PERKINS+WILL

Research Journal

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Perkins+Will is an interdisciplinary design practice offering services in the areas of Architecture, Interior Design, Branded Environments, Planning + Strategies and Urban Design.

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JOURNAL OVERVIEW

The Perkins+Will Research Journal documents research relating to the architectural and design practice. Architectural design requires immense amounts of information for inspiration, creation, and construction of buildings. Considerations for sustainability, innovation, and high-performance designs lead the way of our practice where research is an integral part of the process. The themes included in this journal illustrate types of projects and inquiries undertaken at Perkins+Will and capture research questions, methodologies, and results of these inquiries.

The Perkins+Will Research Journal is a peer-reviewed research journal dedicated to documenting and presenting practice-related research associated with buildings and their environments. The unique aspect of this journal is that it conveys practice-oriented research aimed at supporting our teams.

This is the fifteenth issue of the Perkins+Will Research Journal. We welcome contributions for future issues.

RESEARCH AT PERKINS+WILL

Research is systematic investigation into existing knowledge in order to discover or revise facts or add to knowledge about a certain topic. In architectural design, we take an existing condition and improve upon it with our design solutions. During the design process we constantly gather and evaluate information from different sources and apply it to solve our design problems, thus creating new information and knowledge.

An important part of the research process is documentation and communication. We are sharing combined efforts and findings of Perkins+Will researchers and project teams within this journal.

Perkins+Will engages in the following areas of research:

- Market-sector related research
- Sustainable design
- Strategies for operational efficiency
- Advanced building technology and performance
- Design process benchmarking
- Carbon and energy analysis
- Organizational behavior

EDITORIAL

This issue of Perkins+Will Research Journal includes four articles that focus on different research topics, such as relationships between mental health and resilient design, obstructions in perception associated with tall wood buildings, sustainable retrofits of commercial buildings, and contextual urban design of healthy communities.

"Weathering the Storm: Mental Health and Resilient Design" discusses relationships between resilient design strategies and their impact of the mental health of building occupants. The study evaluated specific design strategies and their impact on mitigating stress in a crisis event, as well as cost of implementation. The results indicate that majority of the of the investigated strategies would have marginal to low costs for new and existing buildings, and that they would mitigate negative mental health impacts on building occupants.

"Tall Wood Survey: Identifying and Analyzing the Obstacles of Perception" addresses the public's perception of engineered wood products to determine if there are perception barriers associated with advancing tall wood buildings. The research methodology included literature review and a survey, where general population responded to a web-based questionnaire. The results indicated that flammability was identified as the greatest perception barrier, followed by strength, deforestation and durability. The study concluded that public education and awareness can increase familiarity with engineered wood products, and may contribute to overcoming perception barriers.

"Sustainable and Energy Efficient Commercial Retrofit: Case Study of Perkins+Will Atlanta Office" reviews the importance of building retrofits in sustainable design, and significant opportunities for improving energy efficiency associated with existing buildings. The research methodology consisted of a literature review and a detailed case study. The article illustrates specific design strategies, building systems, renewable energy sources, materials and water harvesting for Perkins+Wll Atlanta office, and concludes with barriers and opportunities that are currently present for achieving energy efficiency in commercial retrofits.

"A Contextual Study for Healthy Communities in China: Towards Culturally-Sensitive Urban Design and Planning" presents a framework for developing healthy communities in China, considering cultural, social and environmental aspects. The framework is based on the concept that healthcare facilities and their surrounding communities should function as an integrated system. The research methodology included literature review and observations, where a central region in Shanghai was investigated. The article concludes with recommendation how this specific district could be improved in terms of providing healthcare to its residents, as well as general conclusions how the framework can be adopted to other Chinese locations.

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01.
WEATHERING THE STORM:
Mental Health and Resilient Design

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ABSTRACT
The goal of this research project was to evaluate the relationship between resilient design strategies and their impact on the mental health of building occupants during a crisis event. We hypothesized that certain resilient design strategies were better suited to mitigate the negative effects on mental health, and, through analysis of this potential, be ranked by efficacy.

The methodology for evaluating specific design strategies' potential was a formula that measured each strategy's potential to mitigate multiple contributing factors to victim stress in a crisis event. These factors were: the ability to address both acute and chronic events, the ability to address the five major categories of stressors, and finally the ability to address four major types of stress. After being scored against these factors, the strategies were then analyzed against cost of implementation to determine total efficacy.

The evaluation revealed that the majority of the fourteen strategies evaluated have a potential for mitigating negative mental health impacts on building occupants. While some strategies may prove cost prohibitive for many buildings, nine of the fourteen strategies were considered marginal to low cost solutions that are easily implemented in both new and existing buildings.

Once the vulnerability of a building or space is determined, priority can be given to implementation of the strategies best suited to address those factors.

It is recommended that further field testing and data collection through surveys and interviews are necessary to investigate the effects that the design strategies covered in this research have on occupants' stress.

KEYWORDS: mental health, stress, resilience, disaster, design

1.0 INTRODUCTION

The goal of this research project was to evaluate the relationship between resilient design strategies and their impact on the mental health of building occupants during a crisis event. The primary goal of most resiliency-focused design strategies falls under one of several areas: mitigating property damage, preventing disruption of basic utilities such as electricity and water, or minimizing physical threats to occupants. Crisis events affect the mental health of individuals by causing anxiety-related responses that can later evolve into chronic and severe mental health disorders. Studies have recorded elevated levels of stress induced mental health issues in populations who have experienced flooding, and during slow-developing events such as prolonged droughts that include anxiety, depression, post-traumatic stress disorder (PTSD) and increased incidence of suicide[1].

Despite these statistics, little research has been conducted to assess the impact of specific strategies on reducing stress and associated mental health disorders in populations during and after an event. This is likely

due, in part, to the difficulty in predicting the location of future events and in gathering first-hand accounts from occupants pinpointing the impact of specific strategies, however it is critical not to underestimate the potential impact. There has been research compiled and resources are available on the impacts of community-level planning for emergency preparedness and how mental health issues can be addressed at the neighborhood level. As such, the following research focuses primarily on strategies at the single building level. Some community-scale approaches are scalable to single buildings, especially for structures with multiple floors and tenants.

As an example, after Hurricane Katrina, 42 percent of the people who stayed behind said they did so because they could not evacuate with their companion animals[2]. Since then, in 2006, FEMA was directed to develop emergency preparedness plans to ensure that state and local emergency plans take into account the needs of individuals with pets and service animals during a major disaster or crisis[3]. This may illustrate the important role that companion animals often play in mitigating mental and emotional distress for victims, and how failing to acknowledge this undermined the efficacy of other emergency planning measures.

This article aims to establish criteria that predict the potential for different design strategies to impact the mental health of victims. It is intended to provide guidelines to design teams for evaluation of design strategies. Ultimately, the goal is to improve the mental health of victims before, during and after crisis events by helping people cope with stress through design solutions. The framework could also serve as a tool for assisting end users in the decision making process during project scope discussions and long-range planning.

The document assesses a series of design strategies selected for their potential to positively impact the mental health of occupants during a crisis event. It is not intended to be an exhaustive analysis of all strategies for resilience. Due to the limitations mentioned above, the article attempts to predict impacts through analytical criteria rather than analyzing evidence based research.

1.1 Defining Resilience in Design

According to the American Institute of Architects, resilience, in the context of architectural design, is defined as design that is able to "adapt to changing conditions and to maintain or regain functionality and vitality in the face of disturbance"[4]. The American Psychological Association defines resilience as "the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress – such as family and relationship problems, serious health problems or workplace and financial stressors."[5]. While both definitions refer to adaptability, does this refer to the potential for resisting acute hazards during a crisis, or does adaptation refer instead to the chronic hazards in the period after a crisis? How can resilience be achieved at a building or tenant fit-out level, where there is the most direct potential for occupant interaction? With certain building types, is it possible to separate maintaining functionality strategies from promotion of mental health strategies? Based on these questions, for the purposes of this article, we define resilient design as the following:
"Resilient design reduce negative impacts to the physical and mental health of occupants by allowing adaptation in the face of crisis, while providing basic requirements for mental and emotional well-being, thereby reducing stress and the long-term effects caused during and after a crisis event."

This definition addresses both the immediate physical and longer-term emotional needs of victims. Although many efforts assess resilient strategies for impact on reducing damage to property and eminent physical threats, few address the emotional and mental health aspects. More chronic events also have direct psychological impacts. In drought-affected rural Australia in 2007 and 2008, populations reported increased rates of stress, social isolation, domestic abuse, and suicide[6].

Findings like these lead to the question: which common resilient design strategies have the most potential to positively impact mental health of occupants? We hypothesized that certain design strategies would be better suited to meaningfully reduce negative impacts on mental health during an event, and that by analyzing the number of ways a strategy is best suited for acute or chronic stress events, we can predict which strategies will best reduce mental health issues related to stress during an event.

There are strategies that address the mental and emotional health of victims, but they are often only applicable at a community level, with good reason. Communities that are connected with strong social networks are able to better organize themselves and recover more quickly than communities lacking these characteristics. Community efforts following environmental threats often focus on civic impact, typically utilizing community centers and places of worship to facilitate communication between community members. This begs the question, for anything bigger than a single family dwelling, what

are buildings if not small communities, and can these same strategies be scaled down to a building level? Particularly in urban settings, many mixed use, multifamily and large office buildings already operate like small communities.

Resilient design strategies often focus on a few specific building types. Planning for resilience is an increasingly present goal for hospitals and residential buildings. Hospitals obviously provide critical support services before, during and after any crisis event, and with the personal investment we make in our homes, it is easy to understand why this is the case. According to the Bureau of Labor Statistics, Americans spend almost 60 percent of their waking day at work[7], making a business district or office building the most likely place many people will be when short-term events with little warning occur, such as earthquakes, or terrorist attacks. It is just as critical that these buildings be resilient as healthcare and residential facilities.

It is also important to understand the potential duration of a threat, and the impact this has on buildings, occupants and their mental health status. This is important because some strategies are better suited for addressing one type of threat than others. For instance, shelter facilities are intended to provide temporary shelter in the event of a short term event, such as an earthquake or a flood. However, they have very limited impact on resolving longer term threats, such as drought. Conversely, a water reclamation strategy in a building is intended to address long term loss of municipal water supply and has no direct benefit on a short term threat like storm or earthquake.

1.1.1 Acute and Chronic Events

In the climate adaptation and resiliency planning spheres, events are categorized as either being acute or chronic. While the definition of each term varies based on the source, it should be noted that in all conditions the definition of the term relative to a crisis event is also relative to the greater timeline of normal condition as described below.

An acute event is one that has a clearly defined beginning and ending in time. Acute events may or may not provide warning to an affected population to allow for preparations. The most straightforward examples of acute events include weather events, such as tornadoes, hurricanes, and blizzards. Occupants may have minutes or days of notice to prepare for safety. Earthquakes are considered acute events, though aftershocks and effects may occur over several days. Non-weather acute events include terrorist attacks and outbreaks of illness. These events are abnormalities that may leave residual effects on the landscape, but the events themselves do not linger. A heat wave can also be considered an acute event. Even though a heat wave can last for days or weeks, it is generally identified with a beginning and ending, and in relation to the greater weather patterns of a location it is not a continual event. Acute events can also be caused by people. Fires and acts of terrorism may have lasting impacts, but generally have a defined beginning and ending.

Chronic events, on the other hand, may have an identifiable start date, but have a less discernable ending, or are not expected to end. Chronic events may have immediate impacts on a population, but also may have long-term effects that ultimately change the natural, geopolitical, and built landscape of a location permanently. Events such as long-term drought and sea-level rise have lasting effects physically, as well as psychologically. War may begin with a specific violent action, but may continue for months or years and have profound impacts on populations. People develop different coping mechanisms for chronic events than for acute, and they will need to learn to live differently in the longer term.

1.2 Mental Health: Setting the Stage

The predominant negative impact on mental health during an event crisis is stress. Stress can manifest as a host of other related health concerns. Symptoms vary from person-to-person based on physiological make-up, genetics, life experiences and emotional state before an event. Additionally, mental health needs vary according to the severity and scope of an event and individual victims are at risk according to their own severity of exposure[8]. Because of the variability in the extent and type of disaster, no consistent rates of psychiatric illness can be predicted for every situation. While more extreme illnesses like PTSD are easy to recognize, they are not the most prevalent. Common problems attributed to Hurricane Katrina included memory disturbance, anxiety, insomnia, psychosomatic illness and relapses of preexisting psychiatric illness[9]. Stress can lead to physical, emotional and behavioral symptoms that eventually degrade an individual's mental health status. Stress can also impact the mental health of a community following a crisis event, exacerbating perceptions of insecurity in vulnerable communities and influencing aspects of cultural identity[10]. Other common mental health related symptoms can include anxiety, depression, solastalgia (distressing sense of loss), post-traumatic stress disorder and even suicide, persisting for years following an

event[1]. One year after Hurricane Katrina, mental health professionals were reporting that 6.4 percent of the effected population still had suicidal thoughts, and that serious mental illness had increased 89.2 percent from baseline levels in the population[9]. Despite this, it is still common for emergency responders and officials to view the assessment of the mental health needs of trauma victims as secondary, ignoring immediate post-incident interventions. The result is that mental health officials are required to respond to individuals emerging from traumatic events who are already severely impaired cognitively and emotionally[8].

Because the symptoms are so varied, and are based on a combination of personality, history of psychological and emotional response strategies, degree of the disaster's impact, breadth of loss and environmental status, an analysis of the socio-environmental factors causing the distress is the most effective way to eliminate stress and its impact on a survivor's mental health. Stress is linked to the social vulnerability of a community or individual, and is caused by feelings of vulnerability related to access to information, power or control over a situation, access to resources, capacity to adapt to altered environment and means of communication.

In order to reduce or eliminate stress for victims during an incident, it is first important to understand the root causes of stress during the event. Once this is understood, design strategies can be evaluated on their ability to address these stressors. Previous literature suggests that there are seventeen social vulnerability indicators that can be used to predict the vulnerability of an individual, household or community[11].

The indicators range from household structure and housing status to level of education and language skills, and are grouped into the following five larger categories:

- Child care needs
- Elder care needs
- Transportation needs
- Housing and shelter needs
- Civic capacity needs.

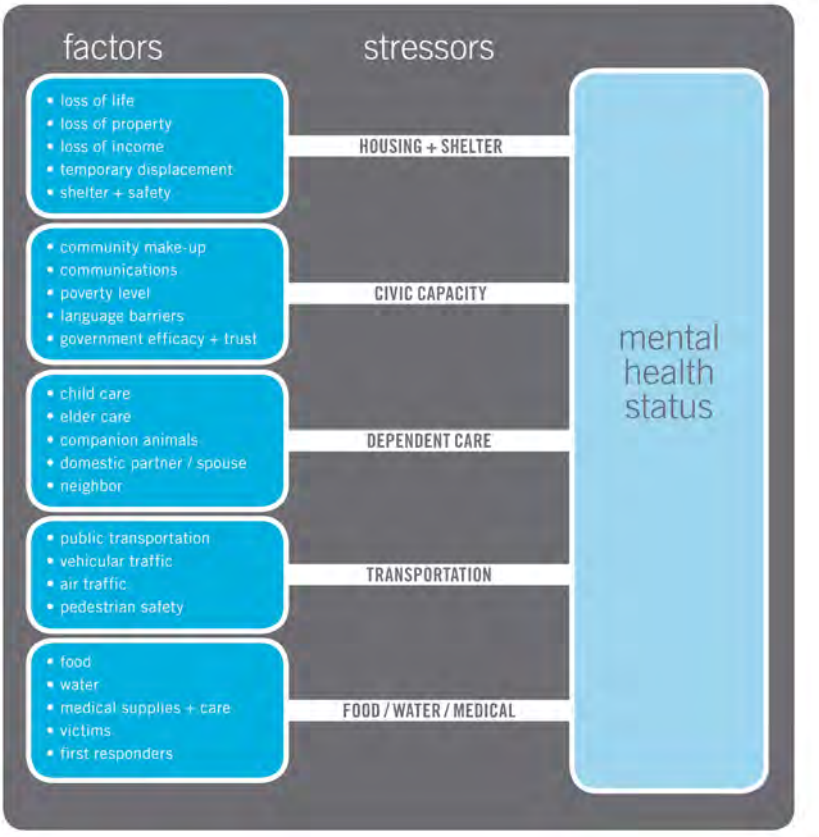


Figure 1: Stressors impacting mental health.

The work hypothesizes that when these indicators exist in a geographic area, that region is less adaptable when faced with a crisis event, resulting in great vulnerability. It is this sense of vulnerability in the face of disaster that is the source of stress for victims, therefore, the same list of needs can be used as the basis of a framework to categorize stressors during a crisis. For the purposes of this study, we have modified the five categories slightly to include the following:

- Housing and shelter
- Civic capacity
- Dependent care
- Transportation
- Food / water / medical.

1.2.1 Stressors

Housing and shelter is often the most immediate cause of stress to disaster victims. The ability to provide for basic physical needs and safe shelter is perhaps the most basic drive for humans. Feeling that these conditions are not met, or that our ability to provide them is compromised, can result in elevated stress levels. The threat of short or long term displacement can begin contributing to elevated stress levels even leading up to an event, if, in the case of storms, the event is to some degree predictable, and can continue long after the event has passed. As many as 23,000 people sought temporary refuge in shelters following Hurricane Sandy, a storm that damaged up to 200,000 homes[12]. Research indicates that disaster-related displacement or relocation including loss of property are factors that contribute to mental health concerns, such as PTSD and depression[13].

Civic capacity, or the make-up of a community and its ability to effectively communicate during an event, is easy to overlook in planning, but can be a significant source of stress to residents when it is compromised. Lack of connectivity to other individuals and lack of access to current information during and after an event can result in elevated stress levels. This can be caused by different situations. Loss of power and cellular networks are common reasons communication from authorities and between individuals are cut off during an event. Socioeconomic status can also impact an individual's or community's access to information. Authorities often assume residents in an area all have access to the same information during planning and execution of disaster preparedness policies. However, studies show that certain communities are inherently distrustful of media and government communications, preferring to rely on social connections within the community. This limits the ability for effective communication[11]. Language barriers are another reason many individuals do not receive current or accurate information during a crisis. The phenomenon known as "urban sprawl", a term referring to the expansion of development across large geographic areas outside major urban settings, also impacts the civic capacity of a community. Low residential and employment density, low connectivity between destinations and dispersed activity centers are common indicators of urban sprawl[14]. These attributes increase the vulnerability of neighborhoods by lowering their civic capacity. Civic capacity also gives rise to questions of social equity. Low-income and minority populations are more likely to inhabit vulnerable communities with the least resources to deal with stressors during a crisis[15].

Dependent care, or in other words, providing care for individuals that are dependent on certain individuals during a crisis, can be a major source of stress for those individuals. Children, seniors, chronically-ill family members and even companion animals impact a household's ability to adapt to environmental issues. Dependents often have limited mobility or communication abilities, impeding the ability to quickly respond to an event. Dependents may be remotely located at primary care locations, requiring additional travel and coordination. This can be physically dangerous when concerns over dependents drive primary caregivers away from sheltered locations during an event in order to provide care. The emotional impact from concern over dependent care can also contribute to trauma. For example, concern over childcare needs in the days following an event might elevate stress levels in individuals who must get back to work quickly after a disaster, before daycare centers have reopened. Additionally, the mental health impacts on children and older adults can manifest differently than average adults. In the wake of Katrina, certain mental health problems were prolific in elderly populations, including higher rates of depression and suicide, resulting from a sense of loss over their life work and savings. These issues can in turn impact the emotional state of those close to them[9]. Other research notes that more severe stress is exhibited in children than adults after disaster[6].

Transportation needs can also be a stressor, particularly in urban settings where residents depend heavily on mass transportation, or where larger percentages of households do not own vehicles. The ability to mobilize resources after an event is critical to treatment, but also to regaining a sense of normalcy. Transportation shut downs affected 8.5 million people following Hurricane Sandy due to the flooding of New York City's subway system and East River tunnels[12]. The impact that trans-

portation can have not only effects those relying on mass transportation. Bridges and tunnels in and out of both Manhattan and Washington DC were closed for at least a full day after the attack on 9/11, leaving many people stranded in the city. Restaurants and stores were unable to receive scheduled deliveries, impacting their ability to serve the numbers of people stranded in the two cities. Similarly, air traffic was suspended, stranding people across the country. Transportation provides critical access to employment, childcare, medical facilities and other resources in many communities, particularly in non-urban settings where services are dispersed. Many low income and minority neighborhoods may lack even basic infrastructure for pedestrian traffic, such as sidewalks, crosswalks and street lights, further impacting occupants' ability to travel when vehicular traffic is impeded[15].

Finally, the need for basic food, water and medical supplies can be an acute stressor in many crisis events, for not only the victims, but emergency responders as well. Challenges in locating food and access to fresh water is often the most immediate stress to impact victims following an event. Locating medical supplies and administering them to injured companions is another stressor that takes a toll on victims. While many care providers, such as police, fire, rescue and paramedics are afforded some degree of protection from mental health impacts during an event due to their formal training, they still often times suffer emotionally after a major event. Informal first responders, often times normal citizens without formal training who might be in proximity, are particularly vulnerable[8]. The stress of locating and administering very basic first aid while waiting for professional medical help can acutely impact an individual's mental health status.

1.2.2. Types of Stress

Categorizing stress can be challenging. The multitude of potential stressors attached to crisis events will affect individuals differently, based on their ability to cope with stress, make decisions, remain focused in pressure situations, and engage a positive outlook whenever possible. Other factors assist individuals in managing stress levels. These factors may include aspects of the built environment around them, but also individual means of coping. Examples may include meditation, exercise, hobbies, or interaction with children and animals.

Related to times of crisis and catastrophic events, it is helpful to see potential stressors as affecting individuals with respect to timing. In his book *From Crisis to Recovery: Strategic Planning for Response, Resilience, and Recovery,* George W. Doherty groups the effect of incidents and events into four categories[16]:

- *Anticipatory* stress is that when individuals have concern for a future issue or event. If we take the example of a hurricane, a person may experience anticipatory stress in the days leading up to the storm hitting his or her location, after the individual becomes aware of the pending incident.
- *Situational* stress is experienced during a crisis situation. The newness, uniqueness, and magnitude of the situation become the concerns of the moment. In the hurricane example, this is the stress experienced while the individual rides out the storm.
- *Chronic* stress is worry over time. This is longer-term emotion that includes prolonged incidents and the immediate after-effects of short-term events. Chronic stress would be felt by those impacted by a long-term severe drought, or in the example of the hurricane would include prolonged weather and immediate effects such as flooding or loss of power. Similar to the definition of a chronic event, the timeframe for chronic stress is relative to the timeframe of the crisis event itself.
- *Residual* stress is that experienced after a crisis event has concluded. This category includes unresolved emotions an individual may feel related to experiencing a catastrophic event, as well as feelings of uncertainty about a repeat of the event. Some psychologists link this type of stress in severe cases to post-traumatic stress disorder (PTSD), often experienced by soldiers returning home from battle and victims of violent crimes[16].

It should be noted that PTSD is sometimes referred to as Delayed Stress, as symptoms or signs may not surface within an individual until well after the event has been experienced[16].

All four types of stress can be impacted by a variety of factors, and these in turn will influence the intensity of an individual's reaction to the stress. Key factors include duration, presence of multiple stressors at one time, the relative importance of a situation to a person, how an individual evaluates stress, experiencing reminders that trigger memories of past events, and an individual's ability to manage or tolerate stressors.

Other research uses different terminology to categorize the phases of stress, but the timeframes are similar to those outlined above. In the compilation "Interventions Following Mass Violence and Disasters" emotional and psychological responses are categorized as immediate, early adaptation, mid-phase, late-phase, and resolution[8].

1.2.3 Mental Health Summary

Many studies link elevated stress levels to degradation of mental health, both in individuals, and communities. Research has also shown that a range of mental illnesses can be found in the victims of climate related crisis events, brought on by the stress endured leading up to, during and after the event, which are classified as Anticipatory, Situational, Chronic and Residual stress. Both acute and chronic term events impact victims in varying ways, and individual symptoms depend on many factors. Low income and minority communities are particularly vulnerable, due to general lack of resources. Stressors during an event can be grouped into five categories, Housing and Shelter, Civic Capacity, Dependent Care, Transportation and Food/ Water/ Medical. It is by studying how resilient design strategies address the combination of the type of stress, and specific stressors, that we can begin to assess their overall ability to impact mental health.

2.0 RESILIENT DESIGN STRATEGIES

Designers have the ability to incorporate strategies into a structure and into the functionality of a space that can positively impact the mental health of occupants throughout the duration of a crisis event. While there are more strategies to consider than the constraints of this article will allow, we have selected a number that represent both design and operational tactics. We have also listed simple, low-cost options suitable for new construction as well as retrofits in addition to more complex solutions that most likely carry a higher installation or long-term cost.

Due to the wide range of potential threats resilient designs try to address, there are many facets to even the simplest strategies which have the potential to positively impact the mental health of victims in the right circumstances. Understanding scale, building type and event duration are all key to assessing the potential for any design strategy.

Many of the strategies presented in this article align with those associated with the concept of passive survivability - defined as a building's ability to maintain critical life-support conditions in the event of extended compromise[17]. While passive survivability focuses more on loss of life and basic physical necessities, minimizing occupant discomfort can be extended to acknowledge the positive mental health benefits of such planning.

Each strategy is briefly described, followed by an analysis of mental health benefits and a conceptual discussion of magnitude of cost.

2.1 Green Roof as Gathering Space

A green roof on a structure has long been considered a multi-faceted sustainable design strategy. When designed properly, it provides thermal insulation at the roof level. It provides for added wildlife habitat and reduces the urban heat island effect in certain settings. A green roof also assists in mitigating stormwater by retaining rain that falls on the surface and slowing the water that flows to storm systems, which is important during heavy precipitation events. A thoughtfully-designed green roof can also provide welcome outdoor amenity space to building occupants.

The roof of a building can be one of the safest places for occupants during or after a catastrophic event, especially if lower portions of the building are compromised. This is easily seen after weather events such as Hurricane Katrina in 2005, when residents took to their roofs in flooded neighborhoods. A green roof provides an added amenity to provide respite from indoor spaces when occupants cannot leave a building, and the green roof will have cooler ambient and surface temperatures than a typical membrane or gravel roof.

Green roofs do have limitations, though. They do not provide shelter from the sun, wind, or precipitation. Their use may be somewhat limited during certain types of crisis events.

Mental Health Benefits

If occupants are required to remain in a building for any length of time due to a catastrophic event, a green roof provides a connection back to nature that is often thought to relieve stress[14,18]. Incorporation of interactive elements, such as walking labyrinths, personal gardens, and space for lawn games provide for mental distraction, even if temporary. Having an alternate space to go to during and after a crisis event, especially one with connection to nature, may reduce situational and chronic stress in occupants, as well as residual stress after an event has passed. A habitable green roof provides an alternate approach to addressing the housing and shelter stressors associated with a crisis event by expanding the area available to occupants if not confined indoors for safety. Civic capacity is also addressed as the roof may be the largest safe gathering space available for all occupants of a building.

Cost

There is a premium to add a green roof to a building, whether as new construction or as a retrofit. Part of the cost is fixed in the type of green roof system selected and can be estimated based on the system's area. How-

ever, a building's roof structure may need fortification for added weight of the system and the water it will retain from rain. Added structure, along with any required roofing assembly repair, needs to be factored into the total installation cost.

2.2 Green Roof as Food Production

A green roof can be an amenity and sustainable strategy in many ways, as noted above. When designed correctly, it can also provide for cultivation of certain types of fruits and vegetables. Studies have called attention to the lack of resilience in many urban areas with respect to food supply, noting it may take a significant amount of time for supply levels to return to post-event levels[19]. Production of food can assist in easing the food needs of a small population directly after a crisis event.

The depth of the green roof system and the growing medium will determine what types of edible plants—if any—can be grown atop a building. Most green roofs tend to be extensive, meaning the depth of the system is usually six inches or less and it is most suitable for sedums, herbs, and other drought-tolerant plants. An intensive green roof system provides for a deeper growing medium and can accommodate a wider variety of plant types. Most green roof systems will not accommodate root vegetables and trees that bear fruit, but other types of edible plants can be cultivated.

Growing fruits and vegetables on a roof requires careful consideration of typical gardening variables – climate, growing season, whether or not irrigation is provided, and soil nutrition. Depending on a building's location, the growing season may be limited. Drought tolerant plants are always primarily recommended. Plants that require regular irrigation should be carefully planned.

Mental Health Benefits

In situational and chronic stress situations, access to fresh food can be severely limited. With power supplies available, perishable foods typically last three to seven days. Without power and refrigeration, perishable food will be inedible in 24-72 hours. Mental anguish can start to occur with the first signs of hunger. Growing fruits and vegetables on a building roof can respond to some of the food/water/medical stressors with occupants knowing there is a food supply available. It has been noted that when people have a problem to solve and focus on, they more easily move from despair to a sense of hope and empowerment[6]. Fruits and vegetables are also generally more nutritious than processed foods, contributing to physical health as well. Finally, cultivation of food on the roof allows for activity and mental diversion from the chronic stressors at hand.

Cost

The same cost factors discussed above are applicable for green roofs that are used to grow food. However, if deeper soils are required to grow certain types of vegetables, the building structure must be adequately designed for the added load of the growing medium and additional amount of stormwater it will hold.

2.3 On-Site Renewable Energy

Renewable energy is not a new concept. The use of non-polluting sources to generate energy on a site has been in practice for years in passive methods and in recent history technology has allowed the sun's rays and changing winds to be converted to energy and stored for later use. Originally criticized for up-front cost on installation, use of renewable energy technologies have dramatically increased over the last twenty years. Buildings and sites can be designed for rooftop energy generation, as well as integrated strategies that allow for solar, wind, and geothermal energy sources within and applied to a structure.

During a catastrophic event, it is not uncommon for buildings to lose power for a variety of reasons. In addition to general building functionality, loss of power can significantly impact the communications systems as well as food preservation.

Mental Health Benefits

On-site energy generation may allow critical building systems to continue to function without significant downtime, addressing situational and chronic stresses. Emergency systems for a typical office building may include modified lighting levels, ventilation (with or without conditioning of the air), elevators, and communications systems.

If communications systems can be maintained and broader systems are not compromised, occupants can maintain contact with dependents and loved ones. As inability to contact dependents is one of the greatest stresses during a chronic event, allowing for power to communications systems—even limited—can alleviate stress.

While most on-site energy generation in urban settings does not completely meet the demand of the building, the renewable energy system can be sized for serving a stripped down capacity of critical needs. Building occupants may feel a sense of security knowing that critical building systems can be maintained during a

catastrophic event (combatting anticipatory stresses), a response to the housing and shelter stressors often associated with a catastrophic event.

Cost
The cost of photovoltaic panels continues to drop, with prices for solar energy systems costing 30 percent less than they did five years ago[20]. However, there is still an up-front cost for new construction to integrate a solar array into the building design. In addition to the system itself, the armature required to support panels tilted toward the sun must be designed to resist uplift from winds, which impacts the connections to building structure below. Other types of energy systems attached to a building also must be evaluated for impacts on the building's structure.

Cost benefit analysis should also be performed between rooftop energy systems and other options, such as green roofs. Systems may compete for space, limiting the building to one roof function.

Like any other building system, there is a cost to operation. This cost includes regular maintenance and general upkeep by building engineers, connections to building automation systems, and costs of repair over time. However, this strategy also has the ability to reduce long-term building energy costs as well. A life-cycle cost analysis can be performed to provide a truer indication of payback and total cost of ownership.

2.4 Building Elements above Flood Plain

It is not uncommon for major pieces of mechanical equipment to be located on a building's roof, especially in urban environments where space at grade is at a premium. If a building is located in a known flood plain, additional planning of building elements may be required to ensure occupant safety during a catastrophic event or natural disaster.

One of the greatest risks for buildings sited in low-lying areas and for building spaces at or below grade is flooding, which can occur as a result of a variety of types of events. Regularly occupied spaces located at or below grade in a flood plain provide for risk of loss of life, loss of property, and loss of function. It is common (especially in urban markets) for daycare facilities to be located in the lower levels of multi-tenant office buildings. This location is chosen for a variety of reasons: easier access for children, less disruption to business workers, and using less desirable space for service instead of tenants. However, the risk associated with ground level or below-grade daycare needs to be carefully considered in areas prone to flooding.

Moving occupants to higher floors also poses challenges. Evacuation plans should be thought through, and the existing building egress stairs analyzed to confirm they can accommodate larger numbers of users. Certain types of occupants - such as small children or the elderly - may also be more challenged in evacuating from higher floors.

Unoccupied regular uses may be more suitable for grade-level spaces in buildings within known flood plains. These uses may include lobbies and circulation, service spaces such as trash rooms and loading docks, bicycle storage, and tenant storage.

Mental Health Benefits
Occupants may feel a lessening of anticipatory stress knowing that their regularly occupied space has a lesser risk of flooding because of the building's interior spatial configuration, or that the entire building is not located within an area at risk of a 100- or 500-year flood. Planning for building elements such as daycare facilities also addresses dependent care, civic capacity, and shelter related stressors.

Having critical facilities and systems above a known flood plain also can relieve situational stress, as building components would not be compromised by flooding.

Cost
Cost for this strategy is difficult to pinpoint, as it relies heavily upon when the strategy is employed—during initial building design or as a retrofit—and what spaces are being located at a higher elevation. When taken into consideration during initial project design, this strategy could be low to no cost. For example, moving critical mechanical systems from at or below grade to a higher floor in a high-rise office building would nott greatly impact the total run of pipe and duct if considered in the design phase. Relocation of a system after the building is operational is a much costlier exercise.

2.5 Transportation for Building Occupants

When Hurricane Sandy hit the New York metropolitan area in 2012, many major transportation arteries were compromised due to significant flooding and lack of electricity. New York City was paralyzed with respect to transportation: rail and subway tunnels were flooded and unusable, and roads were flooded and buckled from soil saturation. During the days after the storm, more people moved through the city by bicycle or walking than by train, car, or bus[21].

A building can provide dedicated parking or storage for occupant-owned bicycles used for daily commuting.

An additional area can be reserved for bicycles owned by the building or landlord that could be used in crisis situations when other types of transportation become unavailable or unsafe.

Sustainability rating programs, such as LEED for Commercial Interior and LEED for New Construction, offer requirements for user-owned bicycle parking as well as space for visitors' bicycles. These designated areas may allow for building- or tenant-owned vehicle storage as well without adding more storage requirements[22].

In locations prone to flooding or within known flood plains, simple inflatable rafts and pumps may be a viable transportation option in crisis. When deflated, the rafts take up minimal space.

Mental Health Benefits

Occupants may feel a sense of relief from anticipatory stress knowing that there is transportation available in their building which could be utilized in a time of emergency. Safe transportation options also relieve residual stress by allowing occupants to move away from the facility after an event occurs. The ability to travel to dependents or loved ones, along with the ability for occupants to leave the building to obtain supplies, medicine, or food could be considered a critical building amenity for those in areas that can expect disruption in normal transportation options.

Cost

While any number of building-owned vehicles represents an up-front cost commitment on behalf of the owner (in addition to regular maintenance cost for upkeep), there could be multiple uses for building-owned bicycles during times of non-crisis in addition to providing a safe and non-fuel-intensive transportation option for occupants during crises.

Inflatable rafts and manual pumps are inexpensive in terms of up-front cost, and require no regular maintenance. If ever inflated and deployed, inspection for leaks and patching is the minimal maintenance time required.

Dedicated space for bicycles may or may not take rentable area away from the larger facility. With bicycle storage generally expected or mandated in most urban environments, and when compared to the area required for parking of one car, the cost for the bicycle storage space would be a minimal consideration. Building-owned alternative vehicles (bicycles and/or inflatable rafts) could be stored in unrentable space (such as under stairwells) to minimize impact on rental income.

2.6 On-Site Storage of Emergency Supplies: Food

Basic necessities of life can be the most critical elements of survival when it comes to crisis management and resilience. Multi-use buildings are typically not stocked with food to support the normal occupant population. Storage of food (and any other good, for that matter) requires dedicated space within a building. This storage space must be sized appropriately for the number of occupants and a pre-determined number of days' worth of nutrition per occupant. The U.S. Federal Emergency Management Agency recommends at least a three-day supply of food per person[23]. The RELi Resilience framework notes thresholds of two, four and ten days' worth of food for two times a building's occupancy[24]. The cost per area of storage space needs to be translated into rentable or non-rentable income as appropriate to the tenant or building owner. Food-storage space should also have the ability to be well-lit, but in general should be kept cool and dry. Canned and packaged foods need to be checked periodically for expiration dates, which requires maintenance time.

Mental Health Benefits

Occupants may experience reduced levels of anticipatory stress leasing up to an event just from knowing there is a supply of food available in their building in the event a crisis situation occurs. They may also experience reduced levels of situational and chronic stresses knowing there are necessities available to weather through an event. For building-wide food storage, this strategy could be considered as a building amenity for tenants.

Cost

There are two general costs related to storage of nutrition for occupants: the cost of the food itself and the cost of the space required for the storage. Generally non-perishable foods are not a high expense, but the cost will be determined by the number of occupants being accommodated and the number of meals allocated to each occupant.

The cost of space may be a greater financial concern, especially in regions that carry high rental costs for tenant space. For example, a lease for commercial office space in Washington, DC may be $55 per rentable square foot of space. If a storage closet is required for a floor of occupants that is roughly 6 feet by 3 feet, that equates to $990 per month in rent for that room on that floor, or $11,880 in rent per year.

2.7 On-Site Storage of Emergency Supplies: Water

Much like the storage of food described above, storage of water for building occupants requires calculation of storage space based on the number of occupants to be supplied and the desired timespan of service. Unlike estimating the number of required meals though, water can be estimated using health standards of gallons of fresh water required per person for survival. According to FEMA, one gallon of water per person per day is required for drinking and health, and a three-day supply of water is recommended per person. Nursing mothers, children, and sick individuals may require additional water per day[23].

Storage of water could be achieved through commercially-bottled products—to be considered a static supply—or could be more dynamic with collection of rain water on the building's roof and site and sent through on-site treatment and purification systems to achieve a drinkable quality. On-site retention and purification can be costly options as they require up-front design and construction as well as ongoing maintenance for operation. Water stored in tanks or cisterns needs to be checked regularly for bacteria and organisms deemed unhealthy to humans. Purified water needs to be proven drinkable to local health authorities on a regular basis. On-site water reuse, though, could be a building operation strategy year-round and in non-crisis times as well, serving the building as long as there is adequate rainfall to do so. Based on connections to local wastewater systems, reused water could be treated to a lesser standard and used for toilets, urinals, and outdoor irrigation. The system could be switched to a higher treatment standard when needed for drinking, bathing, or cooking. Water reclamation systems need to be evaluated by cost with respect to their return on investment, valuing the upfront cost of design and installation with the potential long-term reduction in utility-provided water supply needed.

Provisions for water supply are considered requisite in the RELi Resiliency Action List, and are noted to be sized appropriately for occupant load and a range of timeframes[24].

Mental Health Benefits

Knowing that there is a supply of drinkable water available in crisis situations may allow occupants to experience reduced levels of anticipatory stress leading up to an event. They may also experience reduced levels of situational and chronic stresses when necessities are available to weather through an event. The ability to relieve chronic stress will be directly proportional to the amount of water stored and how long it can last. When on-site water reclamation systems are employed, residual stresses may be relieved as well as the building can return to normal operation faster.

As mentioned earlier regarding food storage, building-wide water storage could also be regarded as a building amenity for tenants.

Cost

The same cost considerations should be studied for water storage that were raised for food storage when undertaking using commercially-available water products. For water reclamation systems the cost will be significantly higher, especially when considered as a building retrofit. There is cost associated with the system components that will clean the water for various levels of use as well as a cost to provide the energy required to pumps and filters on a regular basis. In times of emergency, back-up power would be required to keep the pumps operational. There is also cost associated with taking space in a building for water storage, and finally the cost for personnel to maintain the system.

If the system is planned for use during normal occupancy as well as times of crisis, there may be a cost savings realized in the reduction of utility charges for both potable water and removal of waste water.

Like any building system, a life-cycle cost analysis can be performed to determine total cost of ownership and potential return on investment. Due to the general long-term nature of return on investment with these systems, this strategy may be most applicable for owner-occupied buildings and long-term lease tenant spaces.

2.8 Emergency Communications

As already noted in this article, inability to communicate with loved ones is considered the top stressor in crisis situations. Modern technology may allow us to be in constant contact with others around the world, but if cellular towers are incapacitated during a storm, the devices can be rendered useless. Some events also spark above-average use of cellular service, overwhelming the service and again rendering cell phones useless.

Provision for emergency communications can be designed and constructed into a building or tenant space to allow for occupants to attempt contact with dependents, as well as allow for general communication with emergency services. Examples of emergency communications include traditional phone ("land") lines, NOAA weather-band radios, HAM radios, and limited-use cel-

lular phones ("track phones"). Dedicated wireless internet service may also be a reliable option provided power is available for modems and routers.

The recently-released RELi Resiliency Action List includes communications provisions as a requisite in the Hazard Preparedness category, with enhanced access to a wider variety of communications as a separate checklist item[24].

Mental Health Benefits
As previously mentioned, the inability to communicate with dependents can be one of the greatest stressors during and after a catastrophic event. The simple ability to speak with a loved one or arrange care for those who are remote and cannot care for themselves can ease anxiety when travel to that person or persons is not available. In addition, provisions for alternate communications can assist building maintenance and operators in connecting to municipal emergency personnel and coordinating needed repairs, rescue, transfer of occupants, and supplies (civic capacity).

Emergency communications means would be employed during a crisis situation as well as in the immediate after-effects, addressing both situational and chronic stresses.

Cost
Generally, provisions for communications are low compared to other strategies. Most types of communications do not take up significant rentable area, and service can usually be arranged as a part of overall telecommunications provisions. Some options— such as HAM and NOAA radios—do not need anything more than a supply of batteries and antenna access to the sky.

2.9 Shelter in Place

When designing a new building, certain elements of the structure can be designed with consideration to potential crisis events anticipated in a specific area. The opportunities to impact occupant safety can vary greatly, and may be larger than the purview of this article. However, a few examples that address rethinking building elements include:

- In geographic areas prone to earthquakes, the building structure can be designed for progressive failure. Anticipated compromise of the structure can be pinpointed in the design, allowing a portion of the building to fail (or collapse) without impacting the structural integrity of the rest of the building. Building occupants can be notified of this feature, knowing to retreat to areas designed for greater stability during an earthquake.
- Operable windows are sometimes considered anathema to mechanical systems, but in times of power failure these openings allow for natural ventilation as well as potential escape routes (depending upon height above ground level). They may also encourage the ability for residents to signal to emergency personnel on the ground.
- Buildings considered targets for terrorism often require blast-resistant windows. While this conflicts with the ability to achieve natural ventilation, it may protect building occupants in the event of an act of terrorism.
- An area on each floor of a building—particularly in a common space—can be identified as a safe area for occupants if the enclosure to the area has enhanced fire resistance, structural bracing, and communications methods. Not unlike areas of refuge within a fire stair, larger spaces can be used for emergency gatherings of all occupants when exiting a building is not possible. In regions prone to tornados, designated safe areas are not uncommon building components. This "safe area" may incorporate other strategies listed in this article, such as provisions for food, water, and communications. The design of the space may emphasize safety and calmness in the finishes and colors employed on the walls and floor.

A single tenant within a building can also prepare for safe shelter of occupants without the entire building providing the option. For example, creating a designated safe area as noted above can occur within a tenant space.

Mental Health Benefits
Shelter is considered a basic necessity of life, and providing for a basic necessity is a straightforward way to alleviate some types of individual stress. As society becomes increasingly mobile, traditional links to sense of place have been strained[14], and considering a physical space to be a safe haven may be less common. Notifying occupants that a specific location in a building is designed for specific safety needs may combat the current trend of constant mobility and fragility. Occupants may feel less anticipatory stress leading up to an event knowing there are provisions in the building or tenant suite designed to enhance safety. Situational stress may also be lessened because of the safety provided by the building itself. Other stressors such as dependent care and food/water/medical issues may also be addressed within the designated safe area within a building, but would be determined by individual building needs and spatial capacity.

For buildings designed with resilience aspects as noted above, certain elements may be considered attractive to tenants when looking for new space.

Cost
Cost for this strategy varies greatly based on the aspects of the building affected, and whether the work is planned as part of the initial design or as a retrofit. Designating a "safe area" on each floor of a building may not require more than the designation itself if the area was constructed with high levels of fire resistance, for example. Replacing windows may be a higher cost item, and obviously depends on the number of units being replaced and what qualities the new panes include. Progressive failure of a structure must be designed into the initial construction and can dramatically increase up-front construction cost, but then requires no ongoing operational or maintenance expenses.

2.10 Training for Personnel

When dealing with large groups of people, designated leaders or coordinators are invaluable in keeping the group on track, on task, or in motion. Many buildings rely on volunteer leaders for fire drills to ensure all occupants leave the building and are accounted for. These same volunteer leaders could be called on in crisis to provide key direction to occupants, ensuring safety in the short or long term. For a typical multi-tenant office building, the key personnel may include building engineers, building security, and designated administrative staff for each tenant.

For personnel to be effective in crisis, there are several fundamental elements in which they will need to be well-versed to effectively lead and guide other occupants. Depending upon the total building population and the types of tenants in a structure, these skills include:

- Understanding the crisis management elements designed into a space, such as emergency communications, safe haven areas, etc.
- The ability to give clear direction
- Knowledge of the building or tenant population, including whether transient guests are present and need to be accommodated
- Knowledge of key organizations and municipal departments appropriate for the building and how to get in contact with each (such as fire and rescue, police, the Red Cross, etc.)
- Basic first aid skills to treat common wounds and illnesses, and any training specifically required by a unique occupant group (children, the elderly, etc.)
- Certification in CPR
- The ability to delegate tasks as required, and to assess occupant situations to a decision point.

Training and certifications must be kept current. Key personnel should be required to take annual courses to refresh skills as required, and changes to building policies or elements need to be communicated to all designated personnel.

Mental Health Benefits
Proper training can assist in addressing many categories of stressors, including civic capacity and food/water/medical factors. Occupants may experience less anticipatory stress knowing that there are key personnel trained to assist them in the event of an emergency. Situational stress for occupants may also be decreased with individuals who are charged with maintaining some level of quality of life should they be unable to leave a building during an event. Longer term stress may or may not be alleviated with strong leadership as other elements of the event and environment may become more pronounced.

The designated personnel who act as leaders in crisis may experience elevated levels of stress when put into crisis situations. These individuals should be evaluated for the ability to handle stress when selected for these leader positions, but should also be provided additional mental health support when a situation has subsided as they may be prone to residual stresses. The Center for Disease Control and other organizations provide a framework of resources for first responders and emergency personnel that can be adapted or transposed to event-specific personnel[25].

Cost
General first aid and CPR training is minimal to no cost, and can often be arranged for groups directly through aid organizations, such as the American Red Cross. Annual or semi-annual meetings refreshing knowledge of building features take minimal paid staff time and can offer valuable information on a semi-regular basis.

2.11 Communications to Occupants

Emergency preparedness comes in many forms. Pre-event communication and preparedness training have been strongly encouraged in "disaster prone" areas and those that experience certain "disaster seasons" (such as "hurricane season" in the southeast United States)[6]. At its simplest, buildings notify occupants when there is a change in routine related to preparedness drills and systems testing (such as fire drills and alarms). That same strategy can be extended to communicat-

ing building-level resilience planning measures. Occupants can be informed or reminded on a regular basis of building features that may assist in a time of crisis. These communications can take a variety of forms including emails, posted flyers, permanent placards, and all-hands type meetings. Any communication should be handled prior to crisis, that is, on a regular basis in times of non-crisis to allow occupants to understand plans for dealing with specific types of crisis events. New occupants should be given the information during new employee orientation periods.

Depending on the resilience aspects of a building or space, management should determine the most effective means of communication for the specific group of occupants. Communications may also vary based on the type of event for which specific messaging is being planned. Some catastrophic events, such as hurricanes, allow for more time leading up to the event for communication. Plans can be tailored to specifics of the event. Other types of events, such as tornadoes and earthquakes, do not allow for anticipatory time for instruction. Planning for these events should be communicated ahead of the immediate need so that occupants have a level of preparedness before a crisis situation.

Mental Health Benefits

Occupants who understand the crisis management aspects of a building or tenant space may experience lower levels of anticipatory stress leading up to an event, and may react in calmer and more measured ways during an event (situational stress). Good communication and outreach also deal directly with elements of civic capacity, and depending on the content of communications can also deal with other stressors.

Cost

For many types of communication to building or suite occupants, the cost is virtually nothing as it only takes the time to draft or forward an email or make a general announcement. Communications can be presented in forums already in place, such as all-staff meetings and management updates. Permanent placards may be the most costly form of communication as they take time to design, order, and install, in addition to the material cost of the items. However, relative to other building-wide strategies this tactic is one of the lowest in cost.

2.12 Strategy Summary and Efficacy

The matrix presented in Table 1 summarizes the resilience planning strategies outlined in this research article and their potential impacts on mental health of the occupants. The chart does not rank the strategies in any order, but does offer a snapshot as the variables each strategy represents. Specifically:

- The strategy is categorized as a design approach (D), or an operational approach (O), or impacting both design and operations (D, O)
- Stressor categories addressed: Housing & Shelter (H), Civic Capacity (C), Dependent Care (D), Transportation (T), and Food/Water/Medical (FW)
- Types of stress impacted by the strategy: Anticipatory (A), Situational (S), Chronic (C), and Residual (R)
- Whether the strategy addresses Acute (A) or Chronic (C) events
- A cost factor, relative among the discussed strategies.

Recognizing that stress, stressors, coping, and emotional health are all very much tied to the mental health of the individual, ranking strategies with respect to efficacy is extremely challenging. The variables of geographic location, type of building, climate, and local infrastructure make it almost impossible to say with certainty that one design strategy will be more effective in improving mental health than another.

For the purposes of this research, and to provide a starting point to design teams for decision making, the following explains the methodology of relative efficacy based on the factors previously discussed in this research. The equation below (Figure 2) scores each strategy based on the number of stressors addressed, the number of types of stresses addressed, and whether the strategy applies most to an acute event or both acute and chronic events.

The numeric score for each strategy was plotted on the graph against the relative cost established in the narrative and summarized in Table 2. The chart shows the efficacy of the strategy in relation to cost. This information may assist design teams in determining the value of a design strategy, particularly when budget is constrained. For buildings undergoing renovation, a strategy may carry a greater cost, but may also provide for greater impact on occupants.

The graph shows that the strategies selected to be part of this research are spread fairly evenly among relative cost. The numeric scores calculated with the formula above show that the selected strategies all have high efficacy levels with respect to metal health. There are many other strategies for design teams to employ that may have less effect on occupant psychological well-being, and those have not been considered in this study.

Table 1: Summary of design strategies and impacts on stresses, stressors, and relative cost.

RESILIENCY STRATEGY	DESIGN OR OPERATIONAL	STRESSOR CATEGORIES	STRESS TYPES AFFECTED	ADDRESSES ACUTE OR CHRONIC STRESS	COST FACTOR
Green roof as assembly / gathering space provide for shade, cool roofing, and soft turf for occupants should use of the roof be required for safe haven during an event	D	H, C	S, C, R	A, C	$$$
Green roof for food cultivation + production use a green roof system for growing fruits and vegetables when seasonally and geographically appropriate	D, O	FW	C, R	A, C	$$$
On-site renewable energy incorporate passive energy generation into the structure; power key systems in crisis	D	H, C	S, C, R	A, C	$$$$
Elevate critical equipment above the flood plain mechanical, life support	D	H	A, S	A, C	$$
Locate occupied spaces / at-risk occupants above the flood plain this applies to existing buildings located in a flood plain	D, O	H, C, D	A, S	A	$$
Provide transportation options for occupants bicycles located within a facility	O	T	R	A, C	$$
On-site storage of emergency food stock nonperishable food for occupants	O	FW	S	A	$$
On-site storage of fresh water supply stock water supply for occupants	O	FW	S	A	$$
On-site water reclamation for reuse, consumption filtration of rainwater and / or stormwater for basic needs	D, O	H, FW	S, C, R	A, C	$$$$
Provide emergency communications methods land line phones, HAM and NOAA radio	O	D, C	S, C	A, C	$$
Design for safe haven / shelter-in-place upgraded design or building retrofit	D	H	A, S	A	$$$
Shelter-in-place designate safe haven areas	D, O	H	A, S	A	$
Training for key personnel first aid, CPR, emergency responsiveness	O	C	A	A	$
Communicating resilience to occupants messaging methods	O	H, C	A	A, C	$

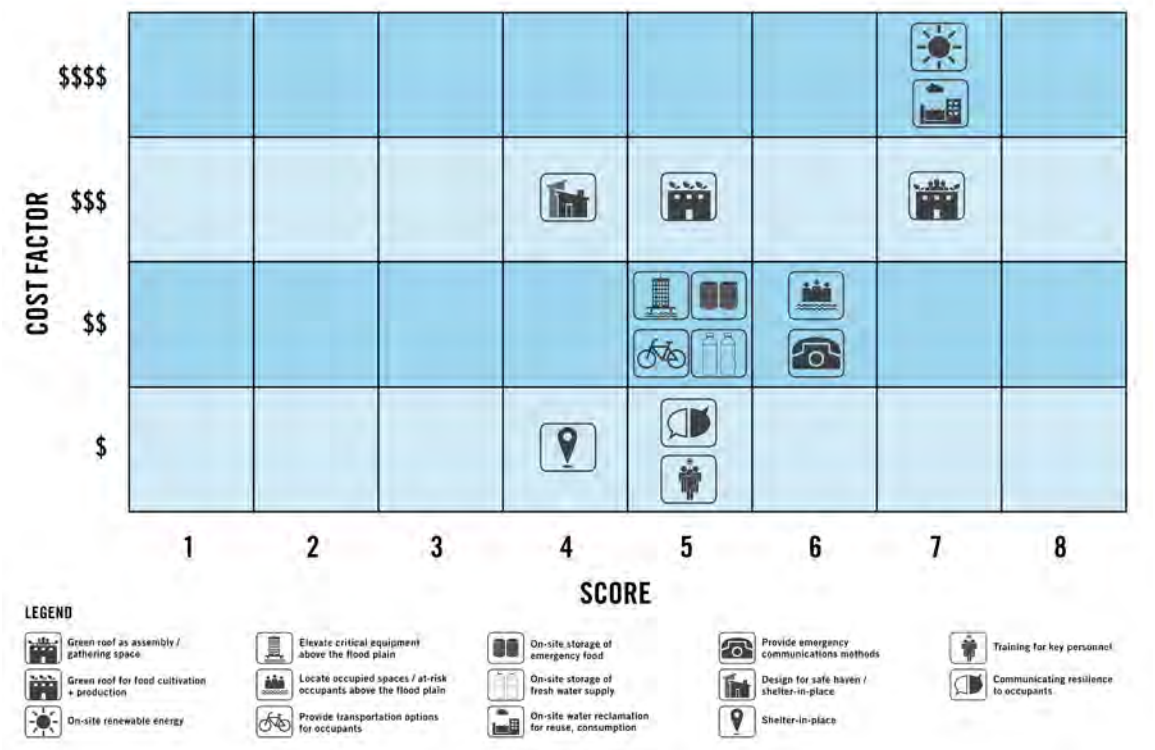
Stressor Categories: Housing + Shelter (**H**), Civic Capacity (**C**), Dependent Care (**D**), Transportation (**T**), and Food/Water/Medical (**FW**)

Types of Stress: Anticipatory (**A**), Situational (**S**), Chronic (**C**), and Residual (**R**)

(# of stressors addressed) + (# of types addressed) + (1 for acute impact, 2 for acute & chronic impact) = strategy efficacy score

Figure 2: Design strategy efficacy equation.

Table 2: Relative cost plotted against efficacy.



3.0 CONCLUSION

As research clearly indicates, there are many ways that stress can take its toll on victims, and how it manifests may vary among individuals. Therefore, how can the best strategies be identified for a project? As with all design strategies, specific project and client goals must always be taken into account when determining the correct course. The first step is to start by determining the vulnerability points of a project site. Which of the five stressors are most likely to impact the occupants of a space? Tenants in an urban office building are much more likely to suffer from transportation related stress if an event forces mass transportation systems or tunnels and bridges to close than those in non-urban settings. Conversely, less densely populated areas typical have a higher ratio of families than urban settings, meaning that dependent care may be a more prominent stressor. The make-up of building occupants can also determine the stressors most likely to impact occupants. Race, gender, age and level of education all influence how an individual or community responds to a crisis.

Once the most eminent stressors are determined, the next step is to evaluate the threats most prevalent in the site's geographic and climatic region. Is the space in California, where earthquakes and drought are real threats, or is the project on the coast of Florida where hurricanes and flooding are of greater concern? Determining the nature of the threat will help to identify the kinds of stress occupants are most likely to suffer from. In the case of California and earthquakes, anticipatory and situational stress may be quite low because there is little warning, and the event itself happens very quickly. This means earthquake victims are much more likely to suffer from chronic and residual stress, as the aftermath of earthquakes may take years to resolve. Strategies that provide accessible food and water would mitigate some of the chronic stress caused by an earthquake. Looking at the coastal Florida example, anticipatory stress plays a greater role in the days leading up to a storm. With the regularity of hurricane season, residents may even experience anticipatory stress annually, whether a specific storm is threatening or not. Operational strategies communicating disaster planning protocol would reassure occupants that a plan is in place, helping to reduce anticipatory stress. Building use will also impact selection of specific strategies. Occupants in a hospital will experience very different stress than those in an office building.

By determining the stressors most likely to impact occupants and the types of stress, it is possible to understand the most vulnerable aspects of a building or space. Prioritizing strategies that address the specific needs of that population is necessary. Investment into resources for solutions with the most potential to mitigate stress on occupants is essential. However, this effort does not always require a large monetary investment. Operational strategies focusing on communication protocol and training require relatively little funding (compared to building retrofits) and can still be impactful if addressed as part of change management.

Any steps taken to eliminate the toll of stress on occupants during a crisis event have the potential to reduce longer term mental health issues. The positive effects can be tremendous. For the occupants, less stress means fewer thoughts and actions that may be risky or dangerous to the individual or others. Studies previously cited note that manifestations of stress often are visible depression as well as volatile actions, such as assault, abuse, and even suicide. For employers, lowering anticipatory and residual stress may result in generally happier and more confident employees as well as lower insurance costs. Finally, the building owner and manager may make a building more attractive to potential tenants showing there is resilience planning in place, and may even benefit from lower property insurance costs. Further research should focus on these various benefits and effects to quantify their value, as well as find ways of refining the strategies that relate to building design.
Climate adaptation planning and resilience can quickly fall into negative and pessimistic dialogue as populations deal with issues such as rising sea level, extreme weather events, and terrorism. Providing design solutions that promote positive mental well-being is one method of turning that dialogue around.

Ideally, designers will begin to use tools and methods, such as those presented in this article, to challenge the notion of good design, adding the psychological dimension to discussions of form and function. The design community as a whole has the opportunity to make resilience and impacts on mental health integral components of a project solution, bringing these issues to the same realm as building aesthetics, structural integrity, and sustainability.

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02.
TALL WOOD SURVEY:
Identifying and Analyzing the Obstacles of Perception

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ABSTRACT

Tall wood buildings are becoming increasingly prevalent around the world, and yet, they are conspicuously missing from the U.S. skyline. Antiquated building code restrictions have put the United States behind its Canadian and European counterparts, preventing the U.S. from even considering the use of wood as the primary structure in a tall building. Recent initiatives from various wood manufacturers and sponsors are pushing back on these restrictions and providing the research and support needed to move engineered wood products forward.

This article aims to address the public's perception of engineered wood to determine if there are perception barriers that may be impeding advancement of tall wood buildings. The research methods included literature review and survey. The survey methodology included a web-based questionnaire, which more than 500 respondents completed.

The general survey population identified flammability as the greatest perception barrier to building tall with wood, followed by strength, deforestation, and durability. However, respondents that identified themselves as more familiar with engineered wood products characterized moisture as the greatest barrier, followed by insurance, cost, and durability. This data revealed that public education and awareness campaigns, which can help increase familiarity with building materials, may contribute towards overcoming these perception barriers and pave the way for building code revisions related to engineered wood products.

KEYWORDS: mass timber, sustainable design, building code, public awareness, education

1.0 INTRODUCTION

According to the United Nations, by the year 2050, our planet's population will rise by more than a quarter[1] and nearly 70 percent[2] will live in urban settings. Our cities are growing, but so is our environmental impact - a staggering one third of global CO_2 emissions comes from the construction and operation of buildings[3]. With this projected surge in demand for high rise buildings, and in light of the climate change crisis, we must consider materials that contribute to a more sustainable built environment – wood. Despite the fact that wood has a lighter environmental impact than today's typical high rise construction materials, it faces many obstacles, not the least of which is public perception[4].

Engineered wood products are manufactured by binding strands, fibers, or veneers of wood together with adhesives to form composite materials. Some examples of engineered wood products used for building structure include Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), Glued Laminated Timber (Glulam), and Nail Laminated Timber (NLT).

In many parts of the world, engineered wood products have been utilized as the primary structural material for high rise buildings over the past 20 years[5], but tall wood applications are only now being employed in the United States[6]. Much of this is due to outdated building codes, which limited the height of wood buildings to five

stories on a concrete podium. However, the adoption of the 2015 International Building Code (IBC) brings many new opportunities for the use of engineered wood products by incorporating updates to the 2015 National Design Specification (NDS) for Wood Construction, which now includes a chapter on Cross Laminated Timber (CLT). The code identifies CLT as a structural product allowing it to be utilized in Type IV construction of exterior walls, floors, and roofs. The 2015 NDS also provides char ratings for CLT and other engineered wood products.

These code changes would not have been possible without the research efforts of engineered wood product pioneers and advocates including Michael Green Architecture (MGA), Skidmore, Owings & Merrill (SOM), and Perkins+Will. Each of these champions has explored various aspects and challenges of tall wood buildings from code constraints to hybrid models to lessons learned on built projects.

Driven to find carbon-neutral and sustainable structural materials for North America's rapidly urbanizing population, Michael Green co-authored the feasibility study "The Case for Tall Wood Buildings"[7]. The 30-story proposal utilizes laminated strand lumber as the primary structural material, while incorporating ductile steel beams to address wind and earthquake forces. The report serves as an instruction manual for building tall with wood.

SOM's Timber Tower Research Project proposes a 42-story hybrid structural system referred to as the Concrete Jointed Timber Frame (CJTF)[8]. SOM utilized the Dewitt-Chestnutt Apartments, designed and built in 1965, as the concrete benchmark for comparison. The resulting timber proposal reduced the carbon footprint of the building by 60-75 percent and is believed to be technically feasible from a structural standpoint. However, the study states that the system requires additional research and testing to validate the performance of the structural system. Therefore, a subsequent study reported on the performance of gravity framing system, consisting of a detailed analysis of the hybrid CJTF system[9].

Forestry Innovation Investment (FII) and Binational Softwood Lumber Council (BSLC) engaged Perkins+Will to visit built tall wood projects around the world and survey the various stakeholders to collect lessons learned. The results of this survey are documented in the "Survey of International Tall Wood Buildings"[10]. The research team also summarized the findings and the most important lessons learned in a journal article titled "Lessons from Tall Wood Buildings: What We Learned from Ten International Examples"[11].

Public opinion can be a considerable driving force for building code revisions and improvements, as it has been for climate change policies for the past decade[12]. In light of our industry's impact on the environment, it has become clear that we MUST build using more sustainable materials. This article aims to determine the perceived barriers to tall wood construction to allow the building industry to develop strategies and overcome these barriers, and pave the way for constructing future high rise buildings with wood as the primary structural material.

2.0 RESEARCH OBJECTIVES AND METHODOLOGY

The aim of this research was to first distinguish if there are barriers as a result of the public's perception of engineered wood and, if so, to identify the greatest of these barriers. With this data, the building industry can develop tools to overcome these perceptual barriers, because, at this point, the barriers are just perceived, not actual, and the growing number of built tall wood projects stand as testaments that wood is a feasible structural material.

This survey was conducted through SurveyMonkey, an online cloud-based survey development company, from February 12, 2015 through February 16, 2015. It was open to all participants (ages 18-100) regardless of background, ethnicity, gender, income level, geographic area, etc. In addition to the data collected through the administered survey, SurveyMonkey provided supplementary information for each survey participant as part of their user profile. This information included age, gender, U.S. region, household income, and device type.

2.1. Survey Objectives

There were four primary objectives to this survey. The first was to gauge participant's familiarity with engineered wood products, the second objective was to identify the barriers of perception, and the third objective was to distinguish which of these barriers were the greatest. And finally, the fourth objective was to cross reference data from the various data sets (age, gender, region, income, and industry) to find correlations and decipher trends in the data.

2.2. Pilot Survey

Once the survey was drafted, a small pilot group was recruited to test the legibility and viability of the ques-

tions to be sure that the information being extracted was worthwhile and that the questions did not bias the survey takers towards a particular answer. The pilot group consisted of six respondents, three men and three women, who identified their industries as *Construction, Machinery and Homes* (1); *Entertainment & Leisure* (1); and *Health Care & Pharmaceuticals* (4). Pilot survey participants provided several points of compelling feedback, outlined here, that were considered and incorporated into the final survey.

Negative
Respondents had mixed opinions on the negative nature of the questions. One pilot respondent noted, "... the wording suggests that all of the barriers are actual problems – not just perceived un-validated problems," while another observed that the survey "swings to the negative side a bit but didn't find it too negative." However, the negative nature of the barrier statements must be considered since the results may be skewed by respondent's tendency to agree with statements without considering carefully, particularly with negative statements[13].

Personalize
Respondents felt the survey questions should be more personal, one suggested, "...rather than what is the general perception I wonder if you should be asking personal views... I would form your check box questions as more personal... I would ask some questions with the check boxes that are like 'would you live/work in a tall wood building?" As a result, a more personal barrier statement was added to the survey – "I would not live in a tall wood building" – written negatively to match the negative nature of the other barrier statements.

Definition
Respondents requested that definitions for Engineered Wood and Tall Wood Buildings be made available, and these were inserted. Additionally, examples of both Engineered Wood and Tall Wood Buildings were added to the survey to provide clarification and references to the participants.

Categories
Many of the pilot respondents felt that they did not fit well into any of the presented industry categories, thus an additional *Design* category option was provided for the Industries classification question.

Comments
A respondent commented that, "You are designing this for the general public and generally, people will be fine with doing the little check boxes, but when it comes to elaborating, you're going to get very few responses unless they feel passionate about the subject." Comment boxes were added to each question so that participants could provide additional information if they wished.

2.3. Administered Survey

Introduction
The survey began with the following introduction to help give the participants a sense of what this survey was trying to achieve:

This survey is made possible by a Perkins+Will Innovation Incubator micro-grant. The purpose of this survey is to gauge the market perception of tall wood buildings. A tall wood building is defined as a structure consisting primarily of mass timber of five stories or more.

Comment boxes have been provided under certain questions if you wish to elaborate on responses, but this is not required. We anticipate this online survey will require approximately 3 minutes to complete.

At Perkins+Will, we've created a practice where design, technology and research converge to create places that improve how we live and work. Our Innovation Incubator program fosters an invigorating culture of innovation by supporting small, focused research projects proposed by staff members through micro-grants of money and time.

In recent years, a number of wood buildings have been constructed over seven stories, including the 10-story Forte building in Melbourne, Australia and the 14-story Treet building in Bergen, Norway, with a few others under design that achieve 30 stories in height.

Thank you in advance for your contribution!

Industry
Following the introduction, question one (Q1) of the survey asked respondents to identify their principal industry (Figure 1). Respondents who chose the *Other* industry were asked to specify their responses in the comment box. Some of those that identified themselves as *Other* were clearly part of one of the industries listed thus were recategorized to the appropriate industry. For example, respondents who identified themselves as a nurse or a mental health specialist in the *Other* industry comment box were recategorized as *Health Care & Pharmaceuticals*. Likewise, a graphic designer was recategorized as *Design*. Respondents who noted they were retired from or studying in an industry were cat-

egorized under their correlated industries. For example, a retired teacher was recategorized with *Education* and a nursing student was recategorized with *Health Care & Pharmaceuticals*. Participants who noted they were retired, a student, or unemployed without specifying their industry remained in the *Other* category. Fifty-seven respondents were recategorized from the *Other* industry group in this manner.


We are very interested in collecting information on your industry so we can track trends in opinions on the barriers of tall wood by market sector.

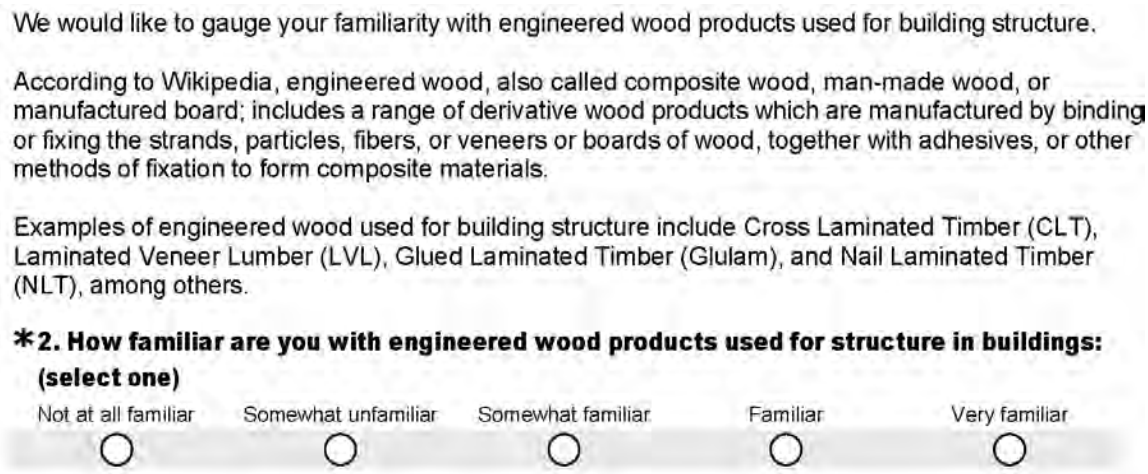
***1. Please identify your principal industry: (select one)**

- Advertising & Marketing
- Agriculture
- Airlines & Aerospace (including Defense)
- Automotive
- Business Support & Logistics
- Construction, Machinery and Homes
- Design
- Education
- Entertainment & Leisure
- Finance & Financial Services
- Food & Beverage
- Government
- Health Care & Pharmaceuticals
- Insurance
- Manufacturing
- Nonprofit
- Retail & Consumer Durables
- Real Estate
- Telecommunications, Technology, Internet & Electronics
- Utilities, Energy, and Extraction
- Other (please specify)

Figure 1: Q1 asked participants to identify their primary industry.

Familiarity

Question two (Q2) of the survey asked participants to gauge their level of familiarity with engineered wood products used for building structure (Figure 2). A definition for this material was provided along with examples of engineered wood products specifically used for building structure. Respondents were asked to rate their familiarity on a scale from *Not at all familiar* through varying degrees of familiarity up to *Very familiar*.


We would like to gauge your familiarity with engineered wood products used for building structure.

According to Wikipedia, engineered wood, also called composite wood, man-made wood, or manufactured board; includes a range of derivative wood products which are manufactured by binding or fixing the strands, particles, fibers, or veneers or boards of wood, together with adhesives, or other methods of fixation to form composite materials.

Examples of engineered wood used for building structure include Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), Glued Laminated Timber (Glulam), and Nail Laminated Timber (NLT), among others.

***2. How familiar are you with engineered wood products used for structure in buildings: (select one)**

Not at all familiar	Somewhat unfamiliar	Somewhat familiar	Familiar	Very familiar
○	○	○	○	○

Figure 2: Q2 asked participants to gauge their familiarity with engineered wood products.

Barriers

Popular barrier statements were chosen for question three (Q3) of the survey to gauge respondent's degree of agreement with barriers (Figure 3). The participants were asked to rate their level of agreement from *Strongly Disagree* through decreasing levels of disagreement to *Neutral / Not Sure* through increasing levels of agreement to *Strongly Agree*. A comment box was provided.

***3. To what extent do you agree or disagree with these statements: (select one per row)**

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral / Not Sure	Somewhat Agree	Agree	Strongly Agree
Wood is flammable; the building will burn quickly.	○	○	○	○	○	○	○
Termites will eat a wood building.	○	○	○	○	○	○	○
The strength of wood cannot compare to steel and concrete.	○	○	○	○	○	○	○
Building more of our tall buildings with wood will deplete our forests.	○	○	○	○	○	○	○
A wood building will cost more than steel and concrete.	○	○	○	○	○	○	○
Wood is less durable than steel and concrete.	○	○	○	○	○	○	○
Wood delivers poor acoustical performance.	○	○	○	○	○	○	○
Wood is vulnerable to moisture; it will rot.	○	○	○	○	○	○	○
Insurance is more expensive for a tall wood building.	○	○	○	○	○	○	○
Building with wood is more time consuming.	○	○	○	○	○	○	○
Wood buildings are aesthetically unappealing.	○	○	○	○	○	○	○
I would not live in a tall wood building.	○	○	○	○	○	○	○

Comments

Figure 3: Q3 asked participants to rate their level of agreement with barrier statements.

Greatest Barriers

Finally, in question four (Q4) of the survey, respondents were asked to choose the three greatest barriers from the list of statements (Figure 4). An additional statement - *I do not believe any of these are barriers* - was included as an option. This question asked participants to select three statements, however only one selection was required to complete the question. A comment box was provided for respondents to elaborate on their answers.

***4. Of the statements reviewed in the previous question, identify the three greatest barriers to tall wood construction: (select three)**

- ☐ Wood is flammable; the building will burn quickly.
- ☐ Termites will eat a wood building.
- ☐ The strength of wood cannot compare to steel and concrete.
- ☐ Building more of our tall buildings with wood will deplete our forests.
- ☐ A wood building will cost more than steel and concrete.
- ☐ Wood is less durable than steel and concrete.
- ☐ Wood delivers poor acoustical performance.
- ☐ Wood is vulnerable to moisture; it will rot.
- ☐ Insurance is more expensive for a tall wood building.
- ☐ Building with wood is more time consuming.
- ☐ Wood buildings are aesthetically unappealing.
- ☐ I do not believe any of these are barriers.

Comments

Figure 4: Q4 asked participants to identify the greatest barriers to tall wood construction.

3.0 RESULTS

Five hundred seventy-two responses were collected through this survey. Five hundred eighteen surveys were complete. Only data from the completed surveys was included in this research.

Median time to complete the survey was 2 minutes and 56.5 seconds.

Population Surveyed

One of the primary goals of the survey was to collect data from a diverse cross section of the United States population to ensure the results were not biased towards one particular group. The respondent population was sufficiently diverse and reflected a nearly perfect cross section of the U.S. population in terms of gender (Figure 5a)[14], age (Figure 5b)[14], region (Figure 5c)[15], and income (Figure 5d)[16]. The cross section for industries (Figure 5e) could not be determined since the industry categories and process for categorization were inconsistent between the U.S. Census Bureau and survey.

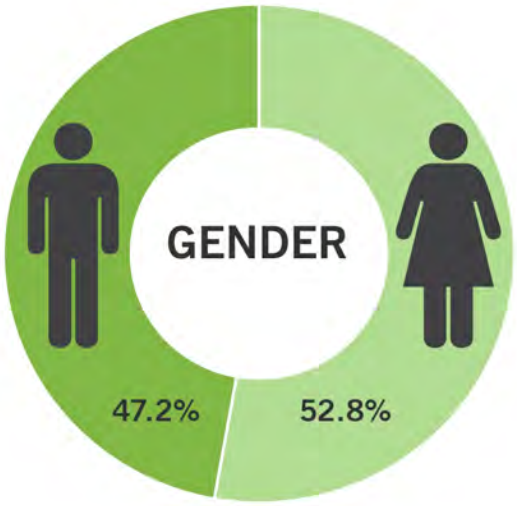


Figure 5a: Respondent population by gender.

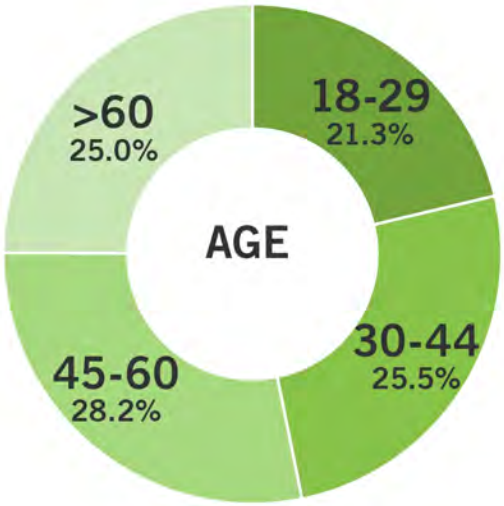


Figure 5b: Respondent population by age.

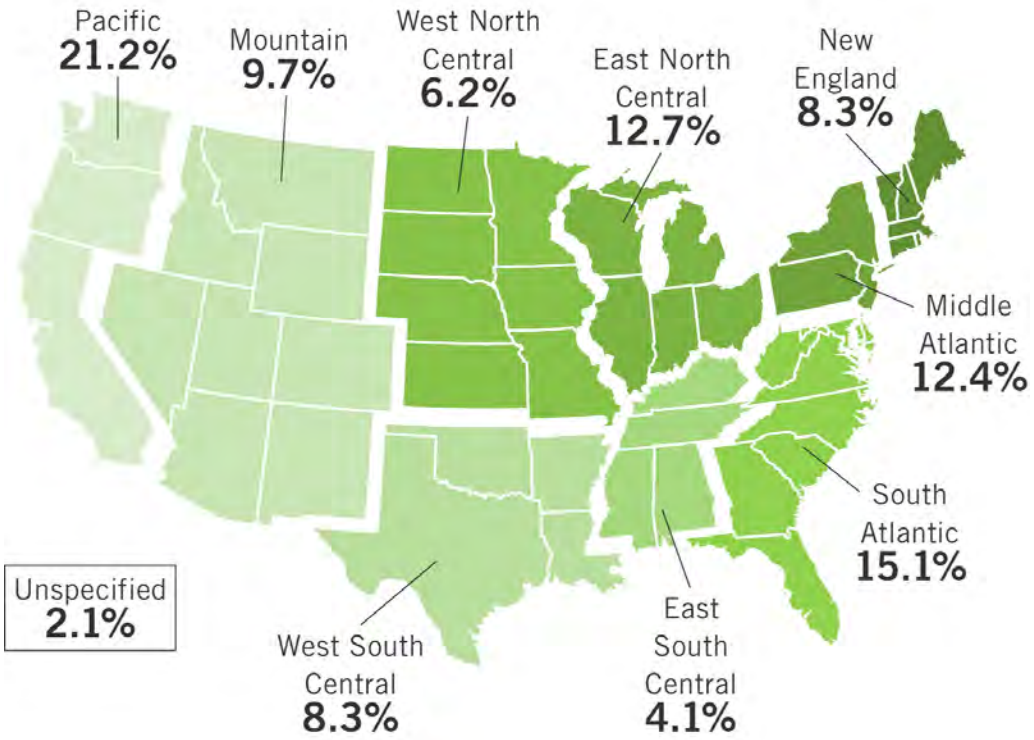


Figure 5c: Respondent population by region.

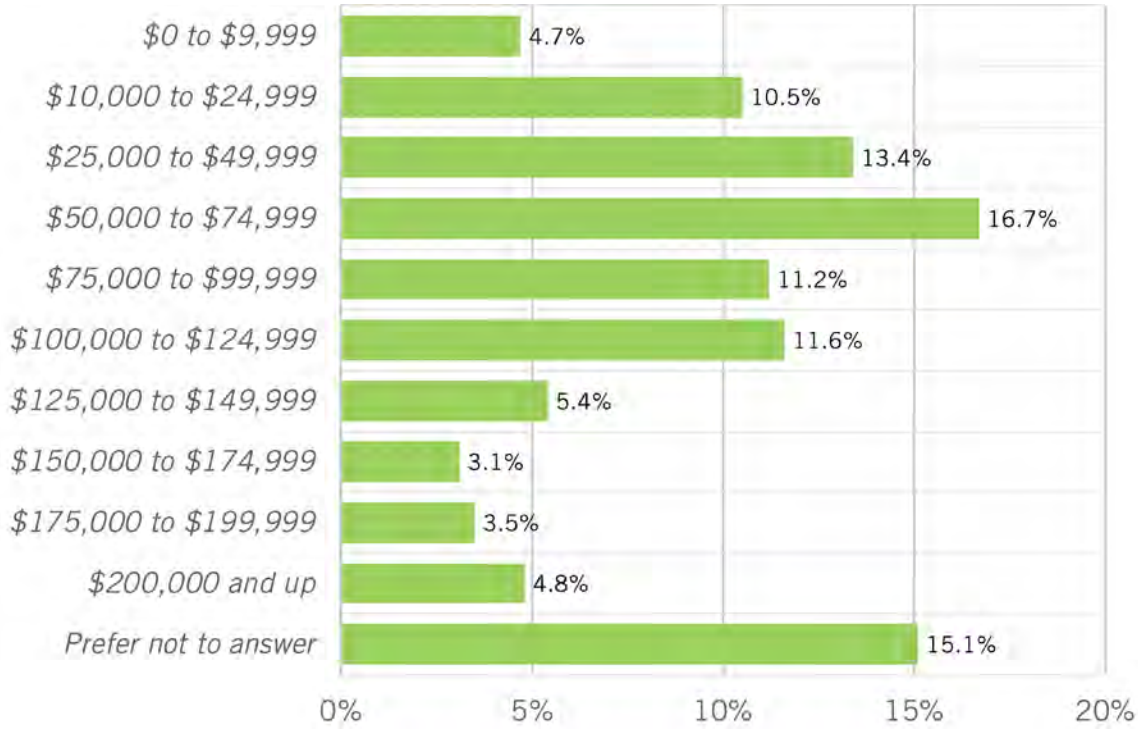


Figure 5d: Respondent population by income.

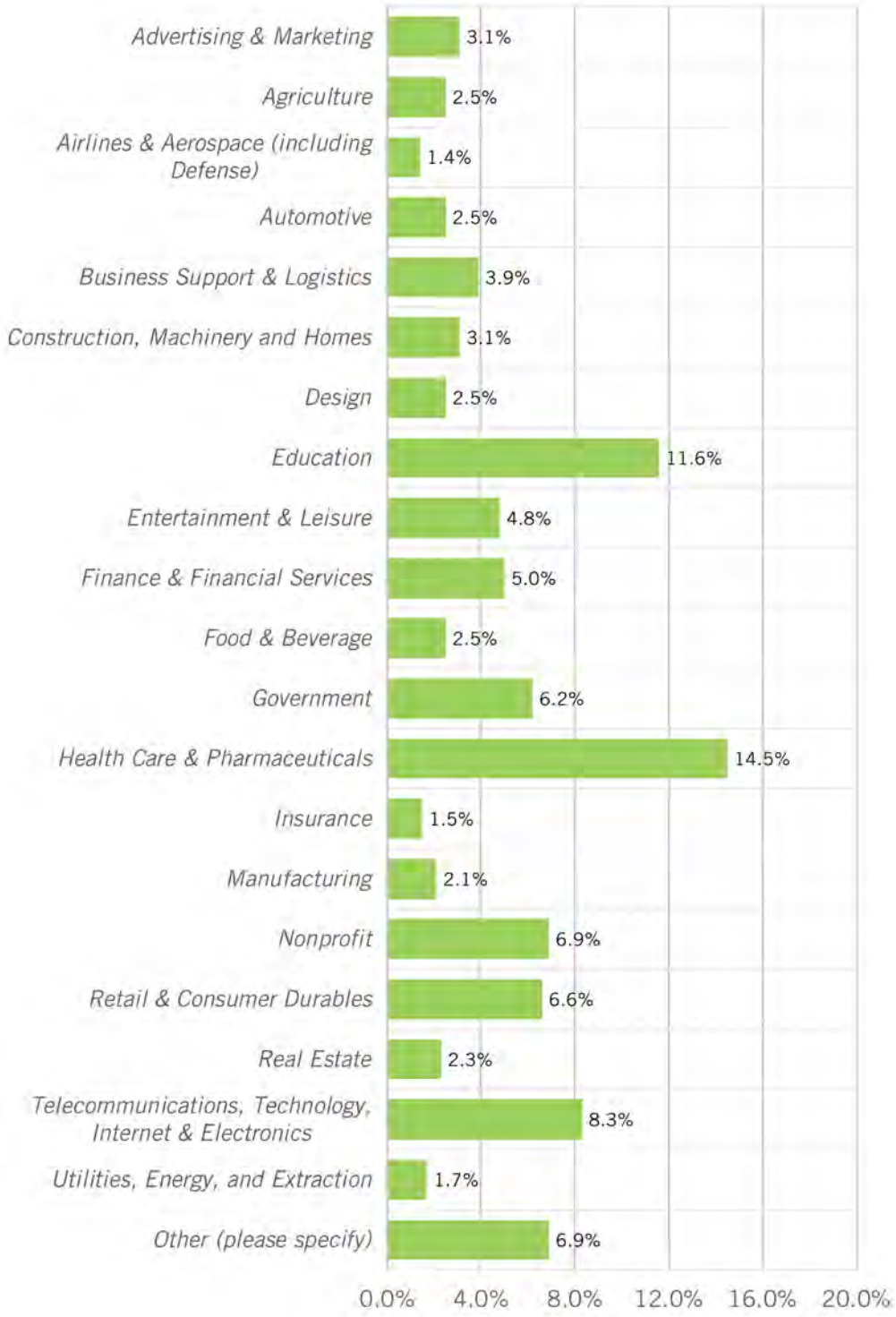


Figure 5e: Respondent population by industry.

Baseline for Familiarity

Nearly half of respondents (45 percent) claimed no familiarity at all, while merely 4 percent of respondents asserted that they were *Very Familiar* with engineered wood products used in building structures (Figure 6). Another 17 percent noted that they were *Somewhat Unfamiliar*, 26 percent professed that they were *Somewhat Familiar*, and 8 percent stated that they were *Familiar* with engineered wood products. Therefore, only one third of survey takers were familiar to some degree with engineered wood products.

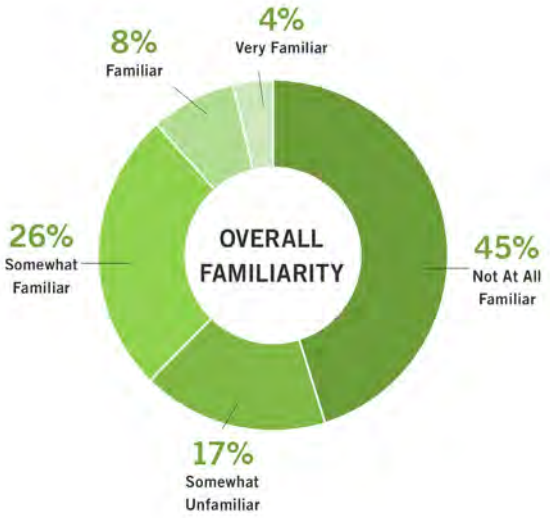


Figure 6: Baseline familiarity with engineered wood products.

Baseline for Degree of Perception

Overall, survey respondents rated P1-Flammability, P2-Termites, and P6-Durability highly as barriers, followed by P3-Strength, P4-Deforestation, and P8-Moisture (Figure 7). Graphs with peaks on the right side indicated strong agreement with the perception statement, while peaks on the left indicated strong disagreement with the perception statement. P5-Cost, P7-Acoustics, P9-Insurance, and P10-Time received a large number of *Neutral/Not Sure* responses as indicated by the sharp spike in the middle of the graph.

Reassuringly, P11-Aesthetics received a high level of disagreement making it definitively not a barrier and supporting the plethora of research[17] that postulates that people who work, learn and live in spaces with exposed wood are healthier, happier and more productive. As for living in a tall wood building, 50 percent of respondents say they would, 30 percent were unsure, and only 20 percent would not live in a tall wood building.

Figure 7: Baseline perception for each barrier statement.

Baseline for Greatest Barriers

Perhaps unsurprising, P1-Flammability was identified as the greatest barrier, with P3-Strength and P4-Deforestation rounding out the top three (Figure 8). P10-Time, P7-Acoustics and P11-Aesthetics were among the least great barriers. Encouragingly, 13 percent of the respondents believed that none of these statements were barriers.

Figure 8: Barrier perception statements ordered from greatest to least.

4.0. ANALYSIS

Outcome Categories

The baselines for familiarity, degree of perception, and greatest barriers have been established in the previous section, the following pages categorize the data by gender, age, region, income, and industry. This section ends with a comparison of familiarity to degrees of perception. The outcomes from these categories have been cross-tabulated with the baseline data to reveal trends and correlations.

By Gender

Surveyed men (44 percent) conveyed a greater degree of familiarity with engineered wood products used for building structure than women (32 percent) (Figure 9). Women agreed to a higher degree than men with three perceptions in particular, P1-Flammability (55 percent men / 67 percent women), P2-Termites (55 percent men / 63 percent women) and P4-Deforestation (49 percent men / 65 percent women) indicating that women believe these are barriers to a higher degree than men do. Women were more likely to agree that wood is aesthetically appealing (P11) (74 percent men / 82 percent women) and three percent more women would live in a tall wood building (P12) than men, while 6 percent more men thought none of the presented perception statements were barriers to building tall wood buildings with engineered wood products.

Men and women agreed that P1-Flammability was the greatest barrier in constructing tall wood buildings, and both were concerned with the strength (P3) of wood to differing degrees (Figure 10). However, men were additionally concerned with the durability (P6) of wood, while women were concerned more over the depletion of forests (P4).

This data also revealed that female respondents only made up 7 percent of the industry that expressed the greatest familiarity with engineered wood products – *Construction, Machinery & Homes*. However, women made up more than half of the three industries that followed in familiarity – *Agriculture* (54 percent), *Design* (69 percent), and *Real Estate* (58 percent). Women also made up more than half of the industry that expressed the least amount of familiarity – *Nonprofit* (55 percent).

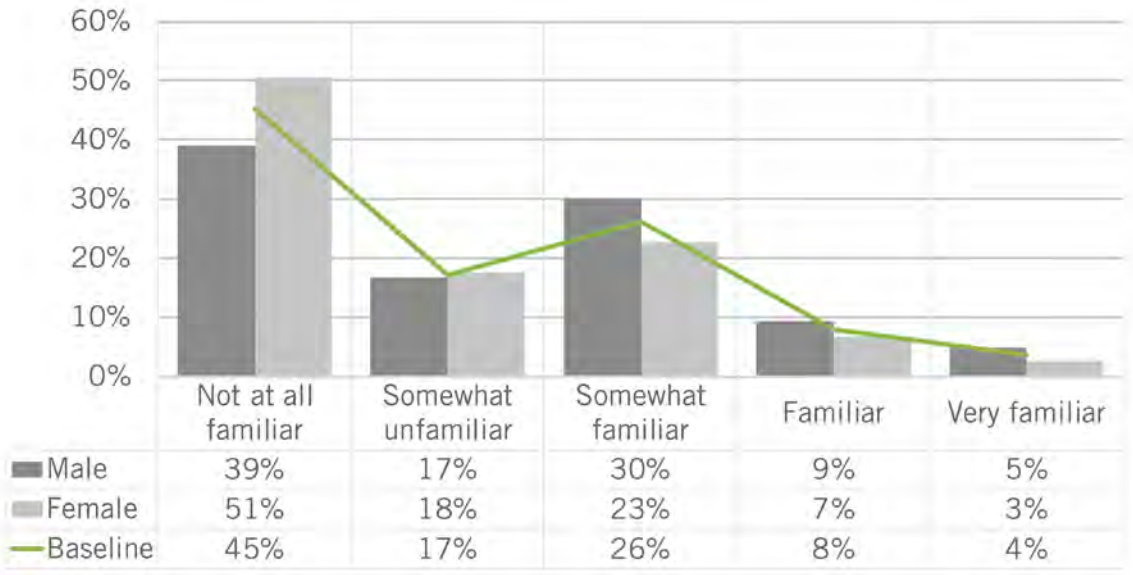


Figure 9: Familiarity by gender.

Figure 10: Greatest barriers by gender.

By Age

The level of familiarity with engineered wood products used for building structure increased with the age of the participants (Figure 11). The youngest group of participants had the highest level of unfamiliarity (62 percent), while the eldest group claimed the highest level of familiarity (47 percent) with these products. Furthermore, respondents from the *18-29* group were more likely to choose *Neutral / Not Sure* for barrier statements than any other age group. In contrast, the eldest group of participants were more likely to disagree with the barrier statements, which suggests that experienced individuals are more familiar with engineered wood products and thus have a better understanding of their properties.

The youngest group expressed greater concern for deforestation (P4) than the older groups (61 percent *18-29* / 54 percent *>60*). Respondents from the eldest group felt wood was more aesthetically pleasing (P11) than other age groups (82 percent *>60* / 73 percent *18-29*) and were more likely to live in a tall wood building (P12) than younger respondents (50 percent *>60* / 44 percent *18-29*).

To some degree, all age groups felt that P1-Flammability was one of the greatest barriers (Figure 12). The data also reflects concern for material strength (P3), durability (P6) and deforestation (P4) from all groups. Despite a certain level of familiarity, 12 percent of each of the youngest three age groups and 15 percent of the eldest group felt that none of these statements were barriers to the construction of tall wood buildings. This implies that public awareness and education campaigns are one way to disseminate knowledge of engineered wood products to increase familiarity and overcome misconceptions.

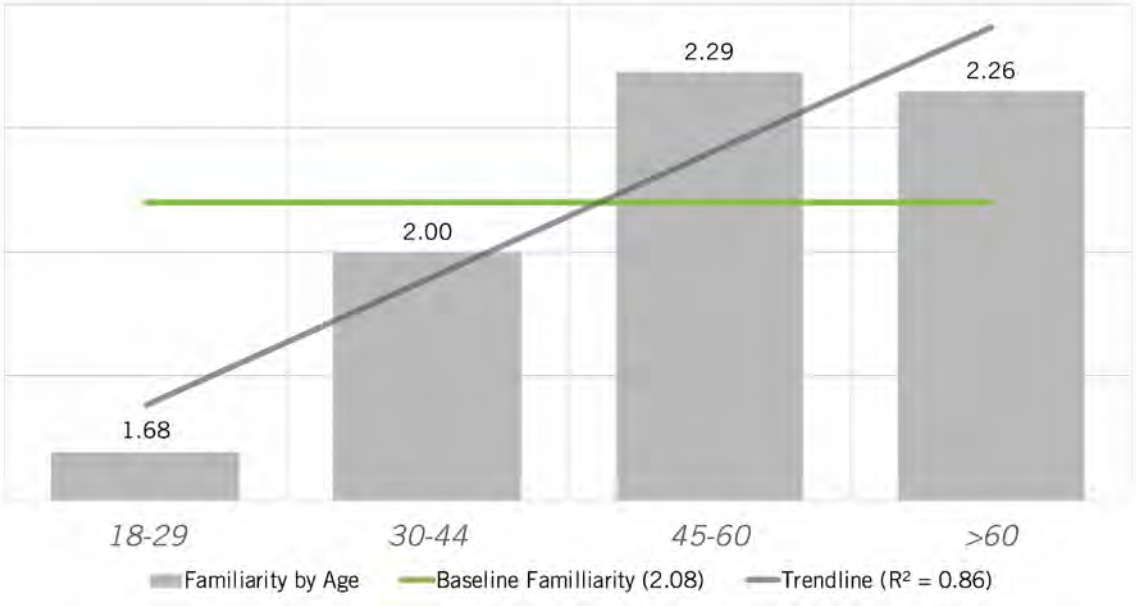


Figure 11: Familiarity by age with trendline (based on weighted average out of 5.00).

Figure 12: Greatest barriers by age.

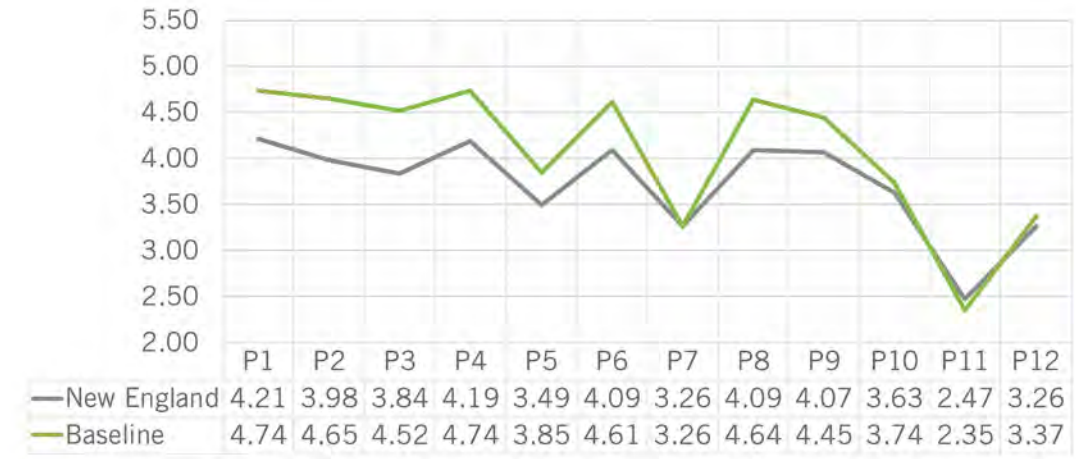
By Region

The data set on regions is likely only large enough to provide some speculations; however, it did provide some insight into how the country's geographical make-up and regional resources might influence our perceptions and familiarity. Forty-seven percent of *West North Central* respondents claimed some level of familiarity with engineered wood products, the most from any region. This data is a bit surprising since the region is not considered a hub for engineered wood manufactory, unlike the *Pacific* region, which boasts over a half dozen manufacturers and yet, only 39 percent claimed some level of familiarity, only one percent more than the survey average. The *East South Central* and *Middle Atlantic* regions were the most unfamiliar with only a 24 percent and a 28 percent degree of familiarity, respectively. Also of note, the *Mountain* region (42 percent) and *New England* region (40 percent) claimed above average familiarity with these products.

Overall, the *New England* and *East North Central* regions disagreed to the greatest degree with the negative barrier statements, meaning these respondents did not consider the statements to be barriers, while the *Middle Atlantic* region and *South Atlantic* region agreed the most with the perceptions (Figure 13). More than half of participants from the *East North Central, East South Central, Mountain, Pacific,* and *West South Central* regions would live in a tall wood building (P12). However, one quarter of participants from the *Middle Atlantic* and *West North Central* regions would not live in a tall wood building (P12).

As with the other data sets, P1-Flammability was identified as one of the greatest barriers for all regions (Figure 14). The regions similarly identified P3-Strength and P4-Deforestation as top concerns. P6-Durability and P8-Moisture also made an appearance in the top three for the *Middle Atlantic* and *Mountain* regions.

The *Unspecified* regions group, which made up only 2 percent of respondents, tended to choose *Neutral / Not Sure* more often than other region groups and also expressed a high level of familiarity (45 percent) with engineered wood products. An astounding 36 percent from this group would not live in a tall wood building.



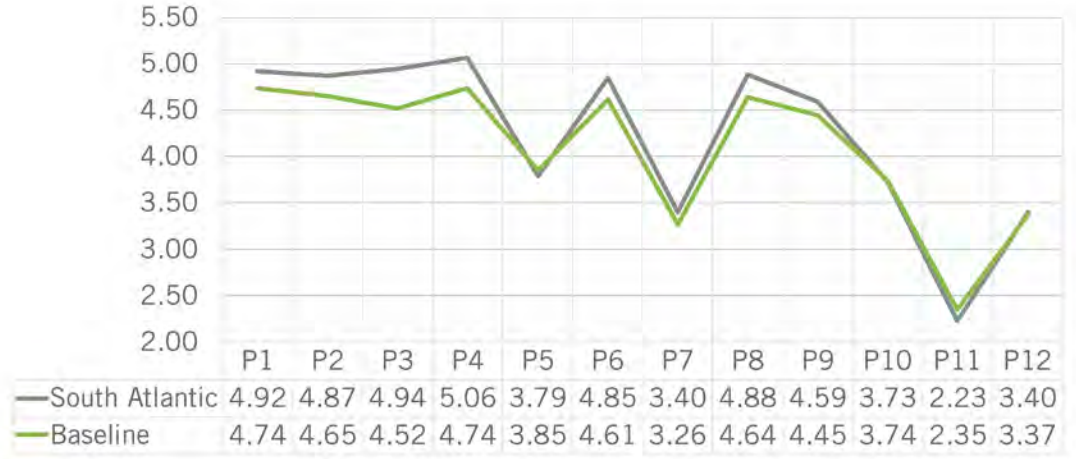


Figure 13: Level of agreement with barrier statements for *New England, Middle Atlantic,* and *South Atlantic* regions (based on weighted average out of 7.00).

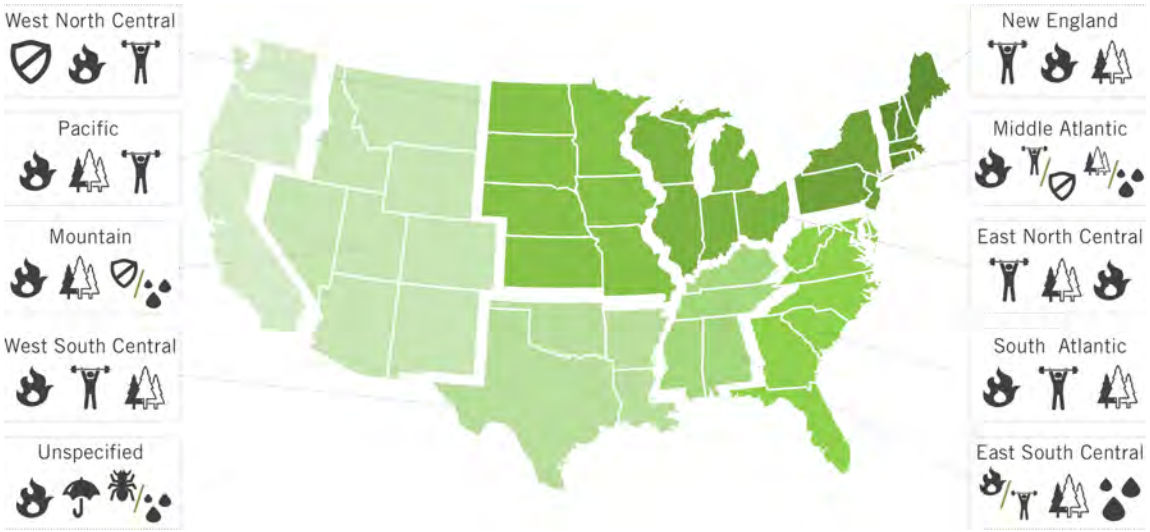


Figure 14: Greatest barriers by region.

By Industry

As with the previous section on regions, the industry data set is not large enough to reach any specific conclusions, but the data exposed some interesting trends. *Agriculture* (77 percent), *Construction, Machinery & Homes* (69 percent), and *Design* (69 percent) indicated the most familiarity with engineered wood products (Figure 15). Participants from the *Other* (22 percent) and *Nonprofit* (22 percent) industries revealed the least amount of familiarity.

The industries that denoted a greater degree of disagreement overall with barrier statements were *Advertising & Marketing; Agriculture; Airlines & Aerospace; Construction, Machinery & Homes; Manufacturing;* and *Nonprofit*. The industries that exhibited a higher level of agreement with the statements were *Entertainment & Leisure; Real Estate;* and *Other*.

The biggest surprise for this set of data is that the barrier which had been prevalent in all the previous data sets – P1-Flammability - was not indicated as the greatest for all industries (Figure 16). Another item of note is the number of ties for first, second and third greatest barrier for many of the industries. This is likely due to the small number of participants in some industries, or it is possible that some industries considered most of the statements to be equal barrier issues. This is particularly relevant for the *Design* industry, which has the greatest tie for third with five barriers. Other industries with an above average amount of ties include *Airlines & Aerospace; Entertainment & Leisure; Real Estate;* and *Utilities, Energy & Extraction*.

Predictably, the *Insurance* industry was one of the few to indicate that cost of insurance (P9) is one of the greatest barriers with 50 percent of industry participants identifying it as the second greatest barrier. Thirty-eight percent of *Advertising & Marketing* respondents indicated that they did not believe these were barriers, followed by *Automotive* with 31 percent and *Airlines & Aerospace* with 29 percent.

Figure 15: Level of familiarity for *Agriculture; Construction, Machinery and Homes*; and *Design* industries.

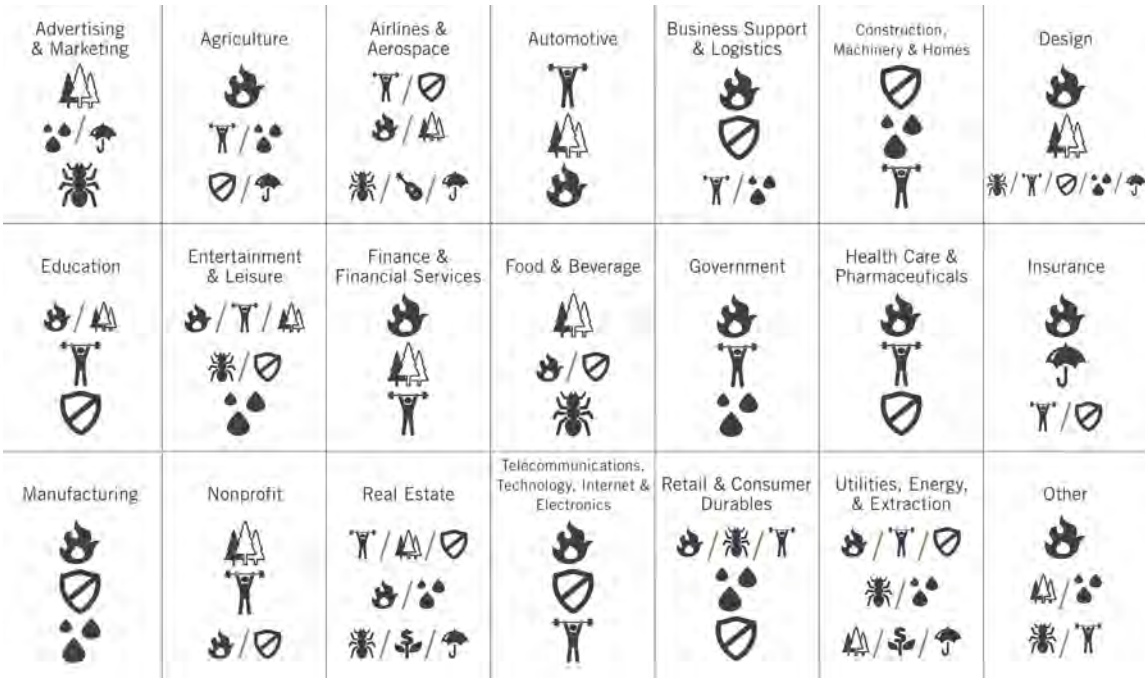


Figure 16: Greatest barriers by industry.

By Income

This income data set had some interesting and unexpected outcomes. The trendline of the familiarity graph revealed that respondents with greater household incomes had greater levels of familiarity with engineered wood products, with a few exceptions. Respondents in the *$10k-24K* (39 percent) range expressed a greater level of familiarity than expected, while those in the *$150k-174K* (31 percent) and *>$200k* (24 percent) ranges conveyed a lower level of familiarity than anticipated (Figure 17). The income ranges that disclosed the greatest degree of disagreement overall with the barrier statements were *$75K-99K, $150-174K,* and *$175K-199K*, while the *$10K-24K* and *$25K-49K* ranges conveyed a higher level of agreement overall. There were a significant number of *Prefer Not to Answer* respondents (15.1 percent), which were excluded from graphs with trendlines.

As with the other data sets, most of the income ranges identified P1-Flammability as one of the greatest barriers to building tall with wood with the exception of the *$10K-24K* range, who did not even identify P1 – Flammability as one of the top three barriers, instead identifying P8- Moisture, P4- Deforestation, and P2-Termites as their greatest. The *$25k-49k* and *$175K-199K* ranges also identified other barrier statements as greatest; P3-Strength and P8-Moisture, respectively.

The *$175k-199k* income group indicated the greatest level of disagreement with the statement "I would not live in a tall wood building." This group also expressed the highest familiarity with wood, which is no coincidence, as the next section will discuss (Figure 18).

Twenty-two percent of the *$100k-124k* income range indicated that they did not believe any of these were barriers – the most of any group, followed by *$10k-24k* with 19 percent.

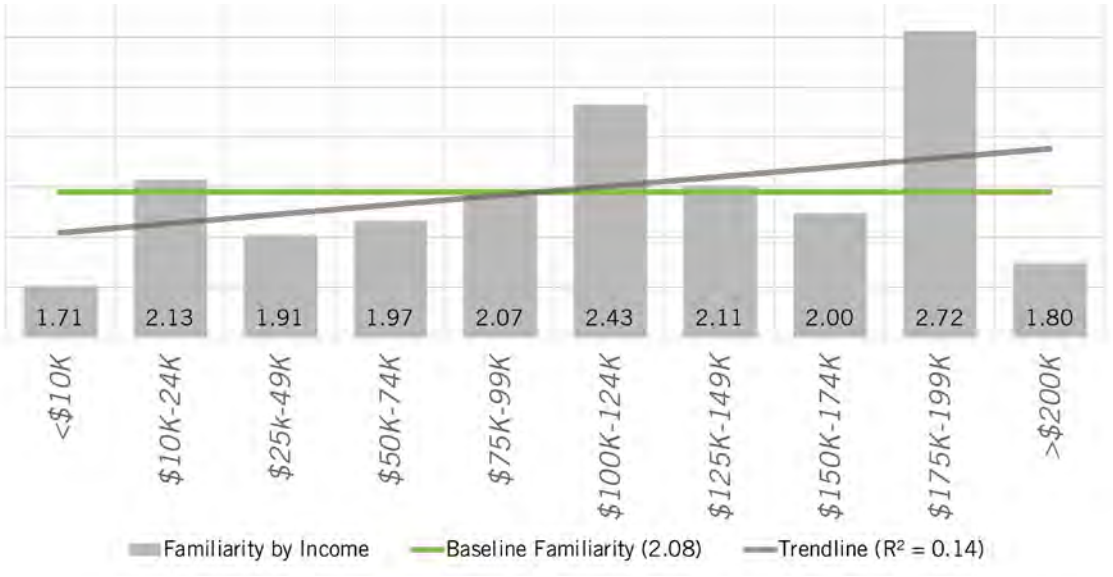


Figure 17: Familiarity by income with trendline (based on weighted average out of 5.00).

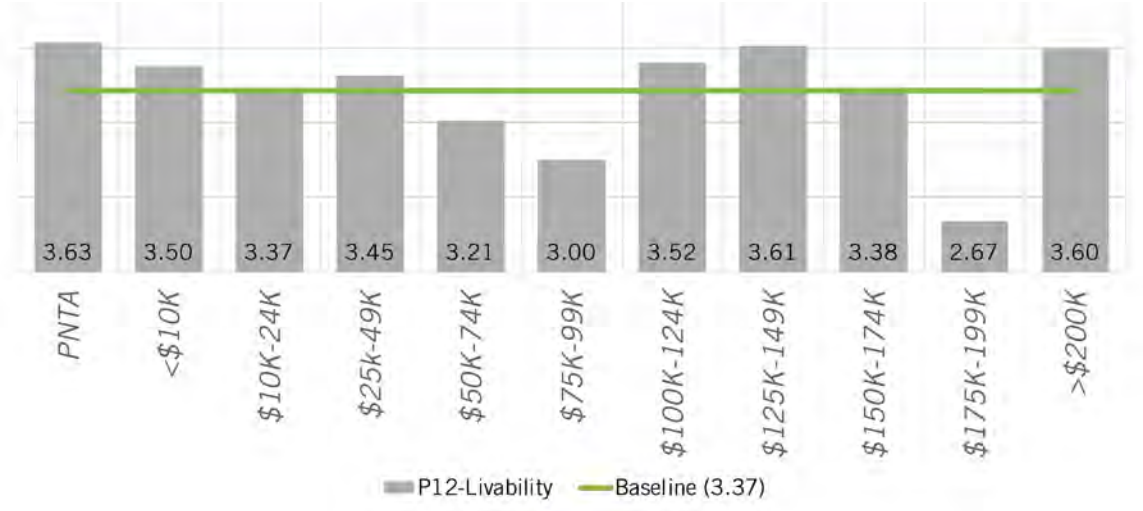


Figure 18: Degree of perception by income of P12-Livability (based on weighted average out of 5.00).

By Familiarity

Respondents who indicated the greatest level of familiarity with engineered wood products had the lowest levels of agreement with the negative barrier statements. In other words, those who were most familiar with wood were the least concerned with barriers (Figure 19). Additionally, these respondents pointed to different and, what engineered wood experts consider to be more realistic, barriers as the greatest concern for building with tall wood including P8-Moisture, P9-Insurance, P5-Cost, and P6-Durability while those less familiar identified P1-Flammability as the greatest.

An encouraging 37 percent of respondents from the *Very Familiar* group did not believe any of these statements were barriers, while only 9 percent of the *Not At All Familiar* group believed the same to be true. The *Very Familiar* (2.16) group are the most likely to live in tall wood buildings while the *Not At All Familiar* (3.57) group is the least likely.

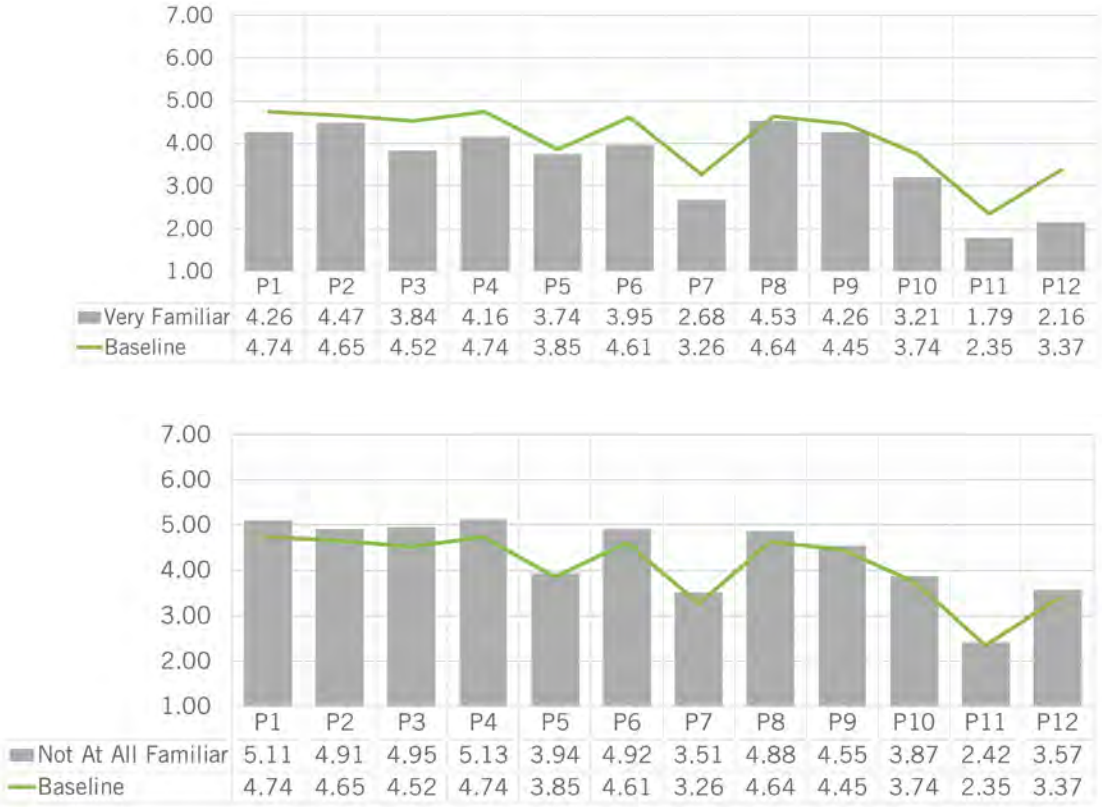


Figure 19: Level of Familiarity cross referenced with Degree of Perception for *Very Familiar* and *Not At All Familiar* groups (based on weighted average out of 7.00).

5.0 CONCLUSION

The survey validated that perception barriers are diminished with experience and knowledge. This data indicates earlier assumptions were correct – by educating the public on the attributes of engineered wood products, perceptual barriers can be overcome. Even considering the negative nature of the statements and the tendency for respondent acquiescence, the degree of agreement with the statements may have been lower, but the results would likely have been similar.

Many of the negative barrier statements are false. For example, P1-Flammability is not a barrier to building tall with wood since timber chars when it burns and insolates itself. A properly designed engineered wood building with a sacrificial charring layer would safely withstand a fire event. However, if the public perceives an engineered wood building to be flammable, the marketability and lease rate may be negatively affected. People are unlikely to live or work in places they identify as dangerous, which is why it is so important to educate the public on the true properties of this material.

This research was meant to be just one of many steps in identifying the barriers created by the perceptions of tall wood buildings. The next step needs to zoom in on our industry by first identifying stakeholders, surveying those stakeholders, and then following up with interviews so that we may refine these barriers. Stakeholders might include contractors, architects/designers, engineers, owners/clients, developers, potential buyers/renters, users, code officials, and authorities having jurisdiction.

To tackle public perception barriers, our industry only need market engineered wood products and educate the people on their properties and benefits. As the public's knowledge of these products grow, so will the demand for tall wood buildings.

Acknowledgments

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03.
SUSTAINABLE AND ENERGY EFFICIENT COMMERCIAL RETROFIT:
Case Study of Perkins+Will Atlanta Office

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ABSTRACT

Existing buildings tend to undergo performance degradations, change in use, and unexpected faults or malfunctions over time. These events often result in significant deterioration of the overall system performance, inefficient operation and unacceptable thermal comfort conditions. However, a building does not have to be new to be efficient. Today's leading building owners are retrofitting buildings, and converting existing buildings into models of sustainability. Commercial retrofit offers significant opportunities for energy efficiency and sustainability in the built environment. Design of energy-efficient and high-performance commercial retrofit requires that building performance and simulation tools are used and integrated with the design process. The objective of this research is to provide building researchers and practitioners with a better understanding of how to effectively conduct commercial retrofit to promote energy conservation and sustainability.

The review of literature identified several general design strategies in the successful completion of sustainable and energy efficient retrofit projects. However, there is not a lot of existing literature that focuses on specific case studies. Therefore, this article discusses a particular building in detail to discuss applicable design strategies, retrofitting design and the impact on energy consumption. A detailed case study review of 1315 Peachtree Street, Atlanta, GA demonstrates some of the barriers that are currently present achieving energy efficiency and sustainability in commercial retrofits, and strategies that were used to overcome those barriers.

KEYWORDS: sustainable retrofit, energy efficiency, building performance analysis, energy modeling, simulations

1.0 INTRODUCTION:

Existing buildings tend to undergo performance degradations, change in use, and unexpected faults or malfunctions over time[1]. These events often result in significant deterioration of the overall system performance, inefficient operation and unacceptable thermal comfort conditions. A study supported by the U.S. Department of Energy identified more than 100 types of faults that may happen in commercial building services systems and these faults can account for 2–11 percent of the total energy consumption of commercial buildings[2]. Perhaps one of the most impactful ways of furthering the cause of sustainability is through the implementation of energy retrofit programs[3].

Whilst sustainability is already an important driver in the new building sector, refurbishment of commercial building are moving this agenda forward[4]. Despite recent improvements in energy efficiency being made in new buildings, it is important that the existing commercial building sector also take action to meet emission reduction targets. The objectives and challenges of such action will reduce the risk of the sector becoming obsolete due to high energy use and poor environmental performance[5].

Retrofitting an existing building can often times be more cost effective than building a new facility. Since buildings consume a significant amount of energy (40 percent of the nation's total U.S. energy consumption), particularly for heating and cooling (32 percent of the energy consumed by buildings)[6], and because existing buildings comprise the largest segment of the built environment,

it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings. But, conserving energy is not the only reason for retrofitting existing buildings. The goal should be to create a high-performance building by applying the integrated, whole-building design process, to the project during the schematic design phase that ensures all key design objectives are met. Designing major renovations and retrofits for existing buildings to include sustainability initiatives will reduce operation costs and environmental impacts, and can increase building adaptability, durability, and resiliency[6].

The objective of this article is to provide building researchers and practitioners with a better understanding of how to effectively conduct commercial retrofit to promote energy conservation and sustainability. The research questions include:

- How to improve existing commercial buildings and their energy consumption?
- What are the appropriate sustainable and energy efficient retrofit strategies?
- How can positive environmental impacts and energy savings be initiated through retrofits?

This article reviews the existing literature, research and studies, and it also discusses strategies available for sustainable and energy efficient commercial retrofit. A detailed case study review of 1315 Peachtree Street, Atlanta, GA demonstrates some of the barriers that are currently present achieving energy efficiency and sustainability in commercial retrofit and strategies that were used to overcome these barriers.

2.0 LITERATURE REVIEW

"Green Retrofitting" is a term used to describe the process of renovating the systems and structure of a building to improve efficiency, reduce resource consumption, and create improved indoor air quality. The US Green Building Council (USGBC) takes this analysis a step further and includes the premise that retrofitting does not end with the installation of energy efficient systems, but also includes continued maintenance of this equipment in order to sustain these improvements over time[3].

Reusing the existing building stock, particularly as a result of performance upgrading, has been identified as having an important impact on sustainability of the built environment[7]. Retrofitting aged buildings can significantly reduce their energy use[8] and "work to the outside of the envelope is likely to be sufficient for most existing buildings"[9]. It should be noted that performance retrofits and the restoration of the existing building stock are inherently sustainable. Every time we reuse a building instead of tearing it down and building a new one in its place we:

- Keep construction debris out of landfills
- Preserve the existing embodied energy of the building
- Prevent the need to use new construction materials that are energy intensive, including aluminum, glass, steel and concrete[10].

A review of literature demonstrates that the most commonly implemented strategies for energy efficiency of retrofitted buildings include improved heating, ventilation and cooling systems (HVAC), improved insulation, and lighting[11]. The energy efficiency of a building is limited by how the building is designed, engineered, constructed, operated and maintained. Achieving greater energy efficiency in an existing building depends on several factors, including the building envelope, system types and efficiency, energy end use, such as plug loads, and building operation and maintenance practices. The efficiency of the building envelope impacts the energy load for the building, including the required energy used to heat, cool and ventilate. Simple strategies to reduce heating and cooling loads include appropriate insulation, optimizing window glazing area, minimizing the infiltration of outside air, and using an opaque roofing material. Additionally, the envelope impacts the lighting load for the building, depending upon how much natural daylight penetrates through windows into the interior spaces[12].

Recent research efforts to improve energy modeling and diagnostics for existing buildings have focused on devising methods based on digital photogrammetry or three-dimensional (3D) laser scanning and thermal imagery. Thermography is a relatively new and powerful tool for building investigations, which helps to identify defects such as missing insulation, moisture in walls, ventilation losses, and thermal bridges[13].

In exploring applicable net-zero energy design approaches for commercial retrofits, rethinking towards the net-zero energy building concept and all the possible strategies that can be integrated into an existing building, it is necessary to consider comprehensive methods for sustainable design, commercial retrofit, and renewable energy systems. Achieving net-zero energy goals in commercial retrofits with available technologies is challenging. However, with careful attention to adaptive design strategies, building envelope treatment, passive design approaches, appropriate HVAC

systems and utilization of renewable energy sources it is possible to achieve that goal. Energy modelling and simulations, which uncover the energy saving potentials for every energy-saving measure, are beneficial tools in retrofit design and should be widely applied. Local resources, environment, and human activity should be considered during the decision making process, contributing to develop an integrated building system that enables new opportunities for energy saving and building performance improvements[14].

The review of literature identified several general design strategies in the successful completion of sustainable and energy efficient retrofit projects. However, there is not a lot literature on specific case studies. Therefore, this article focuses on one particular building in detail to discuss applicable design strategies, what was done and the impacts on energy consumption.

2.1 Sustainable and Energy Efficient Retrofit Technologies

Building envelope is the most effective predictor of the energy which is used for heating, cooling, lighting and ventilation of the buildings[15]. Because of being in direct interaction with the external environment conditions, building envelope is defined as the interface of energy loses. For reducing the energy use in buildings, the energy requirements of buildings must be minimized, the efficiency of energy use must be increased and systems must be set up which support the use of sustainable energy sources[15]. Energy efficient and sustainable commercial retrofit technologies can be categorized into three groups, they are, supply side management, demand side management, and change of energy consumption patterns, i.e. human factors[8].

Energy efficient and sustainable commercial retrofit technologies for supply side management include building electrical system retrofits and alternative energy supply systems to provide electricity and/or thermal energy for buildings such as solar hot water, solar photovoltaics (PV), wind energy, geothermal energy, etc.

Energy efficient and sustainable commercial retrofit technologies for demand side management consist of the strategies to reduce building heating and cooling demand, and the use of energy efficient equipment and low energy technologies. The heating and cooling demand of a building can be reduced through retrofitting building fabric and the use of other advanced technologies such as air tightness and windows shading. Low energy technologies may include advanced control schemes, natural ventilation, heat recovery, thermal storage systems, etc.

In a sustainable commercial retrofit, existing building performance assessment and diagnostics are used to benchmark building energy use, identify system operational problems, and find energy conservation opportunities. Energy audits and surveys enable identification of energy use and costs, from which energy cost and consumption control measures can be implemented and reviewed[16].

2.2 Building Performance and Simulations Tools

Performance analysis, energy modeling and simulations are used during the design process to understand and quantify performance of different design strategies. These methods are also required to inform design in energy efficient and sustainable adaptive reuse[17]. Reliable estimation and quantification of energy benefits are essential in a sustainable building retrofit decision-support system for prioritization of retrofit measures. The performance of different retrofit measures is commonly evaluated through energy simulation and modelling. There are a number of whole-of-building energy simulation packages, such as EnergyPlus, eQUEST, DOE-2, ESP-r, BLAST, HVACSIM+, TRNSYS, etc., that can be used to simulate the thermodynamic characteristics and energy performance of different retrofit measures.

Building information modeling (BIM) can also be used to predict the energy performance of retrofit measures by creating models of existing buildings, proposing alternatives, analyzing and comparing building performance for these alternatives and modelling improvements[18]. Energy simulation plays an essential role in analyzing the performance of retrofit measures. Since different models (and tools) offer different prediction reliabilities with different uncertainties, the model (and tool) selection and its parameter identification are essential to ensure reliable estimates.

2.3 Sustainable and Energy Efficient Commercial Retrofit Strategies

The principles of energy efficiency and the technologies available for a commercial retrofit will be virtually identical to those for new construction, and the challenge for the retrofit project is to select those technologies that maximizes the use of what already exists, exploit the potential of the building and integrate new technologies that complement these and make the building as energy efficient as possible[4]. Some of the sustainable and energy efficient commercial retrofit strategies are given

below:

- Recommission all energy and water systems to determine they are operating at optimum performance; then upgrade energy and water systems to minimize consumption.
- Develop a plan to optimize the recycling and reuse of demolition debris and construction waste to minimize waste sent to landfills.
- Evaluate occupancy patterns, then apply daylight, HVAC and lighting sensors in appropriate locations. Incorporate energy efficient lighting into the project as appropriate for the tasks and functions of the spaces.
- Determine if natural ventilation and fresh air intake are feasible alternatives to reduce heating and cooling loads.
- Investigate renewable energy options that can offset the purchase of fossil fuel-based energy.
- Consider solar shading devices for windows and doors, including those that generate electricity by photovoltaic (PV) devices.
- Replace existing windows with high-performance windows appropriate for climate and exposure. If building requires security upgrade, evaluate blast resistant windows and films. If building is located in a high noise area, evaluate windows that also include adequate exterior to interior noise reduction.
- Analyze the benefits of distributed generation if the building is in a campus cluster or can share the on-site energy produced with adjacent buildings.
- Balance the project's sustainable goals with its security goals including protecting the building and its occupants from natural and man-caused disasters.
- Certain site renovations can improve the energy performance of the building including reducing the heat island effect.
- Determine if a cool roof or green roof are cost-effective ways to reduce heat island effect and stormwater runoff.
- Employ Energy Star and/or a green building rating system for existing buildings like LEED for Existing Buildings: Operations and Maintenance (LEED EBOM) or Green Globes for Existing Buildings to gage the building's level of performance.
- For historic buildings, update systems appropriately to maintain a balance between the need for energy and water savings with the character of the original building fabric.
- Take the opportunity afforded by the building renovation to incorporate sustainable operations and maintenance practices and switch to green cleaning products and methods.
- To ensure a newly renovated building continues to perform as designed, measure the performance of the building regularly.
- If not already metered, plan on installing meters for electric, gas, water and other utilities. Smart meters and submeters are preferable to monitor real-time consumption, control demand and increase tenant accountability (cost control)[6].

3.0 CASE STUDY: 1315 PEACHTREE STREET

1315 Peachtree is a commercial retrofit of a 78,956 square foot 1985 office structure transformed into a high performance civic-focused building. Located in the heart of Midtown Atlanta across from the High Museum of Art, the new building continues to house the Peachtree Branch of the Atlanta-Fulton County Public Library and introduces a new street-level tenant space occupied by the Museum of Design Atlanta (MODA). The Perkins+Will Atlanta office occupies the top four floors with office space for up to 240 employees.

Considering the warm humid temperate climate of Atlanta with hot summers and no dry season, an integrated design approach was followed to evaluate and maximize the energy reductions of the building. Solar studies and energy modeling informed decisions regarding daylighting, glazing replacement, glazing materials and shading systems. These studies, along with lighting analysis, were critical to inform the load calculations and sizing and selection of the HVAC systems. Local psychrometric chart informed the design decisions of HVAC systems to ensure four major factors that determine comfort zone in the building: air temperature (dry bulb temperature or DBT), humidity (relative humidity RH), air movement (velocity fpm or m/s), and internal quality of air.

Atlanta's psychrometric chart shows that the best single cooling design strategy is sun shading, which accounts for 16.8 percent of the hours. It has the advantage of being able to be combined with all the other cooling strategies. The next most effective cooling strategy is natural ventilation, which accounts for 16.4 percent of the hours. Because Atlanta is relatively humid in the summer, direct evaporative cooling could account for only 3.2 percent of the hours. Conventional air conditioning is the only other option for cooling all of the hours that fall outside of these zones on the psychrometric chart.

On the heating side, 25.7 percent of the hours would be comfortable indoors purely because of internal loads (lights, appliances, and people). Passive solar direct gain with low mass could add an additional 9.7 percent of the hours, but if the building was high mass then pas-

sive solar direct gain could create comfort conditions for only about 10 percent of the hours. If wind protection was provided, it could improve thermal comfort for only 1.2 percent of the hours per year. Because it is humid in Atlanta in the summer, 13 percent of the hours would be too humid for human comfort so some form of dehumidification would be required. But, even under the best of passive heating conditions at least 27.9 percent of the hours per year will require combined heating and humidification.

The "living lab" energy and HVAC equipment include a high-efficiency scroll chiller, twin microturbines, a unique adsorption chiller, dedicated OAS and energy recovery wheel and a photovoltaic array.

The design of the HVAC systems combines elements never before used in this hot/humid climate, including radiant heating/cooling, under-floor air distribution, chilled beams, microturbines, an adsorption chiller, 7.2 kW photovoltaic panels and an energy recovery wheel. Energy recovery and desiccant dehumidification strategies were used to reduce ventilation cooling loads. Lighting systems were designed for minimum egress level ambient lighting coupled with LED task lighting, controlled by an occupancy and daylight sensing system. Rainwater is captured and used in a grey-water system. Microturbines produce hot water for building heating and cooling, building hot water and almost 40 percent of building electricity. At the time of certification, this was the highest scoring LEED BD+C 2009 project in the world.

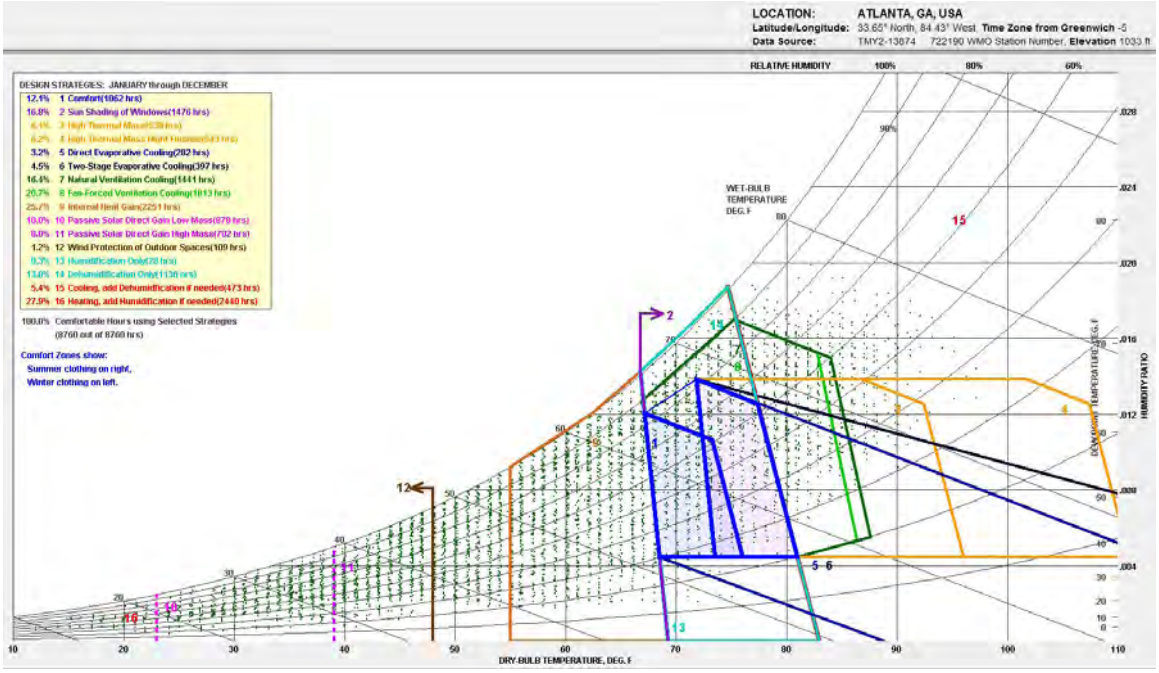


Figure 1: Psychrometric chart for Atlanta climate.

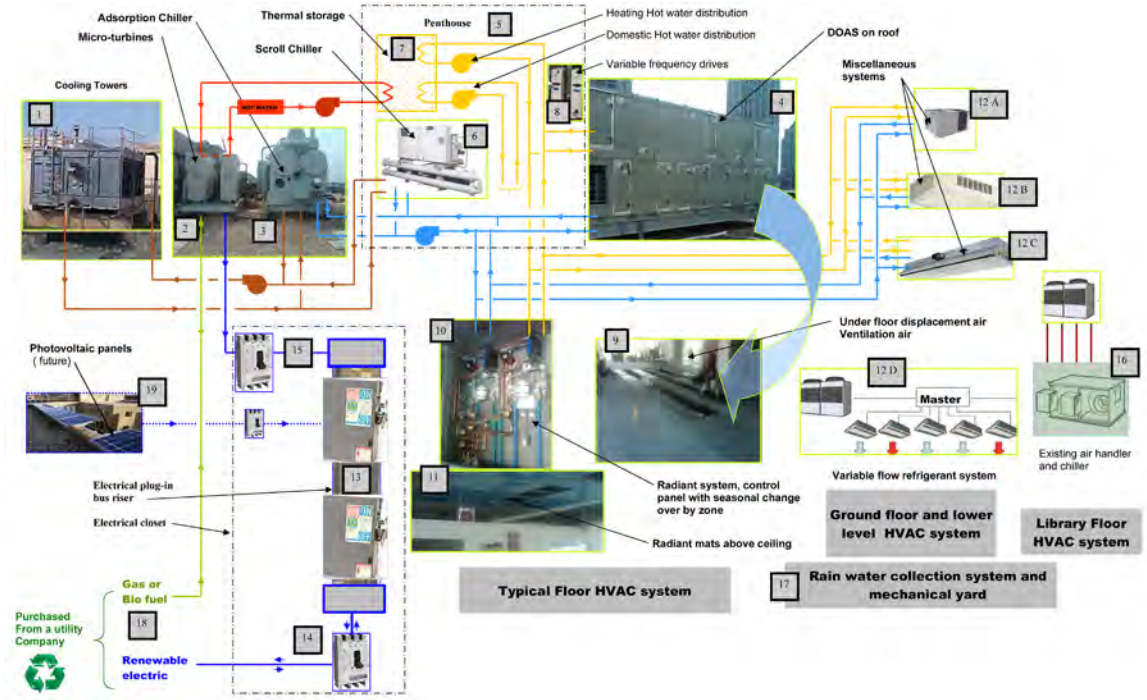
Figure 2: Before and after views of 1315 Peachtree Street. After photo credit Eduard Hueber © Arch Photo, Inc.

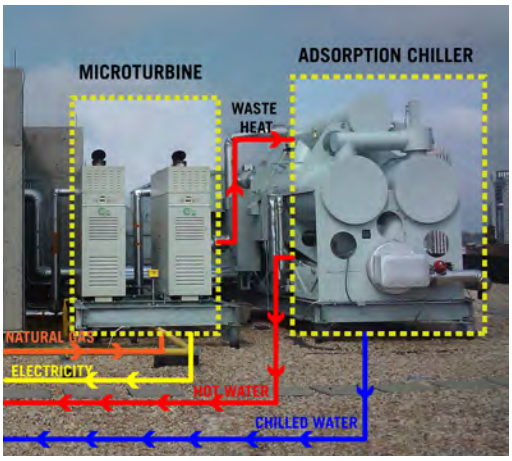
3.1 Building Performance and Simulations Tools

Ecotect was the primary environmental modeling tool, and IES VE was used for daylight modeling. The building automation and monitoring system monitors and records continuous, real-time data for all energy use; chilled, hot and condenser water; microturbines; rainwater collection; CO_2 levels; temperature; and humidity. Since many sustainability strategies used are not commonly found in the region, the owner felt it was important to track performance and share results in order to better inform future design.

3.2 System Solutions

Of the project's stated goals, meeting the 2030 Challenge with a greenhouse gas (GHG) reduction target of at least 60 percent had the largest influence on the system solutions. It was determined from concept phase analysis that to attain the desired reduction in GHG, partial energy source substitution was required. Since approximately 95 percent of the power sold by Georgia Power is generated by burning coal, the utility power for this building is very carbon intensive. The solution involved a cogeneration strategy using natural gas-fired microturbines to provide power, hot water for heating and cooling from a hot water driven adsorption chiller. This combined solution extracts the maximum amount of energy from the natural gas source, which has much lower carbon intensity than coal and resulted in a 67 percent decrease in CO_2 emissions.





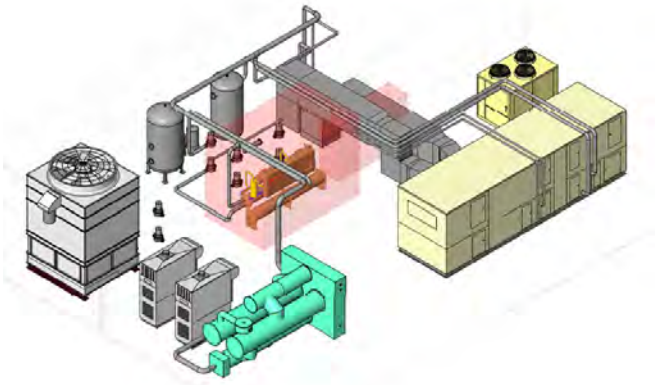


Figure 3: a) 1315 Peachtree Street overall system components diagram. b) MEP Tri-generation or CCHP: Combined Cooling, Heating & Power. c) The "living lab" energy and HVAC equipment include a high-efficiency Scroll Chiller, twin microturbines, a unique Adsorption chiller, Dedicated OAS, energy recovery wheel, and a photovoltaic array (not shown in the diagram).

The generation and distribution of electricity from the power grid often has a transmission loss of up to 65 percent. By generating distributed power on-site through a tri-generation system, waste heat is captured and used for both heating and cooling, thereby achieving much greater efficiencies. In addition, the switch to natural gas as a primary fuel source to generate building electricity reduces CO_2 that would be generated from the local coal-burning power plants.

The building is still connected to the grid and relies on grid electricity when there is insufficient demand within the building for the heating and cooling that the tri-generation system provides. This flexibility has contributed to 58 percent cost reduction and 68 percent greenhouse gas reduction for the project. The system also includes an adsorption chiller designed to cool water by using a silica gel media instead of refrigerants and the "waste" heat from two microturbines. Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent. This process differs from absorption, in which a fluid (the absorbate) is dissolved by or permeates a liquid or solid (the absorbent), respectively. Adsorption is a surface-based process while absorption involves the whole volume of the material.

Significant energy efficiency is achieved by using water rather than air to heat and cool the space. Cold and hot water is pumped through small capillary mats in the metal ceilings panels throughout. A heat recovery unit, also referred to as an enthalpy wheel, exchanges heat and humidity from one air-stream to another on the rooftop. Rather than discard used building air, an enthalpy wheel salvages useful energy and transfers it to incoming, fresh air. This saves energy by reducing the need for cooling in the summer and heating in the winter. Using the waste heat from the microturbines and the adsorption chiller produced "free" heating and cooling water achieved for the radiant heating and cooling system. As adsorption chillers have no liquid desiccants, by not using chemicals such as lithium bromide and ammonia, the potential for hazardous material leaks, aggressive corrosion, and chemical testing requirements are eliminated. Also, adsorption chillers use municipal tap water as the refrigerant, compared to absorption chillers that require distilled water.

In hot/humid climates, radiant systems are rarely used because the warm, moist outside air would produce condensation on the cool-water tubing. Utilizing radiant heating and cooling system (water-filled blue BEKA mats above suspended ceiling tiles) and a low-velocity underfloor air distribution system help carefully balance temperature and humidity in hot/humid climate. The design team had to work very closely to make sure the system was balanced between the amount of exposed concrete, the size and spacing of the radiant mats and the number and location of any operable openings.

Figure 4: Radiant heating and cooling system (water-filled blue BEKA mats above suspended ceiling tiles).

Figure 5: a) Heat recovery unit, also referred to as an "enthalpy wheel". b) Raised floor system with underfloor air distribution. c) 7.2 kW Photovoltaic array on roof.

3.3 Energy Usage

Project lighting utilizes either LED or T-5 Fluorescent lamps for maximum efficiency, with Lighting Power Densify (LPD) of 0.55 W/sf. Pendant direct/indirect studio lights are individually controlled with daylight and occupancy sensors. Corridors use only light borrowed from project team rooms. In addition, most employees operate laptop computers with flat-screen monitors and computational node "clouds" to further reduce plug-load energy use. The radiant system, using water as the energy transmission source is more efficient than air-based systems. Humidity and condensation issues preclude the use of operable windows in most of the studio areas. The modeled energy usage showed that all these would contributes to total Energy Usage Intensity (EUI) of 97 kBtu/sf/yr and net EUI of 28 kBtu/sf/yr. Significant reduction (51 percent) from national median EUI for this building type would be achieved.

3.4 Light and Air Management

West façade was redesigned with high-performance low-e glazing with fixed vertical and horizontal sunscreens to prevent solar heat gain and glare from the west. This was modeled to reduce solar heat gain on this face by about 94 percent compared to the existing configuration. The 5th floor atrium allowed to reshape the structure with minimal impact and provide connections between the floors of the office as well as add an exterior terrace, creating a variety of spaces to support a creative and collaborative atmosphere for office-wide meetings and events. A steel trellis and motorized shade system protects from too much sun penetrating the space.

Air is delivered at very low velocity through a raised floor plenum, maximizing the ventilation air-delivery effectiveness. This system is inherently more comfortable than air-based systems due to the radiant cooling and heating effect and the lack of drafts.

Natural daylight with occupancy and daylight sensors and usable outdoor space reduced the amount of energy needed for lighting by 67 percent. Daylighting at levels that allow lights to be off during daylight hours is 84 percent, and views to the outdoors exist in 98 percent of regularly-occupied areas.

3.5 Water Efficiency

Rainwater from the roof and the 5th-floor terrace is captured and stored in an underground 10,000-gallon cistern. It is filtered, treated with ultraviolet light, and then pumped to all flush fixtures in the building. Excess water is used for irrigation or released into bioswales, and 76 percent of rainwater from maximum anticipated 2-year 24 hour storm event can be managed onsite. More than 172,000 gallons of water are captured annually and used on-site, thereby reducing the demand for municipally supplied potable water. No potable water is used for irrigation.

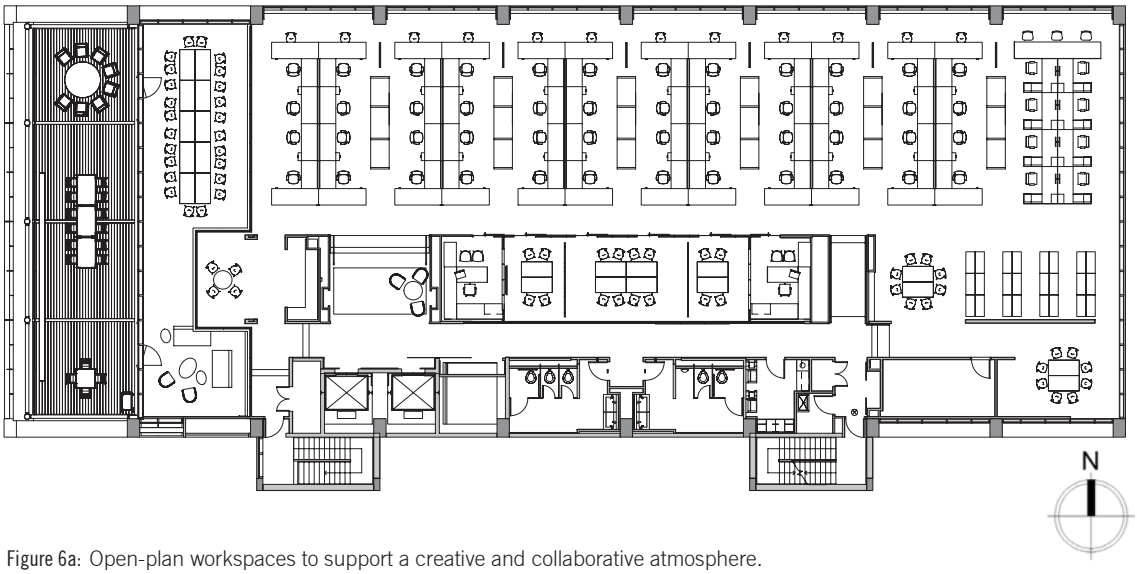
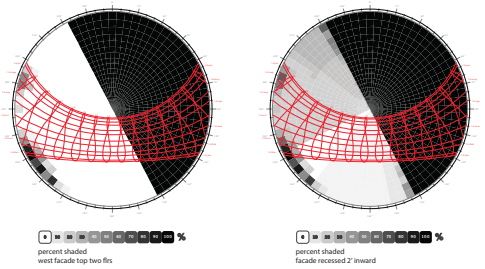


Figure 6a: Open-plan workspaces to support a creative and collaborative atmosphere.



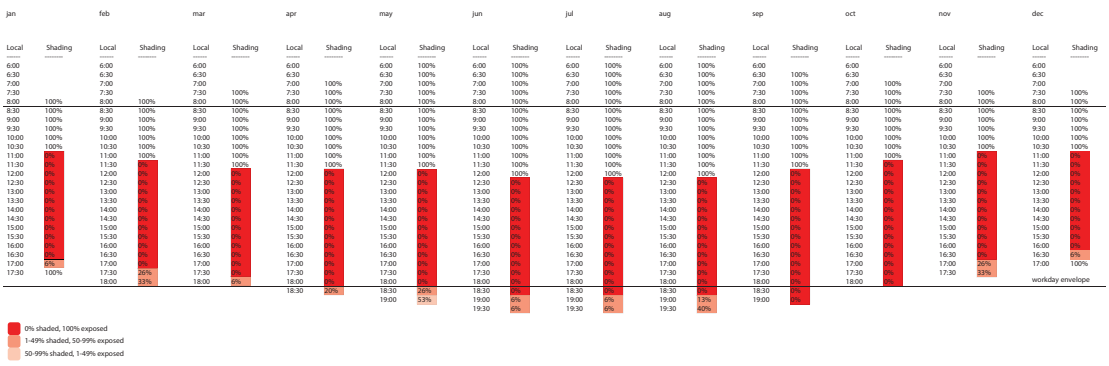
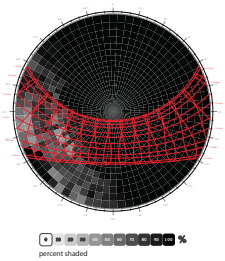


Figure 6b: Existing condition shading study: west façade study without shading.



jan		feb		mar		apr		may		jun		jul		aug		sep		oct		nov		dec	
Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading	Local	Shading
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		18:00	60%	18:00	70%	18:00	90%	18:00	90%	18:00	100%	18:00	100%	18:00	90%	18:00	90%	18:00	47%				
						18:30	67%	18:30	80%	18:30	80%	18:30	80%	18:30	85%	18:30	85%						
								19:00	76%	19:00	71%	19:00	71%	19:00	85%								
										19:30	86%	19:30	86%	19:30	90%								

0% shaded, 100% exposed
1-49% shaded, 50-99% exposed
50-99% shaded, 1-49% exposed

workday envelope

Figure 6c: Redesigned condition shading study: west façade with multiple shading levels.

Figure 6d: A steel trellis and motorized shade system prevent solar heat gain and glare from the west. Photo credit Eduard Hueber © Arch Photo, Inc..

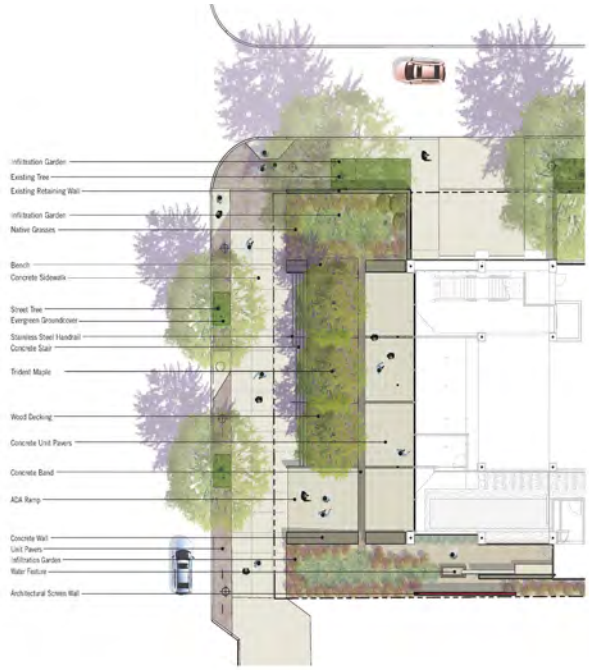


Figure 7a: Vegetation and bioswales around the site.

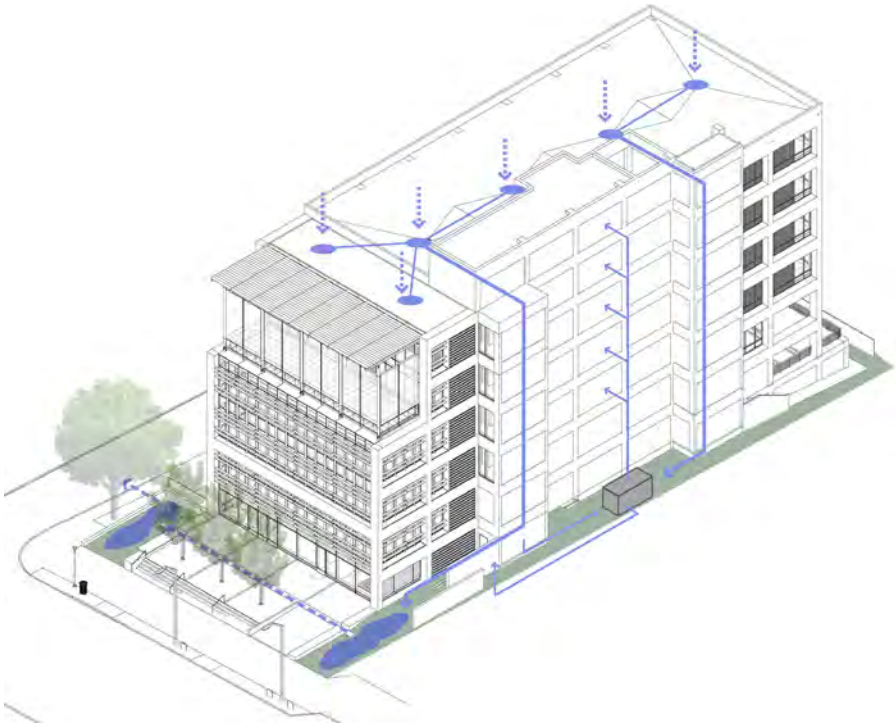


Figure 7b: Rainwater collection and distribution diagram.

Figure 7c: 10,000-gallon cistern under construction.

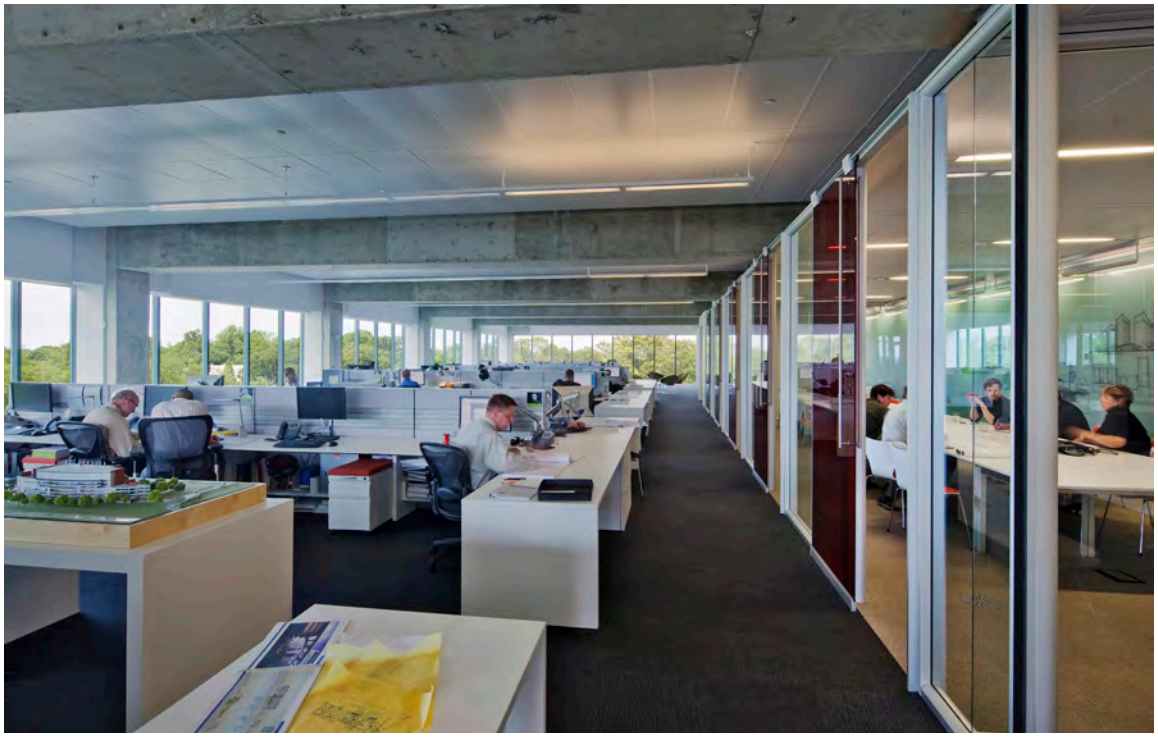
Since the cistern is not visible, a publicly visible water feature adjacent to the civic plaza recirculates captured rainwater or sends overflow water to the bioswales, where it naturally recharges the aquifers. Vegetation within the bioswales improves the quality of water that enters, while soil designed to support infiltration reduces the quantity of water that reaches the storm sewer system. Other water-saving features used are low-flow flush fixtures, including 1.23 gal/flush toilets and 0.125 gal/flush urinals, and sensors on flow fixtures that prevent faucets from being accidentally left running. All these contribute to 77 percent reduction of regulated potable water.

A civic plaza featuring seating and a demonstration garden is an added amenity for the community. A concept of renewing the existing landscape while creating inviting new ground level spaces on the public side of the building was adopted.

3.6 Materials and Construction

In order to reduce the amount of demolition and construction waste sent to the local landfills, the team set a target that 75 percent of waste generated would be reused, repurposed, recycled or otherwise diverted. Approximately 80 percent (630 tons) of demolition and construction waste was diverted from landfills or recycling yards to more than 20 local nonprofit organizations.

(a)



(b)

Figure 8a&b: Use of daylighting, with occupancy and daylight sensors, reduces lighting energy by 67 percent over code. Photo credit Eduard Hueber © Arch Photo, Inc.

Figure 8c: Corridors use only light borrowed from project team rooms. Photo credit Eduard Hueber © Arch Photo, Inc.

Simulated daylight:

Day light - rooms detail analysis

Room name	Floor	Working plane (ft)	Room Area(ft^2)	Average daylight(fc)	Area exceeding 025 fc (ft^2)	Area exceeding 500 fc (ft^2)	% Area meeting requirements[5] (%)	Area meeting requirements[5] (ft^2)	LEED® Pass
Sort A-Z	HI/Lo	HI/Lo	HI/Lo	HI/Lo	HI/Lo	HI/Lo	HI/Lo	HI/Lo	Pass/Fail
Apply		2.5	107	25	75	75	75	75	
sp-106-REGEPTION	bldg-stry-2	2.50	578.8	254.4	572.9	0.0	99.0	572.90	yes
sp-311-BREAK_ROOM	bldg-stry-3	2.50	147.9	280.9	147.9	0.0	100.0	147.85	yes
sp-312-WORKROOM	bldg-stry-3	2.50	246.7	16.6	52.9	0.0	21.4	52.87	yes
sp-313-OFFICE	bldg-stry-3	2.50	138.5	69.1	124.6	0.0	90.0	124.63	yes
sp-314-OFFICE	bldg-stry-3	2.50	139.9	82.3	133.9	0.0	95.7	133.89	yes
sp-315-WORKROOM	bldg-stry-3	2.50	561.6	180.9	557.6	0.0	99.3	557.57	yes
sp-316-OFFICE	bldg-stry-3	2.50	139.8	97.1	135.8	0.0	97.1	135.77	yes
sp-319-RESOURCE_CENTER	bldg-stry-3	2.50	863.4	104.2	733.9	0.0	85.0	733.85	yes
sp-321-WELLNESS_ROOM	bldg-stry-3	2.50	91.3	80.9	73.0	0.0	80.0	73.00	yes
sp-322-OFFICE	bldg-stry-3	2.50	5769.2	63.9	4981.9	0.0	86.4	4981.92	yes
sp-323-ATRIUM	bldg-stry-3	2.50	1348.5	244.1	1332.8	0.0	98.8	1332.80	yes
sp-411-BREAKROOM	bldg-stry-4	2.50	141.2	224.5	141.2	0.0	100.0	141.19	yes
sp-412-OFFICE	bldg-stry-4	2.50	249.4	3.3	0.0	0.0	0.0	0.00	no
sp-413-WORKROOM	bldg-stry-4	2.50	137.1	42.8	88.1	0.0	64.3	88.11	yes
sp-414-OFFICE	bldg-stry-4	2.50	139.9	80.8	129.9	0.0	92.9	129.89	yes
sp-415-WORKROOM	bldg-stry-4	2.50	561.6	164.3	557.6	0.0	99.3	557.57	yes
sp-416-OFFICE	bldg-stry-4	2.50	139.8	99.1	137.8	0.0	98.6	137.77	yes
sp-421-HR	bldg-stry-4	2.50	104.3	80.9	83.4	0.0	80.0	83.40	yes
sp-423-MEETING	bldg-stry-4	2.50	535.8	111.5	465.9	0.0	87.0	465.91	yes
sp-424-OPEN_OFFICE	bldg-stry-4	2.50	5784.1	80.1	4856.8	0.0	84.0	4856.85	yes
sp-425-ATRIUM	bldg-stry-4	2.50	855.1	132.3	851.1	0.0	99.5	851.09	yes
sp-511-BREAKROOM	bldg-stry-5	2.50	126.3	25.8	42.8	0.0	33.9	42.79	yes
sp-512-OFFICE	bldg-stry-5	2.50	139.3	83.2	133.3	0.0	95.7	133.33	yes
sp-513-WORKROOM	bldg-stry-5	2.50	560.4	38.5	342.3	0.0	61.1	342.25	yes
sp-514-OFFICE	bldg-stry-5	2.50	139.9	144.5	139.9	0.0	100.0	139.91	yes
sp-515-MEETING	bldg-stry-5	2.50	965.8	124.1	947.7	4.0	97.7	943.87	yes
sp-516-Room	bldg-stry-5	2.50	5210.3	55.4	3926.5	0.0	75.4	3926.52	yes
sp-517-ATRIUM	bldg-stry-5	2.50	1202.8	181.9	1200.9	0.0	99.8	1200.86	yes
sp-611-BREAK_ROOM	bldg-stry-6	2.50	294.2	257.8	294.2	0.0	100.0	294.22	yes
sp-612-OFFICE	bldg-stry-6	2.50	142.3	87.9	126.0	0.0	88.6	126.04	yes
sp-613-WORK_ROOM	bldg-stry-6	2.50	560.4	170.2	550.4	0.0	98.2	550.41	yes
sp-614-OFFICE	bldg-stry-6	2.50	139.5	97.8	133.5	0.0	95.7	133.54	yes
sp-616-WORK_ROOM	bldg-stry-6	2.50	318.9	264.7	318.9	0.0	100.0	318.89	yes
sp-617-OPEN_OFFICE	bldg-stry-6	2.50	5618.7	78.3	5160.3	0.0	91.8	5160.32	yes
sp-P18-PRINT_OFFICE	bldg-stry-1	2.50	88.2	0.0	0.0	0.0	0.0	0.00	no
sp-P19-PRINT_ROOM	bldg-stry-1	2.50	627.2	0.0	0.0	0.0	0.0	0.00	no
Overall results for selected spaces			35008.6	31.8	29475.6	4.0	83.4	29471.59	Pass

Total area of day lit regularly occupied space(s)	29471.6 ft^2
Total area of regularly occupied space(s)	35008.6 ft^2
Percentage of regularly occupied space that is day lit	84.2 %

Figure 8d: Daylight simulation result from IES VE.

In addition, building materials were rigorously screened to be free of known or suspected toxic substances, including PVC. As a result, materials are 75 percent free of added halogenated compounds, contained 40 percent recycled content and 37 percent were extracted/manufactured within 500 miles of the project site. Wood sourced from FSC-certified forests comprises 82 percent of the total used. The board room conference table is made from cherry baseboards salvaged during the building demolition.

4.0 BENEFITS AND BARRIERS TO COMMERCIAL RETROFIT

Carbon footprint reduction is one key reason for retrofitting an office building. The re-use of an existing building's fabric retains a fair amount of the energy embodied in the original construction[19]. Several economic benefits have been identified to justify the choice of retrofit over a complete redevelopment for office buildings[20]:

- A better balance of risk and return
- Quick delivery back to market
- Lower construction times and costs: depending on the level of retrofit, office retrofit can be from 10 to 75 percent quicker and cheaper than new build
- Maximized value of an existing asset and retaining useful attributes of the original building (e.g. car parking allocation and permitted development density and massing).

On the other hand, some key barriers were found in the commercial property market that prevent owners and developers from investing in retrofits[21]:

- A lack of access and availability of capital funds
- Poor provision of viable business cases for up taking retrofit interventions. The issue of 'split incentive', whereby the owner absorbs most of the costs while the occupiers benefit from energy savings, thus having no incentive for energy conservation
- Unclear criteria and processes for assigning and evaluating the responsibilities of those carrying out the retrofitting interventions
- A lack of appropriate technological knowledge about possibilities, issues and constraints associated with specific retrofit actions. Endemic skills shortage in the built environment sector
- Insufficient focus from policy makers on current building stock, as compared to new buildings.

Some of the major challenges faced and overcome in 1315 Peachtree Street retrofit project are:

- **Greenhouse gas reduction target of 60 percent:** The 2030 Challenge greenhouse gas reduction target of 60 percent was the largest challenge for the system solutions. This was overcome through the design of the HVAC systems that combines elements never before used in this hot/humid climate, including radiant heating/cooling, under-floor air distribution, chilled beams, microturbines, an adsorption chiller, 7.2 kW photovoltaic panels and an energy recovery wheel. This combined solution extracts the maximum amount of energy from the natural gas source, which has much lower carbon intensity than coal and resulted in a 67 percent decrease in CO_2 emissions.
- **Large amount of glazing facing west:** Large amount of glazing along the west facade of the existing building contributed to high solar heat gain and glare. Solar studies and energy modeling informed decisions regarding daylighting, glazing replacement, glazing materials and shading systems. West façade was redesigned with high-performance low-e glazing with fixed vertical and horizontal sunscreens to prevent solar heat gain and glare from the west. At the upper levels, a steel trellis and motorized shade system prevent solar heat gain and glare. This was modeled to reduce solar heat gain on this face by about 94 percent compared to the existing configuration. Also, natural daylight with occupancy and daylight sensors and usable outdoor space reduced the amount of energy needed for lighting by 67 percent.
- **Use of radiant systems in hot/humid climate:** Use of radiant systems in hot/humid climate was another challenge as the warm, moist outside air could produce condensation on the cool-water tubing. Utilizing radiant heating and cooling system and a low-velocity underfloor air distribution system help carefully balance temperature and humidity in hot/humid climate. The design team had to work very closely to make sure the system was balanced between the amount of exposed concrete, the size and spacing of the radiant mats and the number and location of any operable openings. Significant energy efficiency is achieved by using water rather than air to heat and cool the space.

5.0 CONCLUSION

Although progress towards the adoption of energy efficient and sustainable building practice across the globe is encouraging, the sustainability movement mainly focused on transforming building practices for new construction. To date, however, sustainable building practices have underemphasized the importance of existing building retrofits across the globe[18]. Many existing structures were built before the establishment of energy efficiency codes. These buildings, which were designed according to the traditional approaches, are the primary consumers of energy and resources[15].

In most developed countries, more than 98 percent of the building stock consists of existing buildings[18]. Sustainable new construction, no matter how environmentally sensitive and energy-efficient, cannot by itself significantly change the environmental impact of the built environment[18]. Therefore, existing buildings must be subjected to a process of retrofit to create the intended ecological impact. The best opportunity for least environmental impact in retrofitting existing buildings is to retain as much of the structure as possible and upgrade and optimize systems, such as exterior glazing, HVAC, lighting and water[22]. Design of energy-efficient and high-performance building retrofit requires that building performance and simulations tools are used and integrated with the design process[23].

1315 Peachtree Street is a living model for small urban sites that emphasize sustainability. As for energy efficiency upgrades, the building makes use of natural daylighting, energy efficient lighting, lighting controls, passive sun shading on lower levels and an active, dynamic exterior sunshade on the building terrace level to control afternoon sunlight and heat gain. For climate control, the building uses raised flooring and a radiant heating and cooling system, microturbines and an adsorption chiller. Rainwater is collected in a 10,000 gallon cistern and used for landscape irrigation and low-flow toilets and urinals. Overall the building's carbon footprint is reduced by 68 percent and complies with the 2030 Challenge for reduced greenhouse gas emissions. In addition to LEED Platinum, the project is a recipient of the Urban Land Institute's Global Development of Excellence Award.

Most of the previous studies and research were carried out based on numerical simulations. The actual energy savings due to the implementation of the selected retrofit measures were not reported. More research and application work with practical case studies on commercial office building retrofits is needed. This can help to increase the level of confidence of building owners to retrofit their buildings for better performance.

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04.
A CONTEXTUAL STUDY FOR HEALTHY COMMUNITIES IN CHINA:
Towards Culturally-Sensitive Urban Design and Planning

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ABSTRACT

Built upon theories of the built environment's effect on public health outcome and addressing the importance of cultural sensitivity in urban design and planning, this article gives an introductory account of the urban context of contemporary Chinese cities in relationship to it current public health issues. It also reviews the recent healthcare reform in China and its implication on the market and changing urban environment. The objective is to develop a contextual understanding to inform the planning and development of healthy communities in China. The result is proposed in the concept of Health Community. It is an integrated framework of healthcare facilities and its surrounding communities.

KEYWORDS: urban regeneration, China, healthcare reform, urbanization, contextual studies

1.0 INTRODUCTION

There is unprecedented interest in the effects and impacts of the built environment on the health of urban inhabitants globally. From the impact on physical activity, obesity and diabetes, to respiratory health (via air pollution) to mental health, the relationship between built environment and public health has become one of the most important discussions in urbanism in recent years. However, this has been largely a dialogue based on Western public health philosophy, generally in reference to North American and European societies[1].

It would also be important to understand that the effects of the built environment are very much related to its cultural, social and economic context. This article seeks to develop a contextual understanding of the relationship between the built environment and health in contemporary Chinese cities. In addition to the basic ideological differences between eastern and western culture, China has a strong heritage in alternative medical practice that address the body and health.

The articles gives a brief account on the current urban context and development of China's healthcare system, leading to some key public health issues observed within the context of the built environment. The healthcare reform initiated in 2009 was a turning point for healthcare development in China, and this will be the background for our investigation on the relationship between public health and the Chinese cities' built environment.

As a result of the rapid urbanization in the last few decades, a new class of urban residents emerged that gives specific character to the contemporary Chinese society. They are also the key users/consumers in the expanding healthcare market, which was endorsed by the government with encouraging reform policies. Through the reading of their lifestyles, market trends and their implications, the baseline analysis was used to construct our concept of a model that represents the relationship between the built-environment and public health system in China.

A case study was conducted on a city center public hospital in Shanghai and its vicinity to examine the activities and the use of public space, and to discover opportunities for urban design intervention to improve the current conditions. Furthermore, the consideration was extended beyond the hospital premise into its surrounding neighborhood, which leads to the formation of the

concept of a "Health Community". The objective would be to enhance public health outcome through looking into the overlapping area of the healthcare activities and that of general urban life.

The potentials and opportunities of the "Health Community" is investigated in three aspects that contribute to the design of built-environment for a healthy community. In relationship to the current healthcare system issues, the article analyzes the components to build a community-based primary care system. Secondly, through reading into the Chinese philosophy on wellness and a survey of the area's health-related business, the research seeks potentials of preventive care for urban chronic illness. Lastly, as a crucial aspect of a healthy community, we look into the use of public space and its design and planning implication towards an active lifestyle.

This article is intended to be a starting point to support further exploration in strategies and application for a culturally-sensitive urban design of healthy communities. We believe that the built environment affects people's behavior and lifestyle choices, which directly relates to the health and well-being of its residents. In the same time, by addressing the importance contextual understanding, it will enable us to plan and design our communities in a more human-centered, and culturally empathic approach.

2.0 THE URBAN CONTEXT AND KEY PUBLIC HEALTH ISSUES

China has similar land area as the United States, consisting of almost 10 million square kilometers, but with four times the population at 1.37 billion (Figure 1). While western cities have been developing for over a century since the Industrial Revolution, China's urban development essentially began in the 1980's, since the People's Republic of China's economic reform. During this period of a little over three decades, its urban population has grown from 20 percent in 1980 to 54 percent in 2014[2], resulting in movement of over 260 million people from rural to the urban areas.

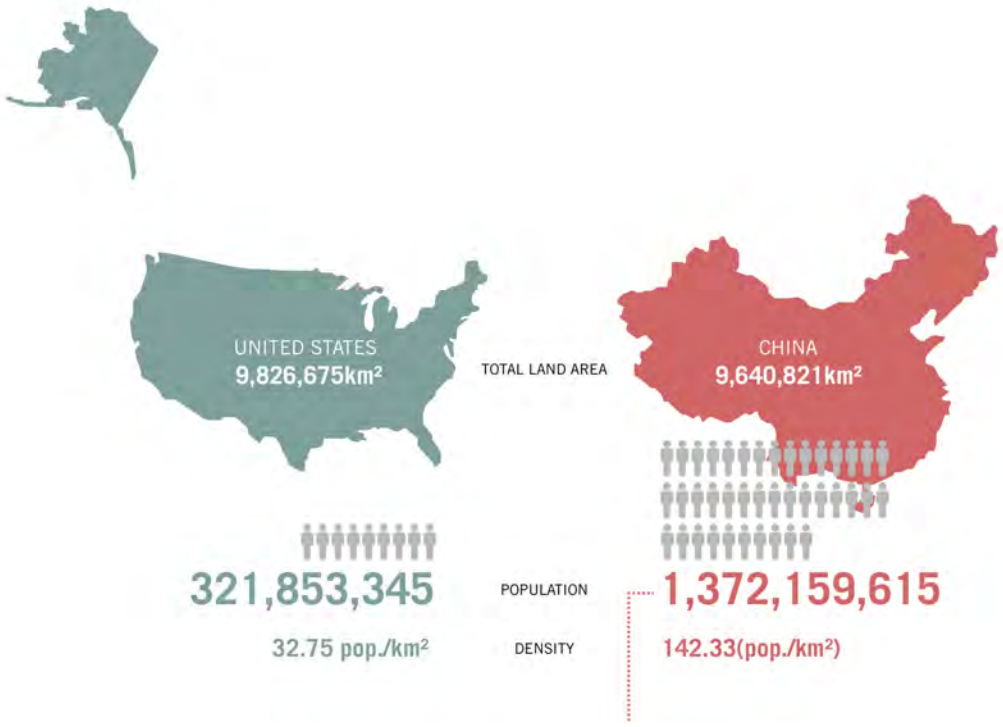

Figure 1: The comparison between land area and population of the United State and China.

The sheer volume of urban immigrants is creating a lot of stress on the nation's healthcare service. To accommodate the increasing urban population, new cities are rapidly growing in size and density. Large new cities of population over one million are being built overnight. Many of them are new developments that are planned in haste and without careful consideration for the well-being of their residents. Oversized street blocks, segregated uses, lack of public space - they are essentially becoming "un-healthy cities" that create negative health impact on the residents. Meanwhile, traditional city centers are also under the pressure to increase population density, with a growing need for public services in large scales – they are faced with the issue of limited land resources and existing over-crowded urban condition.

On a positive note, the high population in large cities can provide the critical mass for effective public service. In high-density urban setting, service can be concentrated in hubs, enabling shorter travel distance and the economy of operation can be optimized. The challenge lies in the upgrade and expansion of existing facilities, which are often situated in small land plots with densely built surrounding.

For example, the Huashan Hospital, in central Jingang District of Shanghai, was established in the early 20th century as a Red Cross China outpost with minimal capacity. Through a century of development, it has grown into a large public hospital with over 1,200 beds and 3.8 million outpatient visits annually. The original structure was demolished and the hospital rebuilt as a cluster of modern buildings with the main tower at 20 stories high. However, situated in the dense urban center, it has grown to reach its capacity without sufficient space to handle daily demand, both in terms of floor space as well as green area. The over-crowded hospital is also leading to the problems for surrounding area with congested vehicle and pedestrian traffic, causing a lot of stress for the neighboring communities.

The combined factors of large population and rapid development has set a particular urban context for Chinese cities when planning for their development and public health strategies. In addition, there is a deep-rooted wellness philosophy in the practice of traditional Chinese medicine, and a different cultural value of the family and social structure. These contextual background would have implication on public health policies and planning strategies. While learning from best practices in well-developed western cities, cultural sensitivity would be important in order to have an empathetic perspective for more effective solutions.

2.1 The Contemporary Chinese Urban Residents (Class Disparity)

The rapid economic growth in the last few decades has attracted many individuals and families from the countryside to the big cities seeking jobs and better livelihood. Some have been living in rural villages or small towns with an agricultural-based lifestyle for generations, yet in the last few decades, many have settled in cities and they have become the new urban residents. According to the publication "From the Soil" by sociologist Fei Xiaotong[3], the foundation of Chinese society is based on a communal bond, which was formed to suit small village community organization. It emphasizes respect and hierarchical relationship among family members, relatives and acquaintances, and this value system still holds true at this age, in the metropolitan urban society with a very different social condition.

This idea is also apparent in Confucius philosophy as the concept of "filial piety" or the respect to parents and elderly (孝). The younger and capable members are expected to care for the welfare of others in the family, and they would feel the obligated to take care of the old and the sick. In the case of serious illness of a family member, many would spend extensive amount of time in the hospital to accompany the patient, or travel with them long distance to seek medical service.

Another character of the new urban residents in China is the reliance on state-provided service. When the People's Republic of China (PRC) was established as a communist state in pre-reform decades, citizens would work for state-owned enterprise and receive full welfare, including medical and other health-related services. Until today, the general medical cost to patient is still relatively low, where a basic visit to the outpatient clinics at public hospitals cost about 20 Yuan ($3 USD). Therefore, many would still habitually go seek medical assistance at the public hospitals regardless of necessity.

The neighborhood residents with minor illnesses, the extensive visitors to inpatients, and the family group to accompany their relatives for medical services—all of these have caused extra volume of visitors to the public hospitals in addition to those with critical needs. The situation is worsened by the spatial design of hospitals, which often have little consideration of visitor flow and public space, resulting in the commonly-experienced over-crowded environment in many Chinese public hospitals. In the case of city center hospitals that have very limited land parcel, the issue of congestion is extended beyond the hospital premise and also affecting surrounding area and residential communities.

These traditional values are in fact slowly evolving, as the big cities are in transition into a more market-oriented society. It is also important to understand another type of urban residents – the rising middle and affluent class. They are the individuals and families with an annual household income above 75,000 RMB[i], as defined by a report from the Boston Consulting Group[4]. The middle and affluent class of the Chinese cities account for 38 percent of urban household in 2013, with projection to grow into 59 percent in 2020.

This new rising urban class could share similar cultural value as described above, but they have adopted to and embracing the new capitalistic lifestyle with further demands. As one of the earliest group that benefit from economic development, the affluent and middle class have high concern of their health and wellness, and they begin to have the means at affording a premium for it. Partly due to the lack of confidence to public healthcare service, they often seek alternative service from the private healthcare operators, who became the main consumer force behind this new market opportunity.

2.2 The Healthcare System and Reform

In 2009, the State Council has initiated an ambitious healthcare reform that aims to transform the country's healthcare service system. The objective is to provide universal healthcare with policies in public health insurance, drugs regulation and the hospital organization[5]. It also encourages a more open market with favorable policies to attract private service providers, with the aim to improve quality of service through market competition. Many policies at the regional and local level have been drawn up since then, in some aspect it is showing promising results, such as the achievement of 90 percent basic medical insurance coverage in 2015[6]. The reform appears to be positive in tackling some of the issues discussed, however, there is still a lot to be done in terms of policy, program and design to address the fast-changing urban development and its challenges.

China's healthcare system, namely "Medical and Health Service System", is accounted for in three major categories: (1) the hospitals that constitute majority of the country's healthcare service, including public and private hospitals for general, specialty, as well as traditional Chinese medicine facilities; (2) the "basic healthcare units", which were originally set up as birth control and public health station in villages and urban neighborhoods in pre-reform days, and they will then become an area of focus in the healthcare reform as the foundation to upgrade into a network of primary care facilities; and (3) the "specialty public health units" are the specific healthcare institutes such as Drug and Food Safety Bureau and Center for Disease Control at a central government level of administration (Figure 2).

Figure 2: The medical and health service system in China.

[i] RMB (renminbi) is the official unit of currency in China.

The public hospitals were positioned to cover full range of service from primary to tertiary care, and many of the urban hospitals are also large in scale (1000+ beds), with top resources in equipment and medical staff. Private hospitals are generally smaller in scale, often established as specialty or senior wellness / rehab facilities that cater to market demand. In 2013, private hospitals accounted for about 15 percent of total bed-count in the country, while a reform memo released in 2015 has explicitly encouraged private healthcare service, with an objective to increase their share of inpatient capacity into 30 percent in 2020[7].

The intention is to improve overall healthcare service quality through constructive market competition. In fact, the direct subsidy from the government only accounts for approximately 8 percent of public hospital revenue[8], the institutions have to rely on their medical service to generate necessary revenue to sustain financially. Currently, the public hospitals have the issue of over-prescription on drugs and procedure to generate revenue through pharmaceutical rebates, as a result they have less concern on patient experience and satisfaction. It is one of the objectives in the reform policy to reduce the hospital's reliance on medical drugs mark-up, with regulations for a new system on prescription and distribution. Along with the opening up of healthcare market, there will be a wider array of healthcare service options, the public hospitals would need to reconsider their operation in a more effective manner and to adopt a more patient / service-oriented approach.

Another critical issue with current healthcare system is the lack of effective primary care facilities as gatekeeping to the system. The "basic healthcare unit" in an urban neighborhood is set up according to a service catchment of 30,000-100,000 residents with one community health center. These centers are responsible for preventive and primary care, however, they have very low utilization in many cases, especially in larger cities where there are other available options. The main reason is the lack of service and limited medical resources in these community health centers. Since there is not a strict referral system between the community health centers and the public hospitals, many would bypass the clinic and go directly to larger hospital for consultation. In fact, it is easier to get referral to specialty doctors through primary care at the hospital internally instead from other clinics. More importantly, there is virtually no difference in cost and insurance coverage between a hospital or community health center, therefore, patients would naturally go to the hospitals for any and every medical need.

The government is responding to this issue by allocating reform budget to upgrade the community health centers as proper primary care facilities. Based on the existing health stations already set up in residential neighborhoods, minimal effort is required for hardware upgrade, but the problem lies in the shortage of qualified general practitioner and medical staff. This was the main cause of the short service hours and negative view from the residents towards its quality of medical treatment.

While increasing capacity with education and training of healthcare professionals will be needed in long term planning, it is necessary to establish stronger connection between the community health centers and public hospitals. This would improve current conditions and can be done in short-term. Doctors from the district's large hospitals can work at the community health centers on a part-time basis, and maintain patient record cross-platform. This will not only increase the service capacity, but also build up positive image for the center's accountability. The neighborhood patients can then grow into a habit of going to community health centers for primary care, where they know that they can get proper consultation and referral to secondary treatment at the hospitals when needed.

2.3 Market Trends and Implications

The healthcare expenditure in China accounts for 5.4 percent of its GDP in 2013, which is very low at an international standard, but the market studies give a very positive projection, with the expectation to grow to 11.8 percent in the next few years[9]. Besides the formal medical expenses, the projection for urban residents on spending related to wellness (such as dietary supplements and gym membership) is also increasing as the awareness increases, in response to escalating chronic illness and the worsening pollution issue in urban China.

The prevalence of chronic diseases applies to urban residents in virtually all sectors regardless of education or income level. This is currently a very attractive market for private operators to offer a variety of services. People who can afford it will opt for private provider service at a higher premium, while the lower-income population continues to struggle for medical attention at the congested public hospitals with limited resources. This is another critical urban issue, the inequality of accessibility to quality healthcare service.

As an example (Figure 3), we can see the contrasting conditions at public versus private hospitals. The Zhengzhou University First Affiliated Hospital in Henan province is a known as "the largest general hospital of the world" with over 7000-bed capacity. However, it is not necessarily the best in terms of medical service and patient / visitor experience. Lacking proper design and planning strategies in its ambitious expansion plan, the super-large hospital has attracted extremely large volume of visitors, many of which are left in poor conditions, such as temporary patient bed and treatment stations exposed in open areas, accompanying families to stay overnight along the corridor or even camping out in the parking lot.

On the contrary, the private hospitals are serving only the very affluent few. An example of the Shanghai Red Leaf International Women's Hospital, the well-known private maternity hospital advertised for its "5-star" service, is also known as one of the most expensive in the country. A grand hotel-like lobby is often empty and there are "customer service representatives" accompanying the patient in addition to the the already high ratio of medical staff.

With the steadily growing urban income level, there will be a demand for mid-price range healthcare market – not just the affluent few but the core middle class who would seek comfortable and reliable service beyond the public hospitals. While the universal public healthcare insurance is underway, there is the potential to allow public insurance holder payable to private operator service. Functionally, it could require the patient for larger portion of out-of-pocket payment comparing to regular public hospital service, as a result, this could serve a substantial group of urban middle class who are demanding for better service and willing to pay within a reasonable range for such service.

The mid-price range service could become an important share of the urban healthcare market in the future. It should also encourage the public hospitals to upgrade and improve their services, for the opportunity to increase revenue through quality medical service instead of the quantity in prescription and procedures. There are already established departments of "premium care service" at some large public hospitals as a test for increasing service charges, but with provision of better patient environment and services, and it has received positive feedback with growing demand. While to overhaul the entire public healthcare system will take some time to implement, the development of a mid-price range service range (with public insurance payable) could serve as a transitional strategy beneficial to both the patient and the institutions.

Figure 3: Comparison of public space condition between public and private hospitals.

3.0 THE BUILT-ENVIRONMENT AS A HEALTH-BASED COMMUNITY

Besides policy and program strategies, the built environment is the other crucial factor that affects public health. Studies have identified two paths contributing to health outcome – the exposure path of environmental factors and the behavioral path that relates to our lifestyle choices[10]. Health outcome is affected by exposure to environmental factors, such as air pollution and water quality, which are also critical urban issues that China faces today. For the purpose of this article, we focus on the health impact through behavioral path.

Our behavior is unconsciously influenced by the surrounding environment, where it gives clues to prompt us into certain lifestyle choices and action[11]. While some of the healthcare issues discussed would need to be resolved at a higher level of policy planning, proper design of the built environment can assist certain level of behavioral changes. The objective is to promote an overall healthy lifestyle, which would ultimately improve citizen health and be less reliant on public healthcare services. With the understanding of how contextual issues in contemporary China are reflected in the urban environment, we can then propose design intervention for healthy communities that is emphatic and sensitive to the social and cultural context.

We examine the health-related built environment in two levels of scale: (1) the public spaces in a hospital and its vicinity, where the medical staff, patients and visitors are interacting with patients directly, and (2) the extended community beyond the healthcare facilities, which affects a larger group of residents (some of them potential patients) and contributes to an overall healthy lifestyle. An area of 1 km radius surrounding the Huashan hospital in Shanghai city center is identified for the study of its spatial setting and patient/resident behavior. While there are already many studies in the best practice for healthcare (hospital) design, in this article we focus on the urban environments at a public space and community scale.

3.1 Case Study: Huashan Hospital – An Urban Center Facility

The Huashan Hospital is an AAA-grade[ii] general hospital with 1200+ beds, regarded as one of the best public hospital in the region. It is situated in the dense city center along a busy commercial street, while the surrounding area consists of predominately residential communities of social housing from the 1970's, with a few new developments. Its city center location and urban development history have given the area a compact urban fabric and concentration of major facilities. The area also has good accessibility to multiple subway lines and public buses.

Figure 4: Huashan hospital and surrounding area, Jingan District, Shanghai.

[ii] The hopstials in China are categorized as A / AA / AAA grade, according to their scale and service standards. The AAA-grade is the highest classification of public hospitals.

3.1.1 Public Space at the Hospital

From discussion in the previous sections, we understand that the high urban population is the main reason for the congested hospital environment, with additional pressure from out-of-town patients and their family members, as well as nearby residents going to the hospital for minor illnesses. The field observation has confirmed this condition as seen in the public area of Huashan hospital (Figure 5), where the entry street and hospital lobby is usually a chaotic scene comparable to a busy subway interchange, especially during peak hours in early morning when patients go for appointment registration.

Figure 5: Out-of-town patients near Huashan Hospital seeking accommodation and directions.

Without sufficient signage and information, visitors would often be confused and ended up taking extra time to get around. In Chinese public hospitals, there is no pre-booking for any general consultation. Patients can only register in-person that morning for an available appointment on that day. Many people would spend a long time in the lobby waiting for their appointment or medication, where the pharmacy is also located at the same public space. There is no defined waiting or resting area, but only rows of aluminum benches, nor are there any amenities such as restaurants or convenience stores on site.

3.1.2 Public Space at Hospital Vicinity

Another challenge shared by many city center hospitals is the small land parcel and narrow street situation where it does not allow for sufficient open space, in addition to parking and traffic issues that further affect the nearby neighborhoods. In the case of Huashan hospital, it sits on the intersection of two busy city roads, with buses and bicycles mixed with the already heavy motor vehicle traffic. The condition is worsened with unregulated street parking and random drop-off of hospital visitors by taxis and private cars. The original hospital entry plaza and walkways are filled with double-parked cars by staff and patients. With insufficient parking space at the premise, the hospital has to be gated to exclude all external traffic, including public drop-off (Figure 6).

Figure 6: Over-parked hospital plaza and congested surrounding streets.

In the case of a hospital situated within dense urban fabric, traffic should be controlled in order to create a pedestrian and patient-oriented environment. A complete street design concept would be appropriate in this case, where street-side parking should be prohibited and car lanes should be reduced to discourage through traffic. Then, with the street space released, bicycle lanes can be designated along the road, or to create a drop-off bay for patients by taxi or private cars. Regulating parking and traffic could return sidewalk space to the pedestrians, with the advantage of existing mature street trees, a wider sidewalk with street furniture could turn the congested street into urban places that allow patients and visitors to stroll, stop and engage into social activities.

Another opportunity is to creatively utilize space, by integrating the design of hospital grounds and public streetscapes. The green area of the urban hospitals is often designed as non-accessible landscape planter within the fence, a typical engineering solution per code requirement on green ratio. With small urban design intervention, spaces such as street corners with narrow side-walk and fenced planters could be turned into a landscaped plaza to be used by residents and patients alike. This type of intervention is an effective example of how the design of built environment can promote activities such as social interaction, which will bring a positive change to enhance recovery of the patients as well as improving quality of life for the residents.

Research has shown beneficial results in patient recovery when they are exposed to greenery, visually or physically[12]. It might be more difficult to have views to nature from the rooms in a city center patient tower, yet there can be many potentials for design to "invent" green space for assisting in the healing and recovery of patients. Less critical patients are allowed to check-out during the day in Chinese hospitals, they would benefit greatly from the improved streetscape and public open space.

Land is a very scarce resource in the densely built-up urban centers, and hospitals are going to have higher volume of visitors as the population increases. Under such conditions, as in the case of many dense urban district, it will become necessary to have a holistic view of healthcare facilities with the community together and seek creative solution with limited resources.

3.2 The Health Community: Potentials and Opportunities

There are multiple definitions and interpretations of a "healthy community", from policy to program development and design. From our investigation, we realized that there is an opportunity for healthcare institutions and the community to share resources (public spaces, services and amenities), and to build a system of programs and places that would benefit the patient as well as the residents. To translate this into potential design and planning strategies, we proposed the concept of "Health Community" to discover the synergy between the healthcare facilities and the surrounding residential communities (Figure 7). The concept changes the traditional view of hospitals as isolated facilities, and focuses on areas where the activity of hospital user and surrounding resident overlaps.

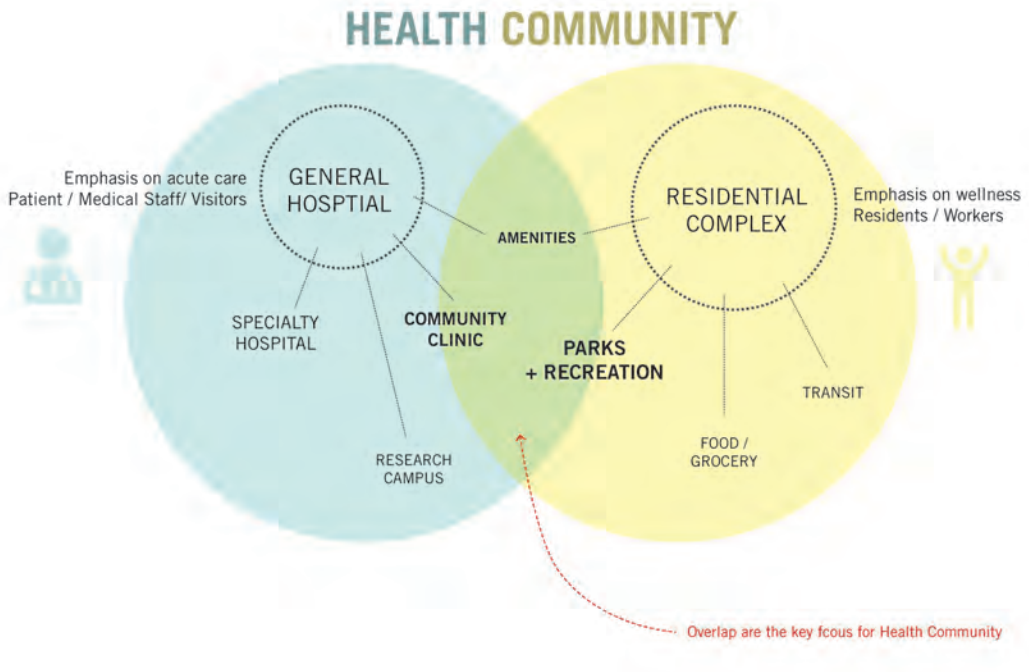

Figure 7: The integrated consideration of the hospitals and the community.

Particularly in city centers, resource sharing would be important and necessary to consider due to land constrains. For communities, it could work more efficiently to have healthcare service provided at multiple levels, with primary care facilities at closer proximity to the neighborhood, particularly for the elderly residents. Working together with programs and urban design projects that are pleasant for walking and recreational activities, it would introduce positive behavioral changes towards a healthy lifestyle. Ultimately, by enhancing overall public health, it could contribute to relieving the urban stress and other issues observed, indirectly, but effectively.

By developing integrated healthcare facilities and withing the community, we can see how these two seemingly independent systems have in fact many opportunities to overlap and benefit each other. Elements such as parks, plazas and amenities, shops and restaurants can be effectively shared by both groups of users, and community clinics can be also used by residents for other activities during off-hours. By sharing of resources, it would create a vibrant community, while at the same time it could help to vitalize local businesses.

3.2.1 Community-Based Primary Care Network

We observed that one of the major problems with the current system is a lack of effective primary care facilities to serve as the "gate-keeping" mechanism for public healthcare services. We concluded from mapping the facilities in the case study area, there are a number of smaller hospitals and community health centers existing within walking distance (400-800 m) of the community. However, many of them are poorly equipped, underutilized or inaccessible to the local residents (Figure 8).

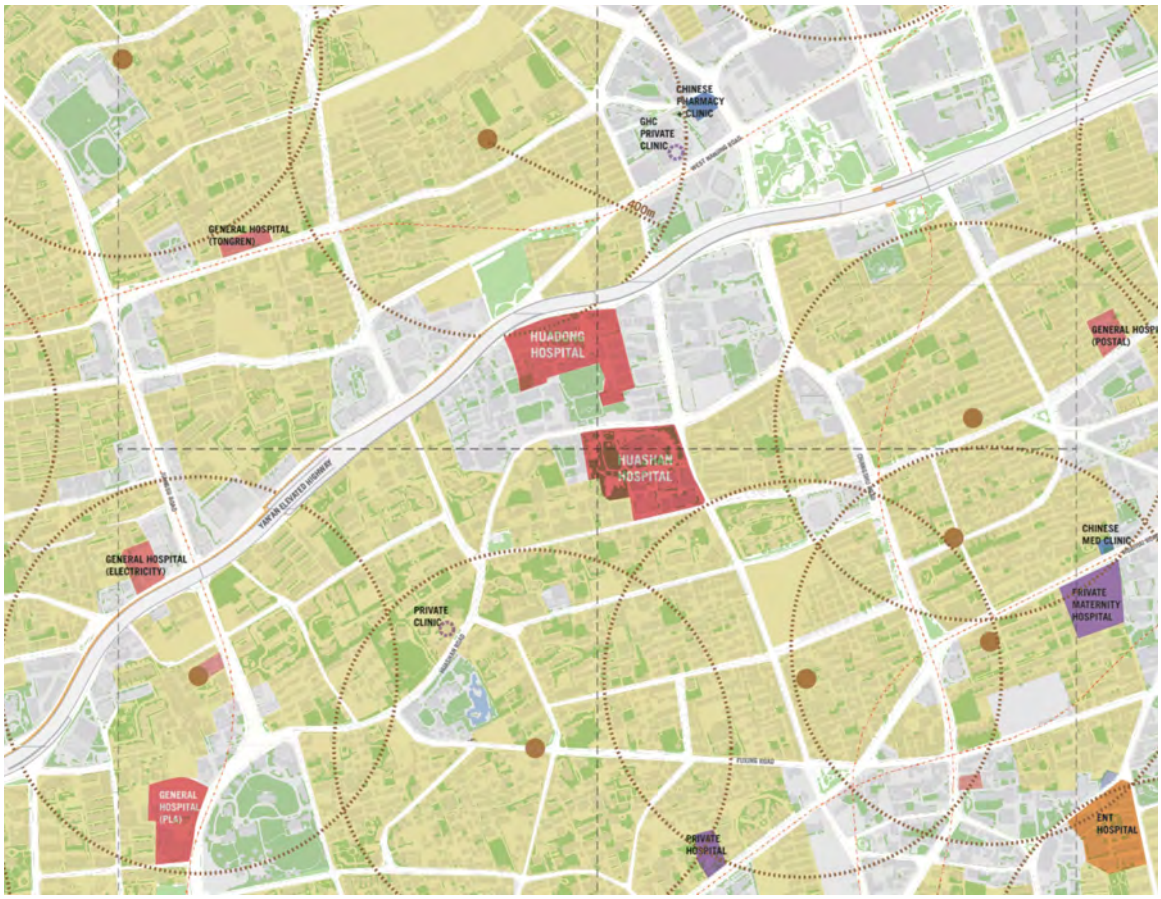

Figure 8: Healthcare facilities in the study area.

The smaller hospitals are usually affiliated with state institutions, such as the military and veterans' hospital or the hospital for the national electricity company. Only current or retired staff and family members, can access these facilities and other walk-in patients are not served in this facility. As mentioned in recent healthcare reform memo[13], there is already a plan to phase out state enterprise healthcare service, from currently a 13 percent share to a 2 percent share in 2020. These facilities have the potential to transform into public hospitals for primary and secondary care, and as a shorter-term action plan, they can begin to receive public patients at spare capacity. These hospitals could become anchor facilities at the community-based primary care network. At the community network level, there are the "Health Stations" (now called Community Health Centers) established according to planning code for residential communities. They were established as neighborhood service units for a smaller population with very basic set-up, but the extensive coverage into the communities gives them an advantage of being highly accessible to all residents, including family with young children and the elderly. As the previous section has discussed issues and potentials in terms of operations, it is important to emphasize their role as the gathering hub for the community and to ensure their accessibility to all residents.

The community health centers also have the potential to become community centers that promote preventive care and healthy lifestyle. Often housed together with elderly activity centers and adjacent to neighborhood parks, their location is ideal for community outreach. There is a good opportunity for these health centers to increase their role in public health education, with programs and activities such as aerobic exercise classes or healthcare seminars. Under current public facility guidelines, they are hardly noticeable from the streets, design interventions with welcoming urban design as simple as connection to the public parks, or seating area at the plaza can help to increase their presence in the neighborhood.

There is also a third type of facilities that has potential to contribute to the community-based primary care network–the Chinese medical clinics. Besides the public Traditional Chinese Medicine (TCM) hospitals, there are still many alternative outlets in the neighborhood that we should consider as part of the Health Community programs. They exist in a variety of format from the formal Chinese pharmacy with its complimentary clinics, to reflexology and acupuncture clinics. It is a common practice, usually among the older generation, but becoming increasing popular in general, to treat chronic disease at the traditional Chinese clinics, where it usually involves multiple visits in a longer period of treatment for a combination of herbal medicine prescription with other treatment. These clinics have the capacity to treat minor illnesses with Chinese herbal remedies, and not necessarily in need of modern medication or procedures.

Together these facilities could form a strong network of primary care outlets to serve the community its basic healthcare needs. They will be essential in acting as the system's "gate-keepers" while helping to reduce the load of large hospitals for higher level acute care. There is a need to improve the primary care facilities' service accessibility and the facilities capacity to increase utilization. Policies such as insurance payable to alternative (traditional Chinese) medical service gives the motivation for increase usage. Finally, with thoughtful public space design intervention and publicity campaigns, these facilities will have the opportunity to become the anchors for their communities.

3.2.2 Non-Medical Wellness Facilities for Preventive Care

The idea of preventive care is not new to Chinese culture, there is a strong heritage in traditional Chinese medicine regarding wellness beyond (or before) acute care. The medical practice focus is less about curing sickness, but more to maintain coherence, or balance, in life so that we would not get sick. In the contemporary Chinese cities where chronic diseases are prevailing as in any large cities in world, to embrace the cultural roots on this wellness philosophy would be a good entry point to consider preventive measures for chronic illness for a healthier urban lifestyle.

The healthcare reform policy is also creating favorable conditions for private service providers, with the growth of health-conscious urban middle class, it presents very attractive market opportunities on health-related products and services. As surveyed in our study area, a variety of health-related businesses can be found, such as the dietary supplement store, the therapeutic massage spa, and the herbal pharmacy with Chinese doctor on-duty. These commercial establishments are not formally "medical", but usually follow some healthcare theory and the aim is towards improving health. They can be characterized as "wellness establishments", that focus on improving health and wellness, which could also be seen as a kind of preventive care to chronic illness that contributes to positive public health outcomes.

Taking on a different perspective than the popular view on "wellness establishments" as purely market-driven and profit-seeking, we should consider them as an important contributor to the Health Community concept. This is where the formal healthcare and informal lifestyle commerce overlaps, places that are very visible in our urban environment. In thinking about preventive care for (urban) chronic disease as largely a behavioral change into a healthier lifestyle, the current market is having extensive influence to our lifestyle and consumption choices. As the health-related products are becoming widely available and more affordable, it should increase the accessibility to healthy choices and reduce urban chronic diseases.

As an example of how these wellness establishments are contributing to preventive care at a community level, we can see in this large medical mall within our study area (Figure 9). It has a storefront with colorful display of precious herbal medicine, the 5-floors include pharmacy for Chinese and Western medicine, sales counter of home-use medical equipment or beauty and cosmetic products, as well as traditional Chinese clinics that service and prepare herbal medicine. It is a community landmark and holds as much importance of a supermarket or library, where residents would come to learn about the latest model of blood-pressure test equipment to be used at home, or to seek advice on the appropriate choice of seasonal herbal supplement.

Figure 9: Chinese Medical Mall that provides a wide range of services and products.

It is indeed debatable regarding the effect of these commercialized establishments. In a negative sense, they could focus on driving sales instead of providing fair consultation to the patient's need. However, as the Chinese cities are in transformation to contemporary society with open market system, we should think about how to embrace these establishments instead of separating them from the discussion of public health. They could have a positive effect in bringing health awareness to a broader audience, and in providing more readily available services to the residents in comparison to traditional healthcare facilities.

3.2.3 Public Open Space for Active Lifestyle

Finally, beyond direct relationship with the healthcare practice, the effect of a Health Community concept should result in the design of places that lead to an active, healthy lifestyle. It is understood to be the most effective way to reduce chronic diseases in a community, which ultimately contributes to reducing pressure on public healthcare services.

Classic urbanism theories, such as those advocated by Jan Gehl, have described how the quality of public space is the key factor to what kind of activities, who, and how often it will be used[14]. This translates into the important role that the design of built-environment plays in the effect on its users' behavior, and in the case of our study, towards an active and healthy lifestyle. In developing the Health Community concept for urban Chinese context, current condition of public spaces and its activities were studied. Together with an understanding of the cultural backgrounds and residents' habits, it can become useful tools to inform design decision for urban environment improvements.

Based on the belief in traditional Chinese medicine's view on wellness, regular exercise and a daily stroll is considered as common practice among Chinese residents. There are community-organized exercise sessions or individual Tai-chi practices, as we would often see in parks and plazas. There are also fitness equipment, installed in many social housing projects. However, the majority of the users appears to be the older group and senior citizens.

There are many recreational facilities for active sports, and in recent years a large number of fitness studios has been established, which are more popular among the younger generation. Usually having elaborate equipment and staff trainers on-site, with better service and longer opening hours that cater to the lifestyle of busy urban residents. This is a result of market development, and also showing a trend towards a preference of indoor activities instead of outdoor. The issue could be the quality of outdoor space according to Jan Gehl's theory on urban space. While little can be done to improve air pollution immediately, we can improve the quality of public space through design, to be more accommodating for all residents to engage and encourage outdoor activities.

For dense urban center communities, space is relatively limited for specific recreation venues. However, there are some interesting observations in the case of our study area in Jing'an District, offering different ways as to how the residents utilize public space for social and recreation activities. For example, residential streets with little traffic, along wider sidewalk with shaded enclaves, would be often occupied by children playing and their grandparents chatting with neighbors. Street furniture is used in unintended ways, such as a tree fence becoming the exercise pole for the senior residents. In city parks, the elevated planting area are used for fitness training or yoga practice. It is also a famous scenery in many Chinese cities that community groups take up the plazas at office buildings during evenings and weekends to engage in group dance or exercise.

In our observations, we learnt that in a community where multiple function and user groups overlap, people found opportunities for innovative use of public space to accommodate their activities. This is a positive result without the need of additional resources and should be encouraged through urban management policies, with considerations in master planning and design strategies for communities.

At an overall master plan level, it will be crucial to ensure the variety of functions and user groups in a community through mixed-use planning, to create the possibility of space sharing at different time for different use. While there should still be sports venues planned in a community, it is not necessary to plan all urban space for designated single use – in many cases flexible public spaces would be more effective. Together with an inclusive and tolerant urban management policy, people will be engaging into activities at a much higher rate in public open spaces. Availability and accessibility are some of the best motivators for our behavior towards an active lifestyle.

This is an important reminder for the urban planners and local officials, that instead of simply taking the total amount of green area as performance indicator, a dynamic network of open space with a variety in scale and quality that allows activity to happen is more effective. The future performance indicator of open space for a Health Community should not only be the green area sum, but the frequency that they are being used and the variety of activities.

Figure 10: Multiple uses of public space for sports and recreation.

4.0 CONCLUSION

The population density and the speed of development has given China a very different context for the consideration of how to design our communities and plan strategies to promote public health. In general, the large Chinese city centers have sufficient density to provide the critical mass for effective public service, and many have a relatively good public transportation system. This has set a good foundation for sustainable development and basis to build healthy communities with low reliance on motor vehicle transportation.

City centers with longer development history have a good compact urban fabric as well, where we can focus on the optimization of dense urban neighborhoods, instead of over-build new cities to replace the old ones. However, in the last few decades the cities have been under pressure of rapid growth and development, where many new cities are being planned in haste. The fast rate of urban development is also leading to a transformation from traditional values to a new social order, which creates the class disparity and its associating issues.

This is being reflected in the character of the new urban residents as we described in this article. There is a very strong tie to family relationship and a reliance on state-provided healthcare, leading to the heavy pressure of public hospital service. Meanwhile, the rising urban middle class is also forming a lucrative consumer market for private service providers, where the issue can be seen in the case of very extreme healthcare services.

The contextual study of the article has focused on the current public health issues in the urban centers of China, where the main problem is congestion at public hospitals, which also affects their surrounding neighborhoods. Recent healthcare reform has started to approach the issue with directions to transform the nation's healthcare system. While the reform is still in early phases and being developed through various regional and local policies, the actual effects towards its goal of universal high-quality healthcare remains to be seen. It should be noted that the encouraging policies for private healthcare investment has created attractive market opportunities, but there should be a delicate balance between the market-driven approach and the vision of social equality in public health.

There is not a simple solution that would work for all. China is a country with very large population and there is a large variety of urban conditions from very different development backgrounds. For these complex conditions, it will be particularly important to conduct contextual studies accordingly. As the ultimate goal of the Health Community concept is the well-being of its residents, and healthy lifestyle has to be archived through some level of behavioral change, the understanding of cultural background and social conventions would be key for any strategies to be effective.

Although this article has provided some generalized character of the contemporary urban residents in China, in order to create successful projects, it will be important to have a more in-depth study of local conditions for strategies that are emphatic to the users' needs. It should be noted that this article has mainly focused on the issues of existing urban centers, with Shanghai Jing'an District as an example. Certain intervention proposals are rather specific for urban regeneration of communities in similar condition. There would be some very different situations for new district developments or rural towns and villages, which should require other type of contextualized strategies.

With the understanding of urban context and the character of its residents, we see that the potential for urban centers lies in the synergy between the healthcare facilities and its surrounding communities. For this, we developed the concept of "Health Community", an integrated approach for healthcare and community planning that considers the facility and the community as a mutually benefiting system. With local sensitivity and integrated consideration, we would be able to plan and design our communities with empathy that can benefit the patients and the residents.

Through specific case study of the Shanghai Jingan District, it was established that there are in fact many available but under-utilized resources already existing in the neighborhood. Many of the current urban spaces can also be turned into effective activity-prompt places with simple design interventions.

While there are many studies currently relating to the Healthy Community theory and practice, not too many studies have been done in the context of Chinese urban development. Further research effort would be needed in order to build a conceptual framework with strategies and guideline for future development in research, theory and practice.

In the case of contemporary Chinese cities which are still under rapid urbanization and growth, the development of healthy communities is crucial to the well-being of its residents and the operation of the public healthcare system. It could be the engine for urban regenera-

tion of many inner-city districts, in bringing the focus back to the center instead of initiating more unnecessary expansion.

The promising reform objective appears to be at a good start in transforming the nation's public healthcare system, with the opportunity to build a strong community-based primary care network. There are also potentials in the private sector to further develop into the market of a mid-price range healthcare services, which could alleviate the unbalance situation of healthcare options that are currently available.

The Health Community concept is about identifying common resources and to facilitate between healthcare facility and the community through mutually beneficial programs and design interventions. Complementary work is required at multiple levels with an integrated design thinking, from a top-down development of reform policies, as well as from the community level on initiatives and specific spatial strategies. As urban design and planning professionals, the ultimate goal would be to take this conceptual framework as a tool, to achieve the vision for a Healthy Community – a socially inclusive and culturally sensitive urban environment.

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