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A Comparative Analysis of Flood Resistant Design and Construction Strategies in Australia and USA

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Abstract
A flood is an overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land. There are many factors that contribute to floods, the most important being rainfall. Flooding is a natural process that human beings have had to deal with for a very long time. Flooding in the United States of America and Australia causes billions of dollars in damages every year. The need to protect property and assets from flood damage is of upmost importance for Americans and Australians alike. In order to prepare for and protect property from flood damage, a flood management plan must be created and utilized. To mitigate risk, one must look at both the chance of a flood and its potential impact. Potential impact can be minimized by implementing design characteristics that favor flood resistance which include building code and regulations. Flood protection practices may be used to minimize damage due to flooding on buildings and communities alike. By performing a comparative analysis of flood resistant design and construction strategies in the U.S. and Australia, one would hope to determine what institutional factors contribute to a more effective flood protection strategy and thus, how flood damage can be minimized.

Keywords
Flood Mitigation, Flood Resistant, Emergency Management, Flood Management

1. Introduction

Flooding is a natural process and can happen very quickly or slowly. 35% of the reported natural disasters around the world are floods (de Waroux 2011). Flooding in the United States and Australia causes billions of dollars in losses annually. The effects of these floods can impact people and property at a small local or community level, or even at a larger state level. With that being said, not all floods are the same. Floods can be caused by a variety of methods such as heavy rains, snowmelt, El Nino and La Nina southern oscillation weather patterns (Garrett 2012). Heavy rainfall is the cause of most of the flooding in the United States and Australia with flash floods being the number one weather-related killer in the United States. In the United States, flooding causes $5 billion in damages per year and is the most

destructive of all weather related events (NOAA, 2011). Human beings play a big role in flood damage through land modification, and more specifically, the development and change of catchment areas. Urbanization and land clearing have changed the natural landscape of flood prone areas causing a greater risk of flood damage.

The volume, rise, velocity, duration, and the extent of the flood classify the severity of a flood. The volume is the total amount of water in the flood, while the rate of rise is how fast the flood rises. The flow velocity is how fast the water is moving, and the flood duration is how long the flood lasts. Finally, the area of extent is the overall area that is affected by the flood. The size of a flood, or its magnitude, can be measured in different ways. The most popular and commonly recognized way of measuring a flood is by measuring its peak level of the water at a particular location. In Australia, The Bureau of Meteorology classifies floods into three categories according to the effects caused in the nearby areas or downstream areas. They are major, moderate, and minor floods. A major flood effects large areas and causes major disruptions in the daily life of the local inhabitants. Moderate floods affect a smaller area than a major flood does and often only require the evacuation of some of the homes within the area. Finally, a minor flood is usually viewed as merely an inconvenience due to the closing of minor roads and bridges (Commonwealth of Australia, Bureau of Meteorology 2011).

2. Methodology

This study was conducted with an interpretive approach. While studying what institutional factors contribute to a more effective flood resistance strategy, it is important to note that the viewpoints of society are a function of a particular set of circumstances coming together at a certain time. The epistemological view or what the researcher views as acceptable knowledge, for interpretivism is rooted in the details of the situation and the reality behind those details. In studying flood resistant design and construction strategies, the context of the situation, the reaction of the event, and those affected must be taken into consideration (Saunders et. al, 2009). The data collection method used for this research is qualitative. This research is a case study of flood resistant design and construction strategies in Australia and the United States. An inductive approach was used to determine what factors contribute to an effective flood resistant strategy. The inductive approach was appropriate for this research because it moves from specific observations about flood protection to broader generalizations and theories about the protection of people and property from floods (Saunders et al. 2009). Government documents, archival records, and semi-structured interviews are the three methods of data collection that are used for this research.

Data was collected through respective government organizations and departments related to disaster relief and mitigation from the two countries. Archival records of previous floods for each country were inspected to determine the need for flood protection in both the United States and Australia. Documentation on flood management plans, property modification, building modification, and building codes from each country was examined to compare the efforts of each country at mitigating a flood and ultimately protecting people and property against flood damages. Finally, semi-structured interviews were conducted with building officials from respective countries, to gain insight into flood prevention initiatives.

3. Results and Analysis

The United States and Australia have emergency management institutions. In the U.S. the Federal Emergency Management Agency (FEMA) is the institution responsible for emergency management. Australia's Emergency Management Agency (EMA) does not directly respond to emergencies. Instead it provides resources, finances, training, and research to the individual states and territories (McEntire & Mathis n.d.). This section of the paper examines the similarities and differences of the approaches towards floods between Australia and the US.

3.1. EMA Australia

In Australia, the National Flood Risk Advisory Group (NFRAG) put together a document to outline the vision and objectives of flood risk management. This document presents the responsibilities of both the Australian government and the local community that is in risk of flooding. The vision of flood risk management in Australia is that "floodplains are managed for the long term benefit of the local and wider community such that hazards to people and damages to property and infrastructure are minimized and environmental values are protected" (McLuckie 2008). Understanding flood risk and flood behavior varies from location to location. Therefore, it is the responsibility of each local authority to know and understand their surrounding catchments and factors that control floods in their given areas. By being knowledgeable about their specific areas' flood vulnerability, each local authority can then have a better understanding of the potential impacts on its people, infrastructure, property and environment. These authorities should then provide a specific floodplain management plan that addresses all categories of floods from minor, more frequent floods, to rarer, larger floods, such as a probable maximum flood (PMF). Strategies must be assumed to gather data after a flood has occurred, and historical flood data must also be utilized when assessing the risk of floods in a given area. Careful note must be taken when considering long term changes that may have impacts on future floods.

3.2. FEMA United States

The flood control acts of 1928 and 1936 laid the ground work for flood control by implementing the building of huge flood control structures to control the rivers and to prevent flash flooding. In the 1960's federal government has moved away from simply prescribing structural measures for flood control and has adopted a floodplain management plan that utilizes non-structural methods as well. In 1968 the National Flood Insurance Program (NFIP) played an enormous role in this development. The 1960s and 1970s were also a time of heightened interest in the environment and its protection. The coordination of flood-loss reduction programs with environmental protection programs has since been a goal of the US government. These measures include: regulations to prohibit development in high-hazard areas, building codes for new buildings in flood prone areas, acquirement and relocation of buildings in high-hazard areas, modifying or retrofitting existing buildings, installing flood warning systems, controlling storm water runoff, and providing self-help advice to property owners. In order to coordinate the efforts of many government programs, Congress created the Unified National Program for Floodplain Management under the National Flood Insurance Act of 1968. This specific program is then matched by a Floodplain Management Task Force. The Task Force takes an in depth look at what exactly floodplain management is and defines it as, "a decision making process that aims to achieve the wise use of the nation's floodplains. 'Wise Use' means both reduced flood losses and protection of the natural resources and functions of the floodplains."

3.3. Flood Insurance

One aspect of flood management planning that is consistently mentioned in the U.S.'s plan is flood insurance. The National Flood Insurance Program was adopted by Congress in 1968 as a means to help property owners protect themselves financially from flood damages. This federally-backed program offers insurance to homeowners, renters, and businesses if their community agrees to participate in the NFIP (FEMA & floodsmart.gov 2012). According to a summary of the NFIP by the Insurance Council of Australia, some key features to the program include the following: Insurance is a requirement for anyone wishing to take out a home loan in flood prone areas. A Federal government statutory agency is the insurer. Local authorities must meet certain criteria including mitigation practices and building standards. A local council area must be approved before insurers can begin to sell coverage on behalf of the NFIP. Commission is received by the insurers for selling and managing the claims. Also, a portion of the

premium charged is put back into ongoing improvements of mitigation systems (Insurance Council of Australia 2006).

Although the NFRAG in Australia notes that flood insurance plays an important role in a community's recovery after a flood, Australia does not have a federally mandated insurance plan like the United States does (McLuckie 2008). The Insurance Council of Australia, in response to the report to the Council of Australian Governments on Natural Disasters, states the need for a national insurance plan. It then references the U.S.'s National Flood Insurance Program and offers amendments to fit within the Australian context. In the context of an Australian national insurance program, the ICA is interested in national mapping, insurance integration, mitigation, and disaster relief. Flood hazard maps are produced by FEMA and are used to identify areas of heightened risk, such as those areas with a 1 percent annual exceedance probability, areas where mitigation activities might be required, and areas where risk premiums can be recognized. Under the NFIP, communities receive incentives or penalties based on their participation in the program. These include discounts for having the entire community being educated on flood preparation as well as response plans. Penalties for not participating or meeting the minimum requirements for awareness, education, and preparation include probation and additional premium charges.

As far as the type of insurance is concerned, the NFIP has policies that are underwritten by the Federal Government. Australia would prefer to take an alternative approach by favoring private underwriting with a goal of integrating the policy with everyday insurance coverage as opposed to an additional flood insurance coverage. Another area that the ICA would like to address is the funding and pricing aspect. In the U.S., it is estimated that 9 percent of households are located in high flood risk areas. However, in Australia, this number is a much lower 2.4 percent. With that being said, the attractiveness of having a risk rated premium and discounts for community awareness beyond the minimum FEMA requirements like it is in the U.S. would still be too expensive for Australians, even at a 45 percent discounted rate (Insurance Council of Australia 2006). Table 1 highlights the similarities and differences of the proposed Australian flood insurance plan and the NFIP in the U.S.

Table 1

Comparison of Proposed Australian flood insurance plan and NFIP in the U.S.

	Insurance Features	United States' NFIP	Proposed Australian Equivalent
Similarities	Coverage Location basis	1% AEP	1% AEP
	Planning Controls and Standards	Included	Included
Differences	Underwriter	Federal Government	Private Underwriting
	Funding and Pricing	Risk-rated premiums due to 9% of households in a high-risk flood area	Risk-rated premiums too high due to only 2.4% of households in a high-risk flood area

3.4. Property Modification

It is the focus on designing the actual floodplain area to better contain floodwaters with the hopes of minimizing damages to existing and future communities. Land use planning is a key part of the floodplain management procedure and can play an integral role in providing community resiliency. The way that a particular area of land is used largely defines the ensuing hazard, or damage, of the flood. By

matching the land use to the hazard, the benefits of using the floodplain is maximized and the risk and consequence of the flooding is minimized (Anon 2000).

In the U.S., FEMA recommends that the use of land should coincide with the land's hazards. This could mean, for example, preserving flood prone areas for parks, golf courses, backyards, wetlands, wildlife refuges, etc. Along with maintaining the use of land to favor flood protection, regulations and zoning should allow developers to achieve their developing goals while simultaneously avoiding the vulnerability to floods. The type of soil that a given floodplain has should also play a role in determining its zoning regulations. Some soils absorb water at a much faster rate, which in return allows for flood water to inundate that said area and then dissipate at a much faster rate.

In lieu of the recent flooding in Queensland, Australia, the Queensland Reconstruction Authority has produced guidelines to aid councils in assessing the future development of floodplains and to better align floodplain management and land use planning. With the production of up-to-date flood maps, the Authority hopes to provide the state of Queensland with the information necessary to compose and execute a more successful flood management plan. In Australia, most of the major towns and cities are located within floodplain areas. The reasoning behind this is associated with water supply, transportation, fertile soils, etc. Therefore, these major areas of population, commerce, and trade are prone to flooding.

3.5. Building Modification

Why would anyone want to build in a flood prone area? Tthe ultimate reason for wanting to settle and live near a river had to do with jobs (Sosnowski 2011). So, if people are going to live in an area where flooding is inevitable, what can be done to protect their homes from loss and damages? In addition to obtaining flood insurance, and as a requirement for obtaining flood insurance, flood protection applications to the particular building are necessary. Common practices of building modification include elevating the structure, flood proofing the structure, and retrofitting existing structures. Elevating a building simply means to raise the lowest level of the building above the Base Flood Elevation (BFE), which is the level at which a flood has a 1 percent chance of occurring in a given year.

The state of Louisiana's topography and geographic location make it one of the most flood prone states in the United States. Two thirds of the nation's rivers drain into the Gulf of Mexico from the Louisiana coastline. Massive amounts of improvements to minimize the damages of flooding across the state have been implemented; however, there are still more flood insurance claims in the state of Louisiana than any other state in the United States. In recent years, Louisiana has made large strides in improving their flood mitigation strategy and more specifically improving their communities' flood protection measures. The East Baton Rouge Parish is known as a special flood hazard area (SFHA). New city code requirements mandated that new buildings be erected 1 foot above BFE. The city of Denham Springs is a suburb of Baton Rouge with a long history of flooding. In the mid-1990s a group of local flood victims in the area teamed up with the Amite River Basin Drainage and Water Conservation District to bring in a slab elevation contractor to help raise their homes.

Elevating buildings in Australia is done in a way that parallels that of the United States. The practice of elevating structures is common practice in Australia to prevent inundation of habitable floors thus reducing flood damage. The Office of the Queensland Chief Scientist notes that this option is not always economical if an area does not receive frequent inundation of at least every 10 years. Not only can it be uneconomical but it can also create more risk for those living in the home in the event of a larger flood (Garrett 2012). In lieu of the 2011 floods in Brisbane, Australian architect Michael Rayner said that there are three schools of thought about rebuilding the city, "retreat, defend, or redesign" (Kelly 2011). Often times, retreating is not an option, therefore home and building owners must rethink how to strengthen their structures against flood damage or even redesign them entirely just as Rayner did when his West End home was destroyed in the January 2011 floods (Wheeldon 2011).

3.6. Codes and Standards

The development of building codes for each country has evolved over time. In the United States, there are a few different codes and standards that each state could use as a model code. A model building code is one that is developed by groups or committees representing government agencies, manufacturers, and contractors for a state or other territory to adopt as their own code (Harris 2004). Minimum flood protection strategies in design and construction are required for a community to participate in the NFIP. In Australia, there is only one nationalized building code called the Building Code of Australia (BCA). It is the first two volumes of the National Construction Code (NCC) and is created and preserved by the Australian Building Codes Board (ABCB) for the Australian Government. The objective of the BCA is to obtain a nationally consistent minimum set of standards and requirements for the benefit of the health and safety, including structural safety and fire safety, of the Australian public. It covers technical provisions for the design and construction of buildings and other structures addressing structure, fire resistance, access and egress, and services and equipment to name a few (Australian Building Codes Board 2011b). The BCA is a performance based code. One of the performance requirements of the BCA states that a building or structure must "withstand the combination of loads and other actions to which it may be reasonably subjected." However, there are no flood specific design or construction provisions listed in the current BCA. In order to address this issue, the Building Ministers representing all of the Australian, state and territory governments gave the go ahead to let the ABCB develop a standard for construction in flood prone areas (Australian Building Codes Board 2011a). A draft standard was published in late 2011 for the construction of new buildings in a flood hazard area and is to be included in the BCA by the year 2013 pending the approval of the ABCB (Brumby n.d.). The acting manager of the board, Mike Balch, said that the intention behind adding in provisions for flood-prone areas is to decrease the threat of death and injury by strengthening the structural performance of buildings. The board plans to first upgrade the standards to flood-proof homes more effectively and then reference that standard in the new code. The desire to want to protect buildings from flood damage comes from the Council of Australian Governments wanting to increase Australia's resilience to natural disasters by implementing stricter building codes that address these specific issues and instances (Ryan 2011).

In the U.S., the elevations are determined using flood maps and are a function of the flood hazard area and type of structure (FEMA 2010a). In many situations there are unknown factors that could make a flood height higher than the defined flood event. Therefore, freeboard heights are also specified in many areas as safety factors (FEMA 2010b). Most homes and buildings have a 1-foot freeboard height requirement and some essential facilities such as hospitals have a 2-3 foot freeboard height requirement. Only temporary storage facilities, agricultural facilities, and minor storage facilities can have their lowest floors at the BFE (FEMA 2010a). In Australia, the height of the lowest floor for a habitable room must be above the flood hazard level (FHL) which is the defined flood level (DFL) plus the freeboard for a given area. If the room is an enclosed non-habitable room, then the floor height must be no greater than 1 meter below the DFL (Australian Building Codes Board 2011c).

Structural attachments in the U.S. are defined and specified in section 4.7 of the ASCE 24-05 as erosion control structures and in section 4.8 of the ASCE 24-05 as decks, concrete pads, and patios (Anon 2006). They are required to be structurally independent of the adjacent buildings, and they must be constructed to break free from the building without producing any damaging debris (FEMA 2010a). Structural attachments in Australia are similar to those in the U.S. They are erosion control structures and decks, patios, stairways, and ramps. Located in section 2.10 of the Australian draft standard, the requirements for such structures also vary from that of the U.S. Erosion control structures that are attached to the foundation or superstructure of a building must not hinder the structural integrity of the said building during a BFE while maintaining structural adequacy. Decks, patios, stairways, ramps and any other similar structures that are also attached to the building's foundation or superstructure must also maintain

their structural adequacy while maintaining the structural aptitude of the building during a BFE (Australian Building Codes Board 2011c).

4. Conclusions

In order to protect property, buildings, and other assets from flood damage, a multi-faceted approach to flood resistant design and construction strategies must be taken. As stated in the Australian draft standard, a mixture of land use planning, flood mitigation measures, flood warning and response strategies, and building codes tailored to flood resistance ultimately provide the most thorough and holistic approach to mitigating the disaster of a flood (Australian Building Codes Board 2011c). The evolution of floodplain management in the United States has caused the U.S. to adopt policies that promote this multi-faceted approach. Through the NFIP, communities have strengthened their resiliency to floods by meeting minimum building requirements as well as educating communities on flood preparation and response strategies. However, these methods of flood protection through mitigation strategies do not always produce the desired results of protecting people and property. Howard Kunreuther has coined a term known as the "natural disaster syndrome." In short, it means that people don't adopt cost-effective loss reduction measures on a voluntary basis. Following a large disaster, the federal government is often called to provide support and relief to the affected areas even if it claimed of having no intentions of doing so. This in turn uses taxpayers' money in an inefficient way and can be avoided if homeowners, property owners, and business owners had been more receptive to adopting cost-effective loss reduction measures earlier. One of the main reasons for the natural disaster syndrome is that people often become complacent with respect to low-probability high-consequence disasters such as a PMF. People often don't see the point in paying for additional protective measures and/or flood insurance when they don't think that large amounts of damage could happen to them (Kunreuther 2006). Jean Palitukof, director of the national climate change adaptation research facility at Griffith University, further validates Kunreuther's idea of the natural disaster syndrome. She states that as time goes by planning conditions will become more relaxed allowing people to begin to creep back into building in flood plains (Gettler 2011).

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