial experience and the natural formation of the city as an organic event, with one building influencing the

\(^{5}\) Jane Jacobs, The Life and Death of Great American Cities, 1961
\(^{6}\) Peter Clark, Problems in the New Zealand Urban Environment, 1972
According to Alexander “At the core... is the idea that people should design for themselves their own houses, streets and communities. This idea comes simply from the observation that most of the wonderful places of the world were not made by architects but by the people”.7

This is a clear rebuttal to urban planning and any top-down control of town development. While Alexander argues that citizens need to take complete ownership of their environment, using guides like a pattern language to help inform construction, the fact remains that the government needs to step up and support initiatives that bring people back into the city at a higher density as a reflection of urban growth. Ian Bentley⁸ gives a detailed review of the processes, agencies and relationships of power which are implicated in the production of urban spaces. Bentley sets out a well-rounded analysis of the shortcomings of the theoretical positions, which inform the design of towns and cities. His critique, which he describes as ‘structurationist’, proposes instead a design methodology based on the adaptation of generic cultural structures or ‘types’.

Cesar Wagner – Urban Dwelling 2002 addresses urban poverty and the strong link between suburban sprawl and a growing divide between rich and poor: he observes the way poorer residents are pushed to the outer limits of the city to find affordable housing, resulting in more expensive travel to work, school and social amenities offered in the central city, costing the family more than they can afford, and potentially resulting in increased poverty and social exclusion. Wagner mentions political initiatives in Brazil, notably through the introduction of Participatory Budgeting (Orçamento Participativo) which allows residents to form community groups and have a say on funding, and its allocation. Although this process is more costly and time consuming, the end result is that the funds are allocated more efficiently, and that residents in the community feel they have a stronger sense of community and social value.

Looking in more detail at urban housing, Matthew Cousins in his book Design Quality in New Housing⁹, discusses the importance of quality in housing and how it can be attained and measured. Cousins analyses the political nature of large housing schemes with regard to government and community involvement and by exemplifying housing schemes in the Netherlands and England. He acknowledges the complexity of such housing schemes, noting that

7 Christopher Alexander, A Pattern Language, 1977
8 Ian Bentley, Urban Transformations, 1999
9 Matthew Cousins, Design Quality in New Housing, 2009
the procurement, design and construction of new housing is demanding and complex with commercial pressures weighing against the time-consuming investment of implementing quality. The case studies demonstrate the importance of urban design, noting how housing developments should offer a variety of well-designed urban solutions for neighbourhoods such as a separation between public, semipublic, and private spaces and courtyards, road layout and spatial design.

Parking Policy and design need to be radically rethought and examples such as new housing projects in the Netherlands and the United Kingdom can be used as a precedent for what can be achieved with a diverse parking environment. There is more central and local government intervention in the development of Dutch housing at an early stage of housing developments than in the United Kingdom. There is a fine line between state intervention and individualism; market forces alone cannot produce good quality housing, and Cousins argues that individual design should flourish through a properly enforced and monitored planning framework. The new Dutch housing projects as documented by Cousins\(^\text{10}\) are of a better standard when applying CABE’s (Centre for Architecture and the Built Environment) 7 point analysis, than the United Kingdom’s projects with a strong connection to more interventionist government guidelines, where design is controlled and monitored.

In 2010, Jan Gehl wrote Cities for People, discussing changing demographics and lifestyles. Gehl emphasizes four human issues that he sees as essential to successful city planning. He explains how to develop cities that are lively, safe, sustainable, and healthy. Focusing on these issues leads Gehl to think of even the largest city on a very small scale. For Gehl, the urban landscape must be considered through the five traditional human senses and experienced at the speed of walking rather than at the speed of riding in a car or bus or train. This small-scale view, he argues, is too frequently neglected in contemporary projects.

New urbanism corresponds to three parallel theories: Transit Oriented Development (TOD), Sustainable Development, and Smart Growth. These theories are all urban responses to improve the ecological sustainability of the urban environment, increasing efficiency and minimising our ecological footprint. The theory of Smart Growth deals with compact urban centres, resulting in transit-oriented, walkable and bicycle friendly land use and mixed-use development with a range of housing choices.

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10 Matthew Cousins, *Design Quality in New Housing*, 2009
New Zealand Smart Growth is referred to as Urban Intensification due to the emphasis on avoiding urban sprawl and intensifying urban centres in key locations. Urban Intensification is a strong driver in New Zealand planning and can be recognised in documentation such as the Auckland Regional Growth Strategy\textsuperscript{11} and the Greater Christchurch Urban Development Strategy\textsuperscript{12}.

In 2009, Gehl Architects undertook a Public Space Public Life Study of Central Christchurch\textsuperscript{13}. The study focused on the area bounded by Kilmore Street, St Asaph Street, Rolleston Avenue and Madras Street and analysed the way people used Christchurch’s central city spaces; the study assessed the quality of these public spaces and looked at how these could better sustain public life and create a better sense of community. The study suggested for Christchurch to create a central city where pedestrians, cyclists and public transport are given priority, where there are strong links between amenities, and to strengthen the city’s identity through the creation of public places, which are good for living, working and playing for all age groups. Gehl’s study criticized the lack of active frontages and hostile streetscapes for pedestrians and suggested removing street parking and widening the footpath as key steps to drawing people back into the city.

These urban planning theories are not only highly influential in New Zealand: some cities in Europe and the United States are beginning to utilise these New Urbanism principles. However, the uptake remains a contested issue with some experts such as Jan Gehl\textsuperscript{14} and Peter Calthorpe\textsuperscript{15} arguing for creating condensed medium density cities that are less automobile dependent, but others defending the status quo. At the same time New Urbanism has been criticized for asserting universal principles of design instead of attending to local conditions\textsuperscript{16}. F. Van Der Hoeven\textsuperscript{17} and Yvonne Rydin\textsuperscript{18} both approach the subject from a planning perspective, pointing out that the principles are only guidelines that need to be redefined and modified to specific cultures, environments and political systems before they will work. Criticism generally focuses on the high reliance of planning regulations to control development, instead of allowing the initiative for construction to be taken by

\textsuperscript{13} Gehl Architects (Urban study of Christchurch) 2009
\textsuperscript{15} Peter Calthorpe, Urbanism in the Age of Climate Change, Washington, DC : Island Press, 2010.
\textsuperscript{17} F. Van Der Hoeven and H.J Rosemann, eds., Urban Transformations and Sustainability, Amsterdam, IOS Press, 2006.
the final users themselves.

The book Growth Misconduct; Avoiding Sprawl and Improving Urban Intensification in New Zealand published in 2011 revisits many of the arguments raised by Peter Clark in the 1960s relating to New Zealand’s particular crisis with urban sprawl. Growth Misconduct goes further, emphasising the consequences of not fundamentally changing the way we plan and control our urban growth and its detriment to our city environment. Now New Zealand, like the United States of America and England in the 1960s, has to look at alternative planning solutions to increase its urban densities. New Zealand cities, Auckland and Wellington have expanded across Greenfield sites, experiencing growth of detached homes along the fringes with consequent issues that include the excessive use of energy for transport as well as many other environmental and social consequences. Various authors also demonstrate how New Zealand has a very different culture with a history of immigrants drawn to the country by its open spaces and the aspiration of owning and, sometimes, working on the land.

Urban design is defined by demonstrating how the urban environment is controlled by an urban plan, with all of the buildings being treated as a whole unit instead of separate entities. When urban plans can have such a huge impact on architecture it is imperative to take a deeper look into the new plans and how they will influence Christchurch to not only use less energy and be environmentally sustainable but also increase the efficiency and enjoyment of daily lives to be economically and socially sustainable.
3.2 CASE STUDIES

1) **The Eastern Harbour District**, Amsterdam, The Netherlands

Total site area: 50ha

Density per Hectare: 100dph; approx. 300 pph.

Outstanding qualities: Variety of typologies, scales, affordability. The long term staging of construction and resident consultation and review system, communication between governing authority, residents/community and private investors is exemplary. Some of the housing was too small with constricting and inflexible design, and not enough gradation between the public and private domain, but overall this is an excellent example of a city housing project: complex in process, but mostly reliant on strict government controls, the scheme encourages the architects to work with what they could within tight design constraints, fostereing creativity. Part of the incentive was for young graduate architects to design the façade treatments on some of the low income housing to encourage variation. The developers also allowed for around 20% commercial occupation and a number of community facilities, incorporating quite a high percentage of mixed-use buildings into this development.
Two docks in Amsterdam take on new life as a suburban-style housing project, pick up an award for urban design, and get star billing at an exhibition at Harvard Design School.

Population (6 May 2012)
- Municipality/city: 820,654
- Density: 3,506/km² (9,080/sq mi)
2) ACCORDIA, Cambridge, United Kingdom.

Total site area: 9.5ha

Density Per Hectare: 80 dph

While 65% of the site was designed by one architecture firm, two more were brought in, resulting in a high quality housing development with a successful variation of housing options. This is more an urban infill and refurbishment project - such as retrofitting old office buildings - than a brownfield site, but it has achieved a good mixed density. Again, the local council was established in a leading role from the outset. Some of the weaker aspects of the site include the low commercial occupancy at only 5%, a lack of community facilities and public space, and an inflexibility in the design, with only a small percentage of the flats having the potential for adaptation, conversion or extension.
Figure 3.2.9 Elevation of housing along park edge

Figure 3.2.10 Private external open space

Figure 3.2.11 Section through apartments
3) BEAUMONT QUARTER, Auckland, NZ

Total site area: 2.4ha

Density per Hectare: 100dph

This housing development is portrayed as one of the most successful to date in New Zealand, winning multiple awards and high praise both from an economic standpoint, and from its residents. The successful aspects of the development are the strong typologies and identity of the site, the staged construction process and the wide range of price options, though this does not extend to low-income housing.
A negative aspect of the site is the lack of usable outdoor spaces and although it demonstrates a clear delineation between the public and private spaces the proximity and overlooking of these spaces by above apartments is such that they become uncomfortable spaces to linger. This is a positive attribute in terms of privacy and safety for the occupants, but a strong negative when it comes to building community identity as it discourages residents from interacting with others living in surrounding streets. It is also a hindrance to businesses using the ground floor of an apartment as it discourages foot traffic. The development is arranged on leasehold land which has lead to severe problems with ground rent renewals, resulting in some freehold purchases recently, following the bankruptcy of the original developer.
3.3 SITE HISTORY

Christchurch is the second largest city in New Zealand and the main economic centre of the South Island. It was home to around 377,000 people in 2010, about 8.5% of New Zealand’s population. The city of Christchurch was founded in 1850 on flat swampland where the Canterbury Plains meet the Port Hills. The uniform street grid was laid out by Edward Jolie with natural elements such as riverbanks, open squares and Hagley Park serving to relieve the uniformity. This strong street grid of large city blocks of 220 by 100m meters remains an important part of the city centre’s identity, especially since a majority of the built environment has been lost. The grid has now gained in importance, and combined with the remaining infrastructure is one of the reasons behind the decision to retain the centre city.

In the 1880s Christchurch became firmly established as the commercial capital of the Canterbury region, while the metropolitan area quickly outgrew the original city. Brick and stone building construction replaced earlier timber constructions with a collection of public and commercial buildings in a variety of styles. Most notably, gothic revival and the Christchurch modern have been the postcard architectural styles associated with the city.

Christchurch was identified as a “Garden City” as early as 1906 at the International Exhibition, with wooded England replacing almost all of the natural vegetation with lawns and specimen trees, most of them being exotic. All of the central city public green areas were lost in the rebuilding that followed the 2010 earthquake.

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19 Christchurch City Council, Christchurch Central Recovery Plan, 2012, p.10

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Figure 3.3.1 Christchurch City Market Square 1852
spaces such as riverbanks, and Victoria, Latimer and Cramner Squares were landscaped accordingly. This demonstrated the strong connection that the Christchurch settlers had with their English homeland. Recreating it helped with homesickness and life in this foreign land, and to this day the English garden connection is a strong part of the identity of Christchurch.

The majority of current housing stock comes from the 1960s, when the increased use of private cars transformed the role of the central city. The use of public transport and bikes declined, and suburban sprawl commenced as a consequence, with new suburbs growing on the city’s periphery, a practice which was also occurring throughout the rest of New Zealand. Decentralization was the planning mechanism at the time. Suburban malls developed as the main hubs of social activity and these trends continued throughout the rest of the 20th century.

The beginning of the 21st century coincided with
a redevelopment of Christchurch, with a focus on low rise, urban infill and adaptive reuse, as outlined in documents such as “The Greater Christchurch Urban Development Strategy and Action Plan” of 2007. These changes in thinking were reflected in projects such as Litchfield Lanes and the Arts Centre, increasing the quality of life within the center city through urban and architectural design.

The central city of Christchurch was then devastated by a series of earthquakes, which began on the 4th of September, 2010. A total of 185 people in the city lost their lives as a result of the following earthquake.
on February the 11th in 2011. Over 150,000 homes were damaged and around 30,000\textsuperscript{20} were seriously affected and needed to be demolished. The phrase “it’s munted” has become stoical shorthand for describing catastrophic damage to homes, heritage buildings, streets and infrastructure\textsuperscript{21}.

With all the positive urban changes that were underway pre-quake, Christchurch seems like a city that could use these catastrophic events to re-design the city, taking advantage of the situation to raise the quality of urban spaces and to reverse the urban sprawl created during the last half of the 20\textsuperscript{th} century, while placing importance on the pedestrian rather than the car.

\textsuperscript{20} Statistics NZ, \textit{The economic impact of the Canterbury earthquakes}, 2012
\textsuperscript{21} Christchurch City Council, \textit{Draft Central City plan}, 2011, 82.

\textbf{Figure 3.3.6} Elevation along Hereford st pre-quake 2012
3.4 CHRISTCHURCH URBAN PLANNING

Christchurch is a well-documented city with a widely acknowledged problematic city center that was dying and becoming dangerous place to reside. As a result the city’s urban fabric and pedestrian movement was studied by Gehl architects in 2009, with their end report resulting in a change of policy through urban planning guidelines and government intervention. In addition to this the following plans demonstrate the direction and approaches to urban planning recently employed by the local government.

1) The Greater Christchurch Urban Development Strategy and Action Plan, 2007: The last significant change made to the urban plan before the earthquake that included the central city of Christchurch was The Greater Christchurch Urban Development Strategy and Action Plan, 2007. This plan was based on New Urbanism theory, with a particular emphasis on social and environmental sustainability and the promotion of densification and centralization as a tool to re-energize the central city.

2) Central City Plan: Draft Central City Recovery Plan for Ministerial Approval 2011: This plan was developed by the Christchurch City Council as the first attempt to provide direction for the city post-quake. There was also a huge public engagement campaign project run by the council called ‘Share an idea’, with a high level of community engagement emphasized throughout the document, highlighting the bottom up nature of the scheme.

“The Central City Plan will be redeveloped to be home to a thriving cosmopolitan community which will celebrate the city’s heritage and promote a bold new vision for urban sustainability” 22

This document is quite comprehensive and contains a substantial number of ideas that were put forward by the NZIA. Five key changes are outlined, which are the focus of the Plan.

1 Green City – more public parkland, urban planting & sustainable building practices.

2 Stronger Built Identity – medium rise, adaptive re-use, densification, more urban design controls.

3 Compact CBD – high density CBD, focused to

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22 Christchurch City Council, Central City Plan: Draft Central City Recovery Plan for Ministerial Approval Christchurch: The Council, 2011.p1
within two blocks of Cathedral Square.

4 Live, Work, Play and Learn – mixed use, high quality urban housing with new residential incentives and building controls.

5 Accessible City – easy to get around including more cycle paths, public transport, two-way streets and free parking.

3) Christchurch Central Recovery Plan 2012: This is the second and to date most defining document for future development that has been produced since the February earthquake 2011.

“A well-formed and vibrant city entre produces economic and social benefits by bringing people together for business, cultural or social activities. The result is greater productivity, connectedness, development of human capital, sharing of ideas and a shared identity”

There are ten central points expressed in this document: Compress, Contain, Catalyze, Support, Repair, Embrace the River, Open Space, Complete, Existing Value and Attract. These points actually pertain to the principal item brought forward in this plan, which is the introduction of the Blueprint Plan. This Plan is effectively a map that shows a generalized master plan for the central city, defined by the four avenues and locating the 16 key government projects that it will focus on, leaving the rest of the rebuild to be privately funded.

This blueprint focuses on sixteen anchor projects, one of which is a city block designated to become a residential demonstration project. The winning scheme in an architectural competition called “breathe” will be developed as a demonstration project.

One of the major new developments occurring since the draft plan was formulated is the introduction of “The Frame”, which seeks to create a boundary that will compact the centre of the city while providing more green space for the residents. The east frame around Latimer Square is dedicated to green, public, open spaces, which include residential developments. This development drastically changed the environment of my original site (which was previously in the
middle of a densely built up area) to an island in the middle of the proposed eastern frame open parkland.

On the larger scale, residential and mixed-use buildings have been side-lined and labelled as undesirable. They are waiting to be clearly zoned, separate from commercial activities, in specific locations and privately funded. This document clearly comes across as having a top-down agenda, containing sweeping statements like the frame project, and due to the official nature of the document and its use as a strong
marketing tool for foreign investors, the images produced already seem to be taking on permanence. For better or worse, this document has become a starting block for rebuilding Christchurch.

Observations: The first two documents allude to a dense mixed-use city focused around people, with the implementation of new standards and controls to improve the urban landscape and streetscape and with a strong emphasis on living in the city. These two documents place social and environmental sustainability as two of the most important factors that will lead to a thriving and forward-looking city. However, the blueprint plan is predominantly economically focused, with the council limiting its involvement in housing to focus only on projects that will bring in revenue. This document clearly separates out and decentralizes events and activities through powerful city zoning, and limits mixed use to the south-east, (the cold and windy part of the site). Housing, apart from the small demonstration block and a smattering of low density housing within the north and eastern frame, has been entirely left out of the plan.

Figure 3.4.3 Imagery Draft Central City Plan 2011
3.5 CLIMATE DESIGN

Vitruvius was one of the first to analyse and document the influence of wind on urban planning. His concept of wind was of "a flowing wave of air moving hither and thither indefinitely, it is produced when heat meets moisture, the rush of heat generating a mighty current in the air". In many ways, wind remained a mystery to Vitruvius. His firm belief in the ability of wind to make an individual sick was coupled with his desire to ensure wind was kept out of the living environment. He classified eight categories of winds, which can be seen on the Tower of the Winds in Athens, Greece. Vitruvius's diagram maps out the directions and names of the winds, which when combined with the ancient Romans' gnomon tool allowed the Romans to map out the paths of the winds and design the city accordingly.

Vitruvius’s diagram (figure 3.5.1 p30) could be interpreted to mark the quarters between each of the primary eight winds to line up the street design, so as long as the streets were obliquely aligned to the harsh winter winds, this would reduce the chilling effects at entranceways and courtyards:

Then let the directions of your streets and alleys be laid down on the lines of division between the quarters of two winds. On this principle of arrangement the disagreeable force of the winds will be shut out from dwellings and lines of houses. For if the streets run full in the face of winds, their constant blasts rushing in from the open country, and then confined by narrow alleys, will sweep through them with great violence. The lines of houses must therefore be directed away from the quarters from which the winds blow, so that as they come in they may strike against the angles of the blocks and their force thus be broken and dispersed.

Since Vitruvius’ time, and especially over the past twenty years, significant advances have been made in the science of wind engineering. In the book Urban Aerodynamics, it is made clear that building height becomes only an indirect factor of wind at pedestrian levels. A building’s shape, location and height relative to nearby buildings are now identified as the main factors that influence street level wind environments. International research has resulted in broad agreement on acceptable pedestrian and street level wind criteria. One of the key tools for measuring and comparing wind is the Beaufort

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24 ( used to measure the rays of the sun over the course of a day.


26 Urban Aerodynamics, 2009

27 Lawson 1973; Isyumov and Devenport 1975
Figure 3.5.1 Vitruvius’s wind dial

scale[^28], an empirical measure that relates wind speed to observed conditions at sea or on land. It is helpful when ascertaining wind speeds over, for instance, open water, but it is a less accurate measure in urban environments due to the turbulence created by ground surface roughness, which refers to objects or built forms that temporarily distort the wind path.

Pedestrian level winds first became a documented issue with the advent of tall buildings, most notably in Boston, in the USA. Tall buildings create a significant difference in the air pressure between their windward and leeward faces when wind blows directly onto them. Any opening through the building offers an opportunity for air to flow rapidly from the high pressure windward region to the low pressure leeward region. In the book Urban Aerodynamics[^29] it is emphasized that Buildings in urban environments are rarely in an isolated setting and wind tunnel studies or CFD computations are needed to predict pedestrian level wind conditions. One method mentioned is to model the tall building and its surroundings in a boundary layer wind tunnel and measure the pedestrian level wind speeds. “Data from such studies can indicate the probability of occurrence of wind gusts of various intensities, and also how much wind gust speeds would increase, compared to conditions before the tall building is constructed.”[^30] These tools allow urban planners and designers to explore the impact of alternative urban development on wind conditions before serious mistakes are made. Such mistakes can be very expensive and difficult to correct.

Winter wind shielding is another key design issue and trees and other vegetation are frequently used to ameliorate undesirable winds in urban areas. Heisler[^31] compared wind speeds in a field study of neighborhoods with and without trees, and found

[^28]: Beaufort Chart attached in appendix
[^29]: Urban Aerodynamics, 2009 page 12
[^30]: Urban Aerodynamics page 17
that neighborhoods with 77% deciduous tree density by plan area had a 43% wind reduction in winter and a 48% reduction in summer\(^{32}\). Further studies in this area have proven significant energy savings in heating and cooling can be made in areas with a similar wind shelter.

“...in high-rise urban centers it is possible to shape and orient large buildings so that much of the pedestrian level spaces are protected from strong chilling winds when they prevail from a particular direction. It is often the case that prevailing summer breezes come from a different direction, allowing designers to achieve the best for both climatic seasons.” (Heisler, 1990; 1393)

**Tools and Techniques for urban wind modeling**

Air flow through models of an urban environment is invisible unless visualization media are introduced into the air flow. In wind tunnel experiments, we used smoke and sheet lasers, and even though they were easy for the naked eye to pick up, they proved difficult to photograph, mostly due to the dense smoke in the foreground which obscured the locations of most interest. As a result we chose a quantifiable approach as a main indicator for design. This took into account the natural variability of wind, as wind engineering is

\(^{32}\) Urban Climatology p 17
essentially an estimation of the statistical probability of wind events at a particular location. This approach is necessary to determine the level of risk associated with the potential damage or benefit of an urban wind effect.

Due to the importance wind could have on the site, with the assistance of Reagan Potangaroa one of my assistant supervisors, I used a boundary layer wind tunnel to test the east-northeasterly wind’s effect on the east north-eastern frame in Christchurch Central City at a scale of 1:500.

Prior reading indicated how a windy environment around the base of a building, particularly near a main entrance or plaza area, will detract from the appeal of the site and perhaps discourage clients and shoppers from visiting the area. Similarly, outdoor pedestrian spaces should be protected from strong winds. There is a direct financial motivation to ameliorate the wind environment if it is going to adversely impact the appeal of a tenanted building. The parameters may include: the ambient wind statistics, local typography, building massing, nearby foliage and proximity to similarly tall structures.

In concluding remarks made in the book Urban Aerodynamics, the importance of and interest in the impact of urban microclimates, including wind effects on urban planning and design promises opportunities for collaboration between urban planners, designers and wind engineers: “City
governments have responsibility for the safety and convenience of people using urban public space in the forms of sidewalks, roadways, parks, and other public open space under their authority.”

From the climatic point of view, high-rise buildings may have distinct impacts on the ground level urban climate around them, especially on the urban wind field. One impact is the increase of the speed and turbulence of the wind, as the wind speed in the streets around high-rise tower buildings can be increased by up to 300 percent, and in specific locations even higher wind speeds could be experienced. Of all climatic conditions, modifying the urban wind conditions offers the greatest potential to improve the urban environment at pedestrian level. Wind velocities at street level can be suppressed or increased by various urban design elements, according to the different comfort needs in different climatic regions. In particular, urban elements such as the orientation of streets with respect to the wind direction, the size, height and density of buildings, the distribution of high-rise buildings among low-rise ones have a great impact on the urban wind conditions.

At particular locations the local wind speed may be very high, to a degree that it becomes troublesome, even in summer. This phenomenon is greatly affected by a high building’s design details and can therefore be controlled by applying appropriate details: “Of all the climatic elements the wind conditions are modified to the greatest extent by urbanization. The urban wind, more than any other climatic elements, is the one with that can be controlled and modified by urban design.”

The reduced wind speeds generated by the roughness in built up urban areas, which are a result of increased surface resistance that has been created, is well documented in many studies as noted in the book Urban Climatology. The roughness elements in a city are mainly buildings and while natural elements such as trees and hedges do assist, they are limited in scale, scope and permanence in an urban environment. “The airflow above and around the buildings attains a lower overall airspeed and a higher turbulence, due to friction by the buildings. Thus the urban wind field is characterized by a lower average speed but higher speed variations and turbulence, as compared with the wind flow over open country.”

This project deals with the transitional zone, which lies between...
the ground and the undisturbed wind flow above the urban air dome most commonly referred to as the urban boundary layer.

The research for this study has identified four key factors that can modify wind conditions:

1) The overall density of the urban area.

2) Size and height of the individual buildings; existence of high rise buildings.

3) Orientation of the streets.

4) Availability, size, distribution and design details of open space and green shelterbelts.

The wind speed and direction, mainly near the ground, is not fixed but changes constantly in time and varies between nearby test points. Gould in his book on climatology, notes that, “The intensity of the winds turbulence can greatly vary with urban areas reaching percentages of around 30% and in rural open areas it reached around 10 % turbulence”\(^\text{37}\). It can be assumed that the wind speed and turbulence in the built-up sections of the cities are different from those measured at the standard stations have, the wind speed may be lower and the turbulence higher.

In my opinion, a more useful approach would be to develop models of the urban wind to deal with the effects of specific urban design features on the urban wind field, as opposed to predicting a general urban wind speed using mathematical modeling.

The effect of urban density and building height on urban ventilation will also play an important role in design as it is usually assumed that an increase in building density reduces the airflow in the urban area due to increased friction. However, this effect depends mainly on the various physical details of the urban space, including the orientation of the streets and the buildings with respect to the wind direction.

The principal factors that determine the urban density effect on the urban wind speed are the average height of buildings and the distance between them. However, the most important factor with respect to a building’s height is the difference in the heights of neighboring buildings. While buildings reduce the speed of the “regional wind” near ground level, individual buildings rising above those around them create strong air currents within the area.

Climatic impacts of street width and orientation can vary when long rows of buildings in a city block are perpendicular to the wind direction, then shielded zones are established between the buildings where...
the wind speed might be just a small fraction of the speed above the buildings roofs, or in comparison to wind speeds in streets that are approximately parallel to the wind direction. On the other hand, when the blocks of buildings and the streets are parallel to the wind direction, the wind can blow through spaces between the buildings and along the streets, with a smaller retardation resulting from the friction with the buildings. In this case, much higher wind speeds will be in the streets, the sidewalks alongside the streets and in the open spaces between the buildings. However, the buildings are exposed to about the same air pressure on both sides, a factor that reduces the potential for natural ventilation of the buildings.

A special case occurs when the wind is oblique to the streets and the buildings along it (assumed parallel to the streets). If the buildings are of medium height, up to two times the width of the street, then the situation will be very different along the two sides of the street. The wind pressure and speeds will be very different over the two sides of the building and along the walkways. Pedestrians on the downwind side of the street will experience a much higher wind speed than the pedestrians on the sidewalk on the upwind side of the street. The reason is that along the downwind buildings a strong downward airflow will be generated by the winds, especially near junctions with cross-streets. The downward sidewalk will be directly affected by this downflow of air, while the other sidewalk will be sheltered from the wind.

It is similarly noted in Building Climatology that: “when buildings form long rows of the same height perpendicular to the direction of the wind, the distances between the buildings (within the context of an urban area with medium to high densities) have little effect on the wind speed of the wind currents between the buildings. This is due to the fact that the first row of buildings diverts the approaching wind current upwards, and the rest of the buildings behind are left in the wind “shadow” of the buildings standing in front of them.”

This is relevant for my site in so far as it is located in a park/open borderland where the urban environment has changed, meaning the buildings to be situated in my site have to be the ones creating the wind shadow, on the edge. This becomes an element in the architectural approach to design.

It is usually the case that the majority of wind comes from the turbulence generated by the air displaced from the currents above the roofs, which through friction generate some turbulence in these sheltered spaces. Streets and sidewalks parallel to the building

38 Building Climatology 1998 p. 293
blocks will also be shielded from the wind by the buildings, except at junctions with intersecting streets running parallel to the wind direction.

The flow pattern around high-rise building depends on several factors:

1) The geometrical configuration of the building, expressed in the ratio of its height to its width (the H/W Ratio).

2) Whether the upwind façade is flat, concave or convex.

3) The existence of lower buildings upwind from, and on the sides of, the high-rise.

4) The wind direction with respect to the façades of the building.

5) Specific design details of the high-rise building itself.

Individual buildings rising high above those around them create strong air currents in the area. This phenomenon is due to the fact that the high-rise building is exposed to the main wind currents that flow above the general level of the urban canopy, which are stronger than those flowing through the urban canopy itself. Against the façade of the high-rise building which faces the wind, a high-pressure pocket is formed, which causes a strong downwind current and in this way mixes up the air layers near the ground between the lower buildings.

In cold countries, and during the winter months in many hot countries, this current is undesirable as far as the comfort of the local residents is concerned, although it is always helpful in dispersing the air pollutants generated near the ground by traffic.

Building on these insights from the literature on climate design, the following ideas for mitigating adverse wind conditions around high-rise buildings are as follows:

1) Large slab buildings should not be oriented normally to the prevailing winds.
2) Circular and polygonal buildings produce reduced downflow.

3) Horizontal projections break and reduce the downward airflow.

4) Important pedestrian thoroughfares and entrances should not be planned at the windward corners of tall buildings.

5) Vegetation may also be used to absorb wind energy in pedestrian areas.

A study on this type of “urban roughness” from various collaborating universities in 2009 conducted a series of wind tunnel experiments using several types of urban building arrays to measure bulk drag coefficient (Cd) and mean wind profile. They concluded that “…the wind condition where transition of dominant flow regime from wake interference to skimming takes place will increase with the increase in height variations of the arrays. It is caused by the fact that the tallest blocks supply the main contribution of the total drag of arrays.”

Further conclusions state that: “… the standard deviation of array increases the total drag. Secondly, the array with the maximum rotation angles will increase the Cd because of increasing the frontal area in which drag force is acting. Lastly we point out that the effect of random geometry on aerodynamic parameters is significant to understand the air flow around the buildings in the real urban city.” (ibid)

In conclusion, there are various methodologies and design solutions that can be employed in Christchurch to greatly improve the comfort of pedestrians at ground level. What has become evident through this analysis is that government controls on urban form will have a key role to play in whether the streetscapes to be built will be inviting to pedestrians or will continue to push them away through the unintentional creation of turbulent wind conditions at pedestrian level.

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40 “Aerodynamic Parameters of Urban Building Arrays with Random Geometry” The seventh International Conference on Urban Climate, 29th June-3rd July 2009 Yokohama, Japan. Kyushu University & University of technology Malaysia. p133
3.6 TECHNOLOGY & SUSTAINABILITY

The earthquake and subsequent aftershocks that damaged so much of Christchurch’s built environment brought into question the feasibility of constructing on such unstable and unknown ground conditions, and further, whether the costs of rebuilding earthquake-proof housing would be too expensive for residential developments. This question inspired an investigation into soil conditions, technology and the affordability of construction post-quake.

Liquefaction due to buildings being situated on uneven soil conditions, and lateral spreading along the banks of the Avon river were the two biggest problems faced within the CBD. Christchurch was effectively built on a swamp which means that the soil conditions under the CBD can change dramatically over the space of a few metres. However, it is possible to build with foundations that respond to these variable soil types when a thorough site survey is done, and ground stabilization, where cement is drilled into the ground below and mixed with the natural sedimentation, effectively creating great concrete piles, can be undertaken. Tonkin & Taylor, with CERA (Christchurch Earthquake Recovery Authority), have published a basic city block by city block assessment of the center city ground conditions, including general guidelines for construction, and foundation requirements for each area\(^\text{37}\). Lateral spreading is most effectively combatted by leaving a 30m wide clearance zone along the edge of the Avon river and identifying where the old streams and springs

\(^{37}\) Tonkin & Taylor, Christchurch Central Core-Simplified Subsoil Zones, 2012

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**Figure 3.6.1** Interior of LVL wooden structure NMIT

**Figure 3.6.2** Canterbury university Post tension LVL seismic testing
were located within the block maps, in order to incorporate them into a design feature and avoid building directly on top of them.

There are also several affordable technologies and techniques for building in earthquake zones, one of them being base isolation and while still relatively expensive, projects are currently underway to improve affordability so these can be used for housing. Another construction technique is Post Tensioned LVL, which is similar to a rocking wall but substituting concrete for Laminated Veneer Lumber. This technique was developed in Christchurch by researchers at Canterbury University, and it is proving popular: it has been used in three two story buildings to date and is undergoing further testing so it can be utilized in tall buildings.

In short, technologies are still being developed but as the rebuild project would span an estimated fifty year period, the probability is that these technologies will in the future become more advanced over time and affordable later on. Perhaps with the scale of the rebuild and with high enough demand the rebuild could become the catalyst for a new building movement based in timber technologies.
A holistic approach to economic, social and environmental sustainability, in which the three areas addressed are given equal weighting where design decisions are concerned, would be the ideal way to approach a large urban housing project. However, after completing small studies in each area I have come to the conclusion that the most difficult aspect of sustainability is social sustainability. This was already a huge factor before the quake and it needs to be specifically addressed in the rebuild if the city is to work.

In this context, the UK-based advisory organization, CABE, made the comment that “place” is significant in holistic definitions of sustainability: “The quality of the public realm is reflected as a place with attractive and successful outdoor areas, and is a place where public and private spaces are clearly distinguished. Ground floors occupied by uses that relate directly to passing pedestrians create activity and interest. Streets and spaces that are overlooked allow natural surveillance, feel safer and generally are safer” and that “A successful place has a system of open and green spaces, natural features that are accessible.”

The design of public spaces should take into account the micro climate, the layout and massing of development should take account of local climatic conditions, including daylight and sunlight, wind, temperature and frost pockets. The microclimate will both influence and be influenced by the form of development, including the orientation of buildings and the degree of enclosure. Public spaces should be protected from downdraughts from tall buildings, as

How can urban design quality be assessed?

I have employed an analysis system that was designed by CABE for their publication ‘The Value of Urban Design’ \(^{38}\) to analyze my three case studies\(^ {39}\) as this system addressed all the issues that were central to my design process and provided a balanced assessment of the social success of such developments.

\(^{38}\) CABE’s *The Value of Urban Design*

\(^{39}\) CABE - analysis charts from case studies have been included in the appendix.
4 SITE ANALYSIS

Developing definitions of Sustainability.

4.1 Environment Analysis.

Christchurch has a dry, temperate climate, with mean daily maximum air temperatures of 22.5 °C in January and 11.3 °C in July. The summer climate is cool and mild and is often moderated by a sea breeze from the northeast. A notable feature of the weather is the nor’wester, a hot föhn wind that occasionally reaches storm force, causing widespread but usually minor damage to property. 40 In winter it is common for the temperature to fall below 0 °C at night. There are on average 99 days of ground frost per year. 41 Snow settles on average once or twice a year in the hill suburbs and in the central city, and about 4 or 5 times every two years on the plain. On cold winter nights, the surrounding hills, clear skies, and frosty calm conditions often combine to form a stable inversion layer above the city that traps vehicle exhausts and smoke from domestic fires to cause smog.

Parts of the wastewater and storm water network in Christchurch consist of ‘brick barrel’ pipes, constructed more than 100 years ago, between 1879 and 1882. These brick barrel pipes, located under streets in and around the city centre and Lyttelton, carry wastewater and storm water to the Bromley treatment plant.

Inside a brick wastewater pipeline. The oval-shaped base maximises sediment movement through the system.

The storm water pipes are circular brick structures and the wastewater pipes are egg or oval-shaped with a concrete base and brick arch. Both sorts of pipes, generally between 450 and 1300 millimetre diameter, and buried at two to four metres deep, suffered significant structural damage in the earthquakes.

MacDow Fletcher, as part of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT), is undertaking repairs and rebuilds on about 5km of brick barrel wastewater and 5.5km of storm water pipes.

Because of the danger of working in this underground environment, most of this work will use trenchless technology, a bit like keyhole surgery, which also minimises disruption on the street. MacDow Fletcher contractors will enter street manholes, then use robotic technology to move material into the pipelines. A machine will line the pipes with a spiral-bound material to seal and strengthen them. Any collapsed sections will be excavated and replaced.

This work will begin around mid April in Moorhouse Avenue and Madras Street, followed by works in Fitzgerald Avenue, Kilmore and Tuam Streets. Residents and businesses in these areas will receive a works notice with further information including confirmed start dates and the time-frame. More streets with brick barrel pipelines will be added in future.

In a previous article, we described some earlier repair work on storm water lines on Moorhouse Avenue [1].

Published: 05 April 2012
4.2 Economic Context

Housing affordability and availability were directly impacted by the earthquakes. Housing demand is now created as a result of housing stock losses after the earthquake. New sprawl due to housing developments on the fringes and lack of options for residents from the east to stay in close proximity to the city or their old neighborhoods is a predictable development industry response. The present location of poor housing shows how the selected site is not only labeled as part of the green frame but has become the edge of the more desirable zone.

An estimate based on an analysis from the Earthquake Commission damage bands contributes to the problem of housing distribution, but does little to resolve the social problem of re-locating and re-conconstructing communities.42

4.3 Social Context

The poorest households were the most affected by the damage from the earthquake, and now need a system to not only replace but improve on previous housing standards, which were, at best, often very inadequate. The disconnect and death of the city before the quakes (Jan Gehls study, 2011), and the need to address issues that were there before the quake, have been largely forgotten. It is no surprise that, “over half the respondents (51 per cent) in the 2012 CERA Wellbeing Survey reported having to ‘live day to day in a damaged home’ and 22 percent said this had a negative impact on their everyday life”.43

Community involvement and co-ordination between government and community groups have stalled, and there is a dis-connect at the human scale:. However, temporary projects (emergency housing, for instance) have demonstrated the potential to work collaboratively.

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42 Page 1 Canterbury Wellbeing Index, CERA Housing Affordability and Availability, June 2013.

43 2012 CERA Wellbeing Survey
Figure 4.1.9 "Void" Photos of site conditions East - West Divide
## Site Area Characteristics

<table>
<thead>
<tr>
<th>Site</th>
<th>Area</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>13.50ha</td>
<td>Large, expansive, empty. Currently earmarked as a big green borderland between commercial center city and low rise residential suburbia.</td>
</tr>
<tr>
<td>North</td>
<td>5.10ha</td>
<td>Residential in nature, has a water connection with the Avon, with a strong link to the north of the city.</td>
</tr>
<tr>
<td>Central</td>
<td>3.64ha</td>
<td>Strong connection between Latimer square and the cathedral Square. Main axis between Central City and residential suburbs.</td>
</tr>
<tr>
<td>South</td>
<td>4.71ha</td>
<td>Borderland with the commercial medium rise, “innovation precinct” CCTV ground location, possible memorial area, and edges with temporary cathedral, new stadium and link to transport hub.</td>
</tr>
</tbody>
</table>

Figure 4.1.10 Eastern Frame Analysis
Figure 4.1.11 Satellite image of site Feb 2011 pre-quake

Figure 4.1.12 Satellite image of site post-quake 2013
Figure 4.1.13 Shematic of unknown and known building footprints around site in context.

Figure 4.1.14 Eastern Frame Urban Plan by Christchurch City Council as part of the Blueprint plan

Figure 4.1.15 Perspective of Urban Plan by Christchurch City Council as part of the Blueprint plan
5 DESIGN PROCESS

5.1 MASTERPLANNING

With the changes made to the centre city plans over the last year my project has shifted focus from developing a design for one small “new urbanist block” to a 14.3ha urban park setting. The issues of sustainability have had to be radically re-addressed to engage the wider implications of urban planning and its impact on the pedestrian environment. Initially, I placed a heavy emphasis on the technological side of sustainability, on the city grid, and more broadly on a New Zealand urban identity. With the switch to a larger site the project developed the potential to have an impact on the whole city center: the design focus shifted from an exemplar city block that would establish design principles applicable to Christchurch to a more site specific urban plan and building typology.

Defining sustainability has now become a discourse about the edges of the centre city and the importance of protected and sheltered vs. exposed and open, and how to proceed from one environment to another. It became essential to identify which aspects of design...
Figure 5.1.5 Privacy from pedestrians in apartment blocks, using front gardens as a buffer.

Figure 5.1.6 Sketch demonstrating South to North gradients in height distribution.

Figure 5.1.7 Low rise diagram /cross section through site from East to West with canal and bridge.
Figure 5.1.8 Attempt to both feather the edges of the built environment and establish a sheltered corridor for pedestrians.

could have the most impact on the quality of the streetscapes to encourage pedestrian movement and the habitation of public spaces.

Since this shift from micro- to macro-urban intervention, I have examined existing and pre-quake building typologies and green belt concepts in the city, focusing on the edge and the expansive wide spaces created by the new plan for the Eastern Frame. The observation that made the biggest impression on me when I was living in the Eastern part of the city centre was the emptiness of public spaces and the lack of people. This was a well-known problem in the Christchurch city centre even before the earthquake, and was also observed in the study by Gehl Architects¹.

Therefore my principal aim became to not only bring more people into the city by providing centralized housing but to also enhance the pedestrian environment through prioritizing design decisions, placing the importance on people and not on cars.

Building on research about public-private partnership models employed by a number of local governments in the Netherlands, most notably the East Harbor Precinct (see: Example 1, Case Studies), the most effective rebuild of this area would be staged in three project areas all working with the larger urban plan but with different characteristics. With this type of ownership model the Christchurch City Council would have more control over building typologies, types of home ownership and the quality of the public environment.

¹ Gehl Architects – Study of Christchurch 2009
With the local government involved it would also be possible to monitor the types of accommodation in order to cater for a variety of incomes and a mix of typologies to encourage a mix of residents and small businesses. Typically, a 20% commercial, 20% high end housing, 40% middle income, 10% low income and 10% social housing range would make up the model. The aim of at least a 60:40 split in owner / renting occupation of the housing would encourage a commitment to the community and respect for the environment.

The developed programme aims to offer a range of housing typologies, from seven-story apartment blocks to three-story row housing. A distinction between different areas on the site provides options other than the typical three bedroom house. The building typologies also seek to respond to climate (wind, particularly), and the different soil typologies, utilizing the more stable ground to build higher, but with extensive soil stabilizing (reinforcements) larger foundations are needed. Underground car parks can be utilized to minimize car parking on the street.
Figure 5.1.10 Sketches analysing gradients between nature and built the built urban fabric

Figure 5.1.11 Introduction of a water feature running through the site along the eastern edge of the site

Figure 5.1.12 Sketch perspective of row housing either side of central waterway
which would allow wider pedestrian footpaths and cycle ways.

The current density of the city of Christchurch is comparatively low in comparison to most cities, with the highest residential density zone capped at 30dph. In initial schemes, I was aiming at increasing densities to 40dph, and due to the fact that Eastern frame is now widely perceived as a public park, I aimed at retaining a ratio of roughly 40% public park, 30% services (circulation roads, pathways etc.) and 30% housing. This schema utilizes planting and community gardens in a utopian model for sustainable suburban
living, with the intention of the housing development being at medium-density and providing for a total of 254 dwellings and approximately 635 people - a cautious approach that attempts to raise the density levels. I was looking to test this model for eventual use for infill housing, with a staged 50 year plan resulting in a much higher density. However, results from the wind testing indicated a huge problem for the pedestrian environment.
Figure 5.1.17 Building distribution diagram with central corridors and different scaled housing blocks conforming to the grid layout.
The main function of the housing will be to provide an affordable city centre living that not only improves the immediate environment of the housing development but also the wind environment within the central city. Key elements will include the arrangement of building, and the landscape design as another element, which would help with the wind environment. The staged plan, as developed, will include a large percentage of parks and allow for further development over the next thirty to fifty years.
The Avon Edge sector – this one-third of the site is conceived as having a transitional function, with a 4 storey height limit, lower density at approximately 50dph, to manage the shift in scale to the low rise historic residential suburbs and wetlands to the East. It will rely predominantly on planting and landscaping to moderate the effect of wind, utilizing rubble and soil excavated from the water features of the site to form hills and raised banks.

Urban Bridge – The main pedestrian link between the city, Latimer Square and the Eastern suburbs, where I will propose to re-locate the new church to be on the same central axis on Worchester Street.

Southern sector – the bottom third of the site borders on the proposed new stadium, and on the edge of the innovation precinct, which will be densely developed with the highest buildings up to 20m or approximately 5-7 stories.

The main features of this strategic plan will be a pedestrian corridor connecting the fan-zone with the High Street and the bus interchange, and a Memorial Park. Within this sector is the site of the Canterbury Television (CTV) building, which collapsed on February 22, 2011, and is the site of the worst casualties suffered from the earthquake.
Figure 5.1.23 Taller apartment block sketch with water introduced to site.

Figure 5.1.24 Apartment layout.

Figure 5.1.25 Section incorporating seismic structure landscape elements and smaller scale buildings.
Whilst participating in a Summer School called Christchurch Studio in February 2013 hosted by CIPT (Christchurch Polytechnic Institute of Technology) and run by a combination of the four New Zealand Architecture Schools, the experience of living in the center city of Christchurch taught me the importance of a habitable urban landscape. Some of the key factors that contributed to this design were a newfound appreciation for the wind and its ability to impact heavily on human comfort levels. For a design to be successful, it must enable pedestrians and residents to linger, essentially by offering sheltered spaces and safe pathways and seating.

Landscaping and planting also became much more of a design focus when earlier studies into the ground conditions and alluvial soil types led towards an investigation of the surface waters to form a better understanding of the landscape history. I was lucky enough to collaborate with local architects and landscape architects, specifically Di Lucas, a prominent landscape architect and community figure in Christchurch heavily involved in the rebuild as well as Jacky Bowring, the Head of School and Associate Professor of Landscape Architecture at Lincoln University. They both provided invaluable feedback, critique and guidance on the role water could play within my scheme and what sort of landscaping and planting systems would best suit the site. This design consideration led me to include a long waterway connecting the South end of the site to the North, feeding the Avon River through day-lighting old Victorian storm water drains. This element is also designed to remove pollutants from the water with a reed bed system. When streams are brought back to the surface and pass through reed beds many of the heavy metal pollutants from the cities runoff can be naturally removed.

This design element provided a backbone to the site and serves as a circulation tool and navigation guide. Pedestrian and cycle ways line both sides of the stream connecting with frequent small bridges as it runs through the center of the site, connecting up with the main features and meeting points. It does so without crossing any roads and linking in with the rest of the Green Frame which could potentially provide a loop circulation path around the city without requiring pedestrians to cross the paths of vehicles, or when doing so offering pedestrians the right of way.
5.2 WIND TUNNEL TESTING

Early research and experience on subsequent visits to Christchurch in 2012 have established the importance for specific design to minimize the effect of the prevailing Easterly wind on the site. Fortunately, I had the unique opportunity to test the wind environment with the supervision of UNITEC Associate Professor Regan Potangaroa, who is an expert in the field of urban aerodynamics, and has participated in the publication of the book *Urban Aerodynamics 2011*. Regan also has experience as a member of the Institute of Professional Engineers NZ (MIPENZ) and Registered Engineers for Disaster Relief (RedR) and his experience has been actively sought after in Christchurch by many of the agencies now dealing with reconstruction. I am greatly indebted to Professor Potangaroa for his guidance in this part of my research.

![Figure 5.2.1 Wind testing device](image1)

![Figure 5.2.2 Dan Sullivan and Regan Potangiora assisting in the set-up of the preliminary post-quake tests](image2)

![Figure 5.2.3 Perspective of Urban Plan by Christchurch City Council as part of the Blueprint plan](image3)
### Table 5.2.4

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1) Wind speeds have increased on average by between 72% to 551%.

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1) Wind speeds have increased on average by between 72% to 551%.

### Figure 5.2.4
Test with Smoke and Laser Light

### Figure 5.2.5
Dan Sullivan testing red and green Laser Light options

### Figure 4.1
Preliminary test results
We first tested the control situations before and post-earthquake (with all damaged buildings removed) at three separate wind speeds, approximately 5, 10 and 15 mps (meters per second) from a North Easterly direction, to establish that there is a clear correlation and that the wind speed measured at the specific points is producing a stable result. This also confirmed earlier experiments results from using the same model with an Easterly wind.

The experiments have been analyzed using relative criteria: having compared the projected wind speed (obtained from the wind tunnel testing) with winds at a location considered to have a wind environment acceptable for public functions.

From this initial testing, I established that a change in wind direction from east to east-nor-east creates a profoundly different effect on the wind environment, minimizing wind speeds at certain points and accelerating them at others, thereby creating different problems. While first testing the Easterly wind from location 4 at the corner of Worcester and Manchester St (along the main access from the centre of Latimer to Cathedral Square), proved to be the windiest with the biggest increase in speed, clearly indicating a strong need to shelter and protect this axis. These results instigated further tests with the control (post-earthquake model) applying the
prevailing east-nor easterly wind. This demonstrated that while there is still a huge increase in wind speed, around 200% at location 4, the streets further south see the biggest increase of wind speeds at points 5, 6 and 7. This result confirms the initial observation that the open park acts like a funnel directing wind into the city rather than providing shelter to the inner city.
Figure 5.1.12 Test of Blueprint plan building layout

Figure 5.2.13 Edge of Latimer Square

Figure 5.2.14 Potential of the Cardboard Cathedral relocation
These tests indicated the importance of developing a central wind barrier, a pedestrian “bridge” connection along the old Worchester street gridline, connecting the new compact centre city with the Eastern suburbs. This approach would utilize the built environment to provide a comfortable pedestrian environment; linking East and West, while minimising the overall wind speed encountered throughout my site and on into the centre of the city.

The next step was to test different building layouts to establish which ones would work best within the context of the site. This testing revealed the most effective layout at minimising the wind turbulence to be the corner connection and elimination of gaps near the edges of blocks. Another important design guideline produced was height to width ratio to induce skimming. For the squares to have less wind turbulence the height of the buildings had to be taller to allow for a wider gap between them before the wind touched down and created increased wind turbulence. These tests were conducted without any trees in the park as it takes time for large trees to become established. These tests indicated the importance of staging the construction in a way that would create a constructed corridor with buildings across the site first and that also allows the integration of the rest of the landscape.
The data collected in the wind tunnel tests are expressed as ratios representing wind speed coefficients, and were collected from the same points on the model at an approximate height of 1.5m above ground level at various wind speeds. The coefficients are an indicator of the probability of occurrence. I have used this quantitative site specific wind data to inform my design process in order to minimise the wind gusts and force at pedestrian level, to the benefit of both pedestrians and the residents of the housing project.
Scheem Comparison on main Street Entry Winds

Figure 5.2.21 Change in wind force pre and post-quake conditions

Figure 5.2.22 Comparison of wind force at central nodes

Figure 5.2.23 Model of pre-quake urban fabric condition
5.3 CENTRAL CORRIDOR

Softening of the urban edges created by the Blue-print plan was one of the first design decisions made in an attempt to lessen the severity of the plans initial contrast between commercial and residential zones. Experiments in scale, building form and facade treatment were conducted in large urban and small localized detail. A preference for two to four story terraced housing typologies was developed at this point in an attempt to avoid the introduction of compulsory elevators and large mechanical systems that would affect the mechanical sustainability of the project. This would also allow for connection to ground and private external entrances to each dwelling.

Relocating the temporary cardboard cathedral designed by Shigeru Ban and Warren & Mahoney Architects to the center of this new site creates a strong axis linking the green frame to the central city and old cathedral with the Eastern suburbs continuing through Latimer Square. The cathedral is ‘temporary’ and only intended to be in use for ten years but has the structural integrity to last for a minimum of 50 years. The building was initially designed with the intent of being later moved to another location and to serve another purpose. I propose that instead of leaving the Cathedral in place for 15-20 years, it be
re-located to this central site within my scheme to establish a civic scale and urban architectural event to the site along with assisting to establish a greater sense of hierarchy and order to the public—private quality of spaces on site.

As this project has grown and become increasingly more complex, the necessity to evaluate the method of construction and evolution of the project became vital as the space needs to become desirable and begin to attract people as soon as possible. A process of
staging was adopted to span over a 50 year period, roughly split into five phases, beginning with the introduction of new infrastructure and landscaping along with the planting of trees to establish a green framework for the proposed built development.

The introduction of community gardens began as a practical design tool to activate parts of the site and break down the large open space into identifiable locations and sections with distinct periods of ownership allotted to them. As the site and city will be under constant development the vacant land needs to be utilized by residents in the formation of community gardens and pavilions/instillations by com-

Figure 5.3.5 Gradation from High to Low Density

Figure 5.3.6 Final staging proposal
Figure 5.3.7 Plan of Final Scheme In Center City Christchurch
Community groups taking inspiration from such local projects as Gap Filler, led by Resident Coralie Winn. Gap filler provides a service for residents and community groups who have an idea to liaise with government and private land owners to lease for free the unused vacant sites for activities and installations bringing people back into the city. The community’s gardens correspond to potential future building footprints, this way local residents can be provided with the chance to interact and become involved with the site and help establish clear definitions between public versus private spaces to activate the unused space with minimum cost.
Figure 5.3.11 Central Block to Develope
5.4 APARTMENT DEVELOPMENT

One of the principal aspirations for the site was to design a scheme that catered for a wide demographic of people. The housing had to be varied or at least offer the possibility of change over time so that the housing units can be seen as a lifetime residence and not just for singles or couples starting out until they can afford to buy a larger place.

This development needed the potential to be flexible. Getting heavily into zoning will consequentially begin to limit the already limited options available to Christchurch residents.

I did not want to commit the crime of falling into a trap of zoning particular demographics and housing typologies together, which form the basis of research into social segregation in Cesar Wagner as well as Jane Jacobs analysis on the failed social housing schemes. The division of social hierarchy into the three distinct layers vertically was a suggestion from my Supervisor and one that after consideration seemed to fit.
Figure 5.3.14 Circulation of the Central Corridor & early design concept for Apartment block cladding.
Ground level properties were reserved for small businesses and universally accessible flats for the elderly and disabled. The lower middle flats on the 3-4th floors could generally be designated to small rental and subsidized housing. On the upper apartments, larger family units with access to private roof terraces and large balconies are placed. To achieve various degrees of separation from public to private spaces, units are arranged so that a maximum of eight apartments share the same entry and exits, offering the opportunity to establish connections and a familiarity with neighbors. The apartment buildings from earlier studies focus on providing cross ventilation for all apartments by using a double-loaded apartment where each unit has two external walls enabling cross ventilation.

Balconies and porches have been included into the façade treatment and can be closed off in winter to create a sun room to make the most of solar gain. Roof gardens and external private space has been included into every apartment as there is no access directly to the ground for the majority of apartments and it has therefore become important to provide this external space. Increased roughness is provided by making units identifiable from the outside.
Early research into emerging seismic design technologies led to the idea of using a LVL (Laminate Veneer Lumber) post tensioned beam structural system and it seemed logical to continue to develop the material’s pallet for the central zone to utilise wood. As wooden buildings are significantly lighter than concrete ones, it makes sense that by constructing the apartments out of wood the cost of foundations could be dramatically minimised as they would be supporting a building that was up to two thirds lighter.

Within this scheme wood has also been chosen for its aesthetic qualities, ability to be prefabricated off-site minimizing construction time schedules and its ability for external cladding to be affordably upgraded or changed and modified to help provide identification to individual units and the possibility for the cladding to be affordably re-vamped and updated in future.
6 DESIGN ANALYSIS

6.1 QUESTIONS ANSWERED

This project has demonstrated how housing has a large role to play in the long-term process of the Christchurch City Center rebuild. Through the application of methods of architectural and urban planning research, this project demonstrates that design can be an effective tool for strengthening the sustainability objectives central to long-term housing projects, while at the same time achieving strategic benefits for the quality of the urban environment, particularly as it affects ground level pedestrian spatial systems.

This project demonstrates the complexity and importance of housing within the fabric of the city and the influence it can have in enhancing the quality of a New Zealand urban lifestyle. The solutions achieved have clearly demonstrated the importance of an urban plan in providing direction, and illustrate the way architects will be required to work with city planners in order to enhance the quality of public and private spaces created as a result of reconstruction.

Figure 6.1.1 Stages 1-5 over a 50 year build timeframe
6.2 PROJECT OUTCOMES

The research and design outcomes reveal the importance of site-specific design and planning for sustainability, and how it’s not limited to the consumption of energy and the carbon footprint, or the material and ecological impacts. However by attempting to respond to the more inexact social and economic sustainable practices as well -weighting them with equal or near-equal importance has revealed how the quantitative, or more technical elements of sustainability have been allowed to dominate the debate in New Zealand literature. Christchurch’s experience, after the earthquake has shown how important the social and economic dimensions are, and why they need to be given wider coverage, and more influence in decision making processes that shape the new city centre.

This project has demonstrated the positive impact housing can have on the quality of life of inner city residents and how a wider variety of housing options are necessary. A detailed and flexible plan of development will not only assist in establishing the city’s long term recovery but in the interim, it can assist the return of city ownership to the citizens.
Figure 6.1.2 Birds eye view of Apartment block

Figure 6.1.3 Cross Sectional Sletch of Central Square
through community involvement and engagement. Application of new sustainable technologies and methods of seismic building construction have the potential to transform the building style and signature of Christchurch and to change the architecture of the city. In this context, the project has drawn attention to the current disconnect between the complex requirements of sustainability in its wider definition, and a lack of apparent application within the context of New Zealand housing.

6.3 WIDER APPLICATION

While there is huge potential for coordinated projects like this one to occur, the importance of community involvement and a rebuild of property as well as of ownership through involvement and clear understanding of what may happen will be of enormous benefit to residents. After the tragedy there is the possibility to not only rebuild, but to improve on the conditions of the past for the future.
7 APPENDICIES
Brick barrel pipes remnant of Victorian age

Parts of the wastewater and storm water network in Christchurch consist of ‘brick barrel’ pipes, constructed more than 100 years ago, between 1879 and 1882. These brick barrel pipes, located under streets in and around the city centre and Lyttelton, carry wastewater and storm water to the Bromley treatment plant.

Inside a brick wastewater pipeline. The oval-shaped base maximises sediment movement through the system.

The storm water pipes are circular brick structures and the wastewater pipes are egg or oval-shaped with a concrete base and brick arch. Both sorts of pipes, generally between 450 and 1300 millimetre diameter, and buried at two to four metres deep, suffered significant structural damage in the earthquakes.

MacDow Fletcher, as part of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT), is undertaking repairs and rebuilds on about 5km of brick barrel wastewater and 5.5km of storm water pipes.

Because of the danger of working in this underground environment, most of this work will use trenchless technology, a bit like keyhole surgery, which also minimises disruption on the street. MacDow Fletcher contractors will enter street manholes, then use robotic technology to move material into the pipelines. A machine will line the pipes with a spiral-bound material to seal and strengthen them. Any collapsed sections will be excavated and replaced.

This work will begin around mid April in Moorhouse Avenue and Madras Street, followed by works in Fitzgerald Avenue, Kilmore and Tuam Streets. Residents and businesses in these areas will receive a works notice with further information including confirmed start dates and the time frame. More streets with brick barrel pipelines will be added in future.

In a previous article, we described some earlier repair work on storm water lines on Moorhouse Avenue [1].

Appendix A - Ground Condition Research Figures.

Figure 7.1 Liquafaction areas

Figure 7.2 Di Luca’s Geographical Images, situating christchurch on an alluvial plane.
Figure 7.3 Tonkin and Taylors Subsoil zoning guide for Central city construction- only a guide, specific design will be required for each individual site.
Borneo Sporenburg Housing Project
AMSTERDAM

Figure 7.6 City Study 3

Kizersgracht/Leliegracht st Housing
AMSTERDAM

Figure 7.7 City Study 4
Figure 7.10  City Study7
Appendix C - Wind Tunnel Test Data

### Control Test - 1 Empty Site
- **Wind Data:**
  - **Point # Slow (5 mps)**
  - **Point # Medium (10.6 mps)**
  - **Point # Strong (14.6 mps)**

### Design Test - 6 Foam Blocks, Density
- **Wind Speed (mps):**
  - **Slow:**
    - **Point # Slow (5 mps)**
    - **Point # Medium (10.6 mps)**
    - **Point # Strong (14.6 mps)**

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Note: Ratios have increased by an average of 72% to 551%.
### Design Test - 6 Foam blocks, density with corner block

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### Design Test - 4 Foam blocks, density

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**Figure 7.12** Wind Tunnel Tests Phase 2 (a)
Appendix D - Presentation Documentation

Figure 7.13 Arial view of project looking West

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