STUDY OF ENVIRONMENTAL VARIABLES AFFECTING WALKABILITY:
LEARNING FROM MAIN STREET IN DOWNTOWN FORT WORTH

by

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Abstract

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Walking has widely been considered by researchers to be important for physical health and a key to increasing social interactions in the local community (Layden, 2003), as well as a mode of transportation in such an era of high fossil fuel price (Maibach, 2009). The negative effects of low-density, automobile-dependent, segregated-use patterns of land and transportation systems typical of postwar suburban development are attracting public health attention. As a result, more designers and urban planners are beginning to take the concept of “walkable design” into consideration in their projects. In order to promote walking activity in terms of urban design, potential needs of study on the relationship between physical environmental variables and an individual’s walking activities have been identified by many researchers (Saelens et al., 2003; Brownson et al., 2009).

The purpose of this research is to study the impact of environmental variables affecting walkability on Main Street downtown Fort Worth. This research identifies the environmental variables accounted in design literature, and assesses their impacts on the relationship between walking activity and build environment on Main Street, Fort Worth. A comprehensive literature review has been done on the associations between
environmental variables and walking activity, as well as the measures for walkability level.

This research adopts quantitative methods (Deming and Swaffield, 2011) to understand environmental variables impacting walkability on Main Street, Fort Worth. Data collection methods primarily involve walkthrough survey (Lynch, 1959; Gupte, 2009) of 25 users who are selected as a result of convenient sampling. The research also uses passive observation techniques (Francis, 2002), and review of secondary and archival data with the Graphic Information Systems (GIS) to further delineate physical environment in downtown Fort Worth. The data analysis is the triangulation (Cohen and Manion, 1986) of the data collected from various sources to identify and assess varying impacts of environmental variables.

The results of the research show the various environmental variables and conditions of the built environment influence walking activity in the case of Main Street Fort Worth. Results of the study indicate that environmental variables such as fenestration, the dimension of sidewalk and presence of retail affecting walkability the most on Main Street. The findings from this research provide insight into how landscape architects can better understand the interaction between the built environment and walking behavior in influencing each other. This research can help landscape architects and other design professionals in their future design projects to develop and choose more walkable urban design alternatives by predicting walking activity and providing suggestions on improvements of walkable urban spaces.
Table of Contents

Acknowledgements .................................................................................................................... iii
Abstract ................................................................................................................................... iv
List of Illustrations ..................................................................................................................... x
List of Tables ............................................................................................................................. xiii

Chapter 1 Introduction ................................................................................................................. 1
  1.1 Problem Statement ............................................................................................................... 1
  1.2 Downtown Fort Worth ......................................................................................................... 2
  1.3 Purpose of the Study ........................................................................................................... 3
  1.4 Research Questions ............................................................................................................ 3
  1.5 Methodology ...................................................................................................................... 4
  1.6 Definitions .......................................................................................................................... 6
  1.7 Significance and Limitations ............................................................................................... 7
  1.8 Chapter Summary ............................................................................................................... 8

Chapter 2 Literature Review .......................................................................................................... 9
  2.1 Introduction ......................................................................................................................... 9
  2.2 History of Walkability ......................................................................................................... 9
  2.3 Environmental Variables ................................................................................................... 13
      2.3.1 Macro-Scale Environmental Variables .................................................................... 14
      2.3.2 Micro-Scale Environmental Variables ................................................................... 18
          2.3.2.1 Roadway ............................................................................................................ 18
          2.3.2.2 Buffer Zone ....................................................................................................... 19
          2.3.2.3 Building Setback and Property ....................................................................... 20
          2.3.2.4 Street Tree and Street Furniture .................................................................... 20
          2.3.2.5 Street Scale and Enclosure ............................................................................. 21
Chapter 2 Measuring Walkability

2.4 Measuring Walkability .................................................................................................................. 24
2.4.1 Perceived (self-reported) Environment Measures .......................................................... 24
2.4.2 Observational Measures ........................................................................................................ 26
2.4.3 GIS-based Measures .............................................................................................................. 27
2.5 User Perception .......................................................................................................................... 27
2.6 Walkability in Downtown Fort Worth ..................................................................................... 28
2.7 Chapter Summary ....................................................................................................................... 30

Chapter 3 Research Methods ........................................................................................................ 31

3.1 Introduction ............................................................................................................................... 31
3.2 Research Design ......................................................................................................................... 31
  3.2.1 Site Selection and Application .......................................................................................... 32
  3.2.2 Study Population ............................................................................................................... 32
  3.2.3 Data Collection ................................................................................................................... 33
    3.2.3.1 Walkthrough Survey .................................................................................................. 34
    3.2.3.2 Passive Observation .................................................................................................. 37
    3.2.3.3 Archival and Secondary Data Review ....................................................................... 38
  3.2.4 Data Triangulation ............................................................................................................... 39
  3.3 Bias and Errors .......................................................................................................................... 40
  3.4 Chapter Summary ....................................................................................................................... 40

Chapter 4 Analysis and Findings .................................................................................................... 41

4.1 Introduction ............................................................................................................................... 41
4.2 Overview of Research Methods ............................................................................................... 41
4.3 Survey and Observation Findings ........................................................................................... 42
  4.3.1 Fenestration ...................................................................................................................... 43
4.3.2 Overhead Structures .................................................................................................................. 45
4.3.3 Scale and Proportion of the Buildings to the Streets ............................................................... 47
4.3.4 Presence of Retail .................................................................................................................... 50
4.3.5 Presence of Restaurant with Outdoor Seating .......................................................................... 51
4.3.6 Signage ................................................................................................................................... 53
4.3.7 Seating ................................................................................................................................... 56
4.3.8 Lighting ................................................................................................................................. 58
4.3.9 Street Trees ............................................................................................................................ 60
4.3.10 Greenery .............................................................................................................................. 63
4.3.11 Curb-Cuts, Ramps, and Rails ............................................................................................... 64
4.3.12 Pavement .............................................................................................................................. 67
4.3.13 The Dimension of Sidewalk .................................................................................................. 69
4.3.14 Safety ................................................................................................................................... 69
4.3.15 The Speed or Volume of Vehicles ......................................................................................... 70
4.3.16 Noise ................................................................................................................................... 71
4.3.17 People ................................................................................................................................... 72
4.3.18 Art Work ............................................................................................................................... 74
4.3.19 Historical Characteristics ...................................................................................................... 77
4.3.20 Aesthetics Quality ................................................................................................................ 79
4.4 Analysis of Archival and Secondary Data .................................................................................... 80
4.4.1 Sidewalk Connectivity ............................................................................................................ 80
4.4.2 Land Use .............................................................................................................................. 82
4.4.3 Crime ..................................................................................................................................... 83
4.4.4 Bike Route ............................................................................................................................. 84
List of Illustrations

Figure 1.1 Study Site on Main Street .......................................................... 5

Figure 3.1 Walkthrough Survey Map ......................................................... 36

Figure 4.1 Survey Result of Fenestration ................................................... 44

Figure 4.2 Blank Façade of The Worthington Renaissance Fort Worth Hotel .... 45

Figure 4.3 Survey Result of Overhead Structure ....................................... 46

Figure 4.4 Overhead Structure in Segment 1 ............................................. 47

Figure 4.5 The Canopy in Sundance Square in Segment 2 ......................... 47

Figure 4.6 Survey Result of the Scale And Proportion of Buildings to Streets .... 48

Figure 4.7 High-rise Buildings in Segment 1 ............................................. 49

Figure 4.8 Low-rise Buildings in Segment 3 ............................................. 49

Figure 4.9 Survey Result of Presence of Retail ......................................... 50

Figure 4.10 Retail with Exhibition Window in Segment 3 ......................... 51

Figure 4.11 Survey Result of Presence of Restaurant with Outdoor Seating .... 52

Figure 4.12 Restaurant with Outdoor Seating in Segment 1 ..................... 52

Figure 4.13 Restaurant with Outdoor Seating in Segment 2 ..................... 53

Figure 4.14 Survey Result of Signage ....................................................... 54

Figure 4.15 Informational Signage Along Main Street ............................... 54

Figure 4.16 LED Signage an Sundance Square in Segment 2 ..................... 55

Figure 4.17 Signage of Heritage Trails in Segment 3 ............................... 55

Figure 4.18 Survey Result of Seating ....................................................... 56

Figure 4.19 Lacking Seating in Segment 1 .............................................. 57

Figure 4.20 Ample Seating at Sundance Square in Segment 2 ................... 57

Figure 4.21 On Street Seating in Segment 2 .......................................... 58

Figure 4.22 Survey Result of Lighting ..................................................... 59
Figure 4.47 Historical Building in Segment 3 ................................................................. 78
Figure 4.48 Survey Result of Overall Aesthetics Quality ........................................... 79
Figure 4.49 Sidewalk Connectivity .............................................................................. 81
Figure 4.50 Land Use ................................................................................................. 82
Figure 4.51 Crime ....................................................................................................... 83
Figure 4.52 Bike Route .............................................................................................. 84
Figure 4.53 Overview of Environmental Variables Findings by Segment ................. 89
Figure 4.54 Overall Findings of Environmental Variables on Main Street .............. 90
List of Tables

Table 2.1 Macro-scale Environmental Variables Literature Review Matrix ...................... 17
Table 2.2 Micro-scale Environmental Variables Literature Review Matrix ....................... 22
Table 3.1 Most Common Environmental Variables from the Literature Review ................. 34
Chapter 1

Introduction

The purpose of the study is to evaluate the walkability of Main Street in downtown Fort Worth by documenting and analyzing its environmental variables and then identifying which key factors impact walking activity and experience. Questions are raised about this purpose, the definitions and research methodology are defined in this chapter. The significance and limitations of the research are also discussed. The chapter ends with a summary.

1.1 Problem Statement

Walking and biking, as well as modern public transportation systems, have many benefits to human and environmental health. Since the early 1920s when automobiles entered the transportation market in the U.S., they have become more and more popular until they revolutionized the American transportation system. However, using automobiles has a few downsides. By burning gasoline, cars and trucks have become an important contributor to climate change and air pollution. For example, the air pollution, mainly caused by car emissions emerged in Los Angeles and other southern Californian cities during the 1940s and worsened from the 1950s to the 1970s (Bachmann, 2007). Automobiles can also cause pedestrian injuries and deaths. According to the U.S. Department of Transportation, 4,743 pedestrians and 726 bicyclists were killed in crashes with motor vehicles and 33,782 people died in crashes on roadways during 2012 (http://www.pedbikeinfo.org/, 2013). Furthermore, using automobiles can cause damage to human health. In addition to the health problems caused by polluted air due to car emissions, automobile dependency can cause declines in physical activity and increases obesity (Maibach, 2009). On the other hand, a significant proportion of car use for short
trips can easily be taken with the environmentally friendly and human-active transportation options: walking or cycling. Unfortunately, the average number of trips made on foot declined sharply in the past several decades (Maibach, 2007). There are immediate and practical needs and opportunities for the U.S. to implement policies or program to reduce short car trips and increase active transportation (Maibach, 2009). Research has demonstrated the potential of the built environment to influence walkability. Certain characteristics of the built environment can influence the amount people walk for active transport – that is, walking as a part of day-to-day activities, such as getting to work or making a trip to the grocery store – and can therefore increase physical activity levels in the population as a whole (Saelens et al. 2003). Places designed for walkability – those that are human-scaled, comfortable and convenient for pedestrians – could encourage more walking, and therefore could promote greater overall health (Sallis et al. 2011).

1.2 A Brief Background of Downtown Fort Worth

Downtown Fort Worth has the largest concentration of historic structures in Tarrant County. The historical buildings in this area tell the story of the forces that shaped Fort Worth’s early growth - cattle, railroads, and oil. Within the downtown area, buildings and other urban elements are grouped closed together so that it is easy to walk from one place to another (Roark, 2003). The City of Fort Worth’s long-range vision for its downtown is a place where it is pleasant, even exciting, to be, indoors and outdoors. In describing this vision, the city’s appreciation of its scale, open spaces, and historic and cultural resources dictates a certain image for the city. According to Downtown Urban Design District Standards and Guidelines (2009, pg. 6), “downtown Fort Worth strives to build upon its image of the most vibrant, walkable, mixed-use urban center in the region
focusing on exceptional design of both private and public places”. The vitality of a
downtown area can possible be used as a barometer to gauge the overall health of the
city. Acting as the center for government and business functions, the downtown area
delivers important services to the entire region. The Fort Worth downtown area has many
highly-developed districts and historical/cultural areas which are of the highest priority to
preserve and maintain (Burbank, 1995).

1.3 Purpose of the Study

The purpose of this research is to study the impact of the environmental
variables on walkability on Main Street downtown Fort Worth. Specifically, the study
documents environmental variables impacting walkability from the literature, reviews their
relevance and impacts by walkthrough surveys, passive observations and archival and
secondary data in order to identify the key factors impacting walkability. Main Street is the
primary activity spine of Fort Worth, containing historical architecture, popular
restaurants, active retail and entertainment centers, and the nationally recognized
Stockyards Historic District at its northern end (Burbank, 1995). Due to the center
location and close distance to other destinations in downtown Fort Worth, Main Street
has been designed as a more and more livable and walkable urban environment.

1.4 Research Questions

The research questions presented in this section define the focus of this thesis
paper. The topic of interest is the relationship between the environmental variables and
walkability, and the following primary research questions attempt to be answered
throughout this document:

1. What are the environmental variables that affect walkability?
2. How do these environmental variables impact the walking experience of pedestrians in the context of Main Street Fort Worth?

3. What are the walkability lessons learned from Main Street Fort Worth?

1.5 Methodology

This research primarily adopts quantitative methods to understand the impact of environmental variable on walkability. This research adapts three data collection methods to find solutions to the research questions: (1) walkthrough survey ((Lynch, 1959; Gupte, 2009), (2) passive observation (Francis, 2002), and (3) study of the archival and secondary data. These methods evaluate the walkability of Main Street in downtown Fort Worth. After the data collection, a data triangulation method (Cohen and Manion, 1986) is used to analyze the findings from these three research methods. Triangulation helps obtain an in-depth evaluation of the walkability of the Main Street in downtown Fort Worth.

For the purpose of this study, the 9 blocks, approximately 0.45-mile, downtown stretch of the Main Street was equally divided into three segments, each segment including one public open/green space: 9th & Main park, Sundance Square plaza and Weatherford St. & Main park (See Figure 1.1). The walkthrough survey method adopted for this research involves citizens above eighteen years old with or without design background (bachelor, master or Ph.D. of architecture, landscape architecture, urban planning) walking along these segments of the street to answer the survey questions. The participants answered questions based on their observations of Main Street and on their design knowledge.
Passive observation of Main Street in downtown Fort Worth by the researcher provided insights on environmental variables that enhance walking experience. Photographs were taken to highlight the positive and negative impacts of the environmental variables on the walkability.
Archival and secondary data also is a supporting resource to study the district level environmental variables. The Geographical Information System (GIS) maps show the analysis and detailed findings of this research. The findings from the three research methods are then analyzed using data triangulation techniques to illustrate varying impact of environmental variables in the case of downtown Fort Worth.

1.6 Definitions

The following definitions are based on the literature reviewed and adjusted related on this research. Definitions also depend on the purpose for which they are used.

**Walkability:** the quality of an urban space or neighborhood that provides safe, convenient, well-connected, comfortable, permeable and usable walkable facilities for pedestrians (Litman, 2011).

**Environmental Variables:** factors that influence walking activities in a city, such as street trees, sidewalk width, city block sizes, traffic speed, traffic volumes and mixed land uses (Hall, 2001).

**Urban Environment:** construction of a space or spaces, including the physical and contextual elements, found within a city (Alexander, 1964; Eckbo, 1964; Simonds, 1998).

**Built Environment:** individual’s external surroundings which are human-made or modified, as compared with naturally occurring aspects of the environment. (Papas et al., 2007).

**Experience:** “combination of continuous, concurrent, interrelated, and parallel sequences of actions, feelings, and thoughts whose key aspect is the individual’s sense
of participation in an immediate and present ongoing dynamic process” (Thiel, 1997, pg. 117).

**Sense of Place:** “life in the space, the climate, and the architectural quality support and complement each other to create an unforgettable total impression” (Gehl, 1987, pg. 152). How people define themselves and urban identity based on relationships between other people, land, house, and events (Convery, et al., 2012).

**Perception:** the objective of perception is to present our brain with a coherent and meaningful picture of the outside world and to give each object its place in an organized whole (Coeterier, 1996, pg. 28).

**Fenestration:** the arrangement, proportioning and design of windows, doors and other openings in a building (Gupte, 2009).

### 1.7 Significance and Limitations

The significance of this research is:

- A better understanding of the value of walkability for landscape architects, planners and citizens;
- Providing design recommendation for landscape architects and planners to design a better urban environment.

The limitations of this research are:

- Study focuses on small portion of Main Street downtown Fort Worth and mainly focuses on the physical environment, qualitative aspects (culture, spirit of place, and etc.) of the site was not part of this study.
- Some archival and secondary data are not up to date, so they may affect the accuracy of findings.
1.8 Chapter Summary

Walkability has been gaining great importance in recent years and is becoming an key component of landscape architecture, urban planning and design in order to make urban environment more walkable. This research aims to identify which environmental variables in downtown area that affect walkability. Pedestrians’ perception and professionals with design and planning background were surveyed for the purpose of this research and their comments noted. Data triangulation was used to analyze the data obtained from the research methods. The results of the Main Street downtown Fort Worth study identify significant architectural and landscape elements and demonstrate their ability to enhance the pedestrians’ overall walking experience. In addition, more people would get exercise as part of their daily lives if the built environment supports pedestrians and bikers.

Following the introduction, this research focuses on the literature reviewed for this research (Chapter 2) focusing on environmental variables impacting walkability. The literature review is followed by chapter three on research methods. This chapter focuses on research procedures for data collection analysis and research design along with study location and population. Walkthrough surveys, passive observation, and study of the archival and secondary data are the three methods used for this research. Chapter 4 presents the analysis and findings of this research. Conclusions, summary findings as well as implication for landscape architecture, and future directions are reviewed in Chapter 5.
Chapter 2

Literature Review

2.1 Introduction

To understand walkability in relation to environmental variables, a comprehensive literature review that addresses the history of walkability, environmental variables, and measures of walkability must be presented. This review starts with study of the history of walkability in landscape architecture and urban design literature in the United States, followed by a more specific focus on Main Street downtown Fort Worth. Environmental variables are considered some of the key elements by designers and planners affecting walkability, so environmental variables covered in the past decade in design literature has been reviewed in the second section of this chapter. The final section of this literature review focuses on the measuring walkability. The chapter concludes with a summary of the reviewed literature.

2.2 History of Walkability

Before the mid-19th century, people traveled primarily by walking and animal power. As a result, buildings and people in cities were typically tightly packed together in a relatively small area within walkable distances. This traditional urban form was characterized by smaller block sizes built to human scale, and continually increasing in the number of streets and structures, as well as a complex, highly mixed of land uses (Wheeler, 2008). Thereafter, this traditional form was changed since early entrepreneurs turned farms into picturesque landscapes, which were attractive to families looking for a different lifestyle. These people started the trend of living in countryside on large plots of land (Hayden, 2003). With the advent of the railroad in the 1830s, numerous residential clusters near railways materialized and developed outside the built-up urban area (Muller, 2008).
However, the suburbs near train stations were only been occupied by wealthy people who could afford the daily travel expenses and time, while moving out of the city was unachievable for middle-income residents because they could not afford the extra time and travel spends for this living pattern. So these middle-income or low income residents still lived within a small area with everything in walkable distances (Fishman, 1987).

The rapid urban growth and industrialization in this era caused many environmental issues and cities subsequently became largely unlivable. After the 1850s, further development of rail transportation system provided a slight improvement in mobility within a city, so people, especially the middle class, did not have to move too far away from the city to have access to the high-amenity environment of the suburban area (Muller, 2004). Also, the horse-drawn streetcar came out and provided middle-income residents access to the “horse-car suburbs” (Hayden, 2003, pg. 36). However, the growth of urban population due to the migration of middle-income residents to the city’s fringes did not last long. Speed of growth and immigration of middle classes exceeded that of the horse-drawn streetcars. City crowding was more prevalent and urban populations were quickly outgrowing the capacity of their cities’ planned infrastructure (Barker, 2012).

In the late 1880s, the invention of the electric (streetcar) traction motor presented a mode of transportation that middle-income residents accessed to the outside of the city’s edge. After that, cities began to develop into much larger surrounding countryside. The average speed of an electric streetcar was about 15 miles per hour, which was triple of that of the horse-drawn streetcar. Thus, by using the electric streetcars, an access to much larger radius of land on the city’s outer edge was facilitated (Muller, 2004). The “streetcar suburb” pattern was characterized by larger, rectangular blocks, often around 300 feet by 600 feet and typically oriented perpendicular to horse-car or streetcar lines.
(Wheeler, 2008, pg. 36). At the same time, cross-town lines also provided opportunities for people to travel from one suburban center to another, and interurban lines connected outlying towns to the central city and to each other (Foster, 1981). The City Beautiful movement which started in the 1890s, aimed to make cities and neighborhoods more appealing and livable by implementing plans and designs. It stimulated advances in city planning and urban design fields and created many charming neighborhoods and cities that had timeless architecture, walkable streets, diverse mixed of land uses, highly visible open spaces, and parks accessible by foot or bicycle (Jacobs, 1961; Martin, 2012).

In the early 20th century, suburban landscapes emerged due to the extension of central streetcar systems. Many large landowners capitalized on this opportunity to subdivide (Hayden, 2003). Development of the streetcar until the 1920s also caused the first rise of automobile in United States. Automated assembly line by the Henry Ford made the automobile affordable to the middle class. With more American families owned cars, automobile-oriented suburbs of single-family houses on spacious lots were created and became the quintessential American landscape of the 20th century (Scott, 1971).

People were able to move further outside the city as the fast development on the periphery became more widespread. Also, businesses, factories, and warehouses moved away from the city center, and distribution centers were able to locate outside the railroad corridors due to the increased use of rubber-tired trucks (Rowe, 1991). As automobile use became more dispersed, developers were no longer tied to the areas that were accessible by public transportation, so cities expanded farther from the city center (Muller, 2004).

During the mid-20th century, Interstate Highway Act was issued. It promoted a nationwide effort to build high-speed freeways, which revolutionized American transportation. After this, automobiles got much greater mobility but the urban grid
degenerated further and became much less connected for the pedestrian (Jackson, 1985). The freeway era allowed populations to become more spread out and had the antithesis of the old cities: separated land uses, larger street grids with automobile-oriented amenities, few to no amenities within walking distance of residences and buildings and signs built to automobile scale rather than to human scale (Muller, 2004).

The growth of high-speed transportation continued to dominate development patterns through the late 20th century, creating essentially fully auto-dependent communities with less connection to the surrounding urban form (Wheeler, 2008). The term “sprawl” has come to describe such communities with low walkability, low density, and high auto-dependence (Sallis et al. 2011).

Nowadays, crowded cities and excessive car use have caused many environmental issues and health problems. Researchers have begun to focus more intently on the effect that this type of sprawling built environment has had on our health. As mentioned by Frank, et al., “In the old cities, getting enough physical activity during one’s day was not an issue because it was as much a part of life as eating or sleeping. Today, physical activity has been engineered out of most aspects of life” (2003, pg. 418). People are now required to seek out physical activity and plan it into their leisure time. Designers and planners can structure the built environment to encourage the integration of walking and other physical activity into daily life.

A brief review of walkability above within the context of urban development illustrates that among varying developments within the 19th and 20th centuries. The physical factors - environmental variables - seemed to play an important role affecting walkability. The following section focuses on defining and identifying environmental variables.
2.3 Environmental Variables

Environmental variables are factors that influence walking activities in a city, such as street trees, sidewalk width, city block sizes, traffic speed, traffic volumes and mixed land uses (Hall, 2001). The review of literature especially in design and planning fields illustrates that numerous studies have already investigated how built environments effect on walking activity (Ball et al. 2001, Booth et al. 2000, CDC 2001, Troped et al. 2001, Handy et al. 2002, and Greenwald and Boarnet 2002). In addition to other sociopsychological factors, environmental variables have been identified that impact walking in general (Sallis et al. 1999, Sallis et al. 1997, Giles-Corti and Donovan 2002, CDC 2001, Brownson et al. 2001, Giles-Corti and Donovan 2002b, Saelens et al. 2003a, and Pikora et al. 2003). Although these studies show that walking activity is influenced by the characteristics of the neighborhood or urban environment, a comprehensive list of environmental variables that affecting walking activity still needs to be studied. One significant reason for identifying a comprehensive list of environmental variables is to consider them in walkability research in addition to sociodemographic variables (Kockelman 1997, Frank and Pivo 1994, Kitamura, Mokhtarian, and Laidet 1997). It is also important because only a few environmental variables have been empirically reviewed for their impact on walking activity and the need for comprehensive and detailed environmental measures is essential (Clifton et al. 2007, Kwon et al. 1998, Painter 1996). This research develops a comprehensive list of environmental variables that have been either perceived or empirically tested to be associated with walking on Main Street Fort Worth.

Several studies in the past decade have shown that both macro- and micro-scaled physical environmental features can affect people’s desire for physical activities (Alfonzo et al., 2008; Rodriguez et al, 2006). However, research on landscape
architecture, urban design and walkability commonly emphasizes macro-scale features more than micro-scale features of the physical environment. Macro-scale features such as block length and number of intersections can be measured by geographic information systems (GIS) and aerial photographs, while the micro-scale features such as street trees, street amenities, sidewalks, and conditions of the buildings (Alfonzo et al., 2008) cannot be measured by these technologies. As the literature review illustrates, both macro- and micro-scale features are can be influential to the way people perceive the environment (safety, pleasantness, accessibility, etc.). The following section reviews these environmental variables in detail to understand how they affecting walkability.

2.3.1 Macro-Scale Environmental Variables

Macro-scale environmental variables are features such as block length and number of intersections can be measured by geographic information systems (GIS) and aerial photographs (Alfonzo et al., 2008; Rodriguez et al., 2006). Saelens et al. (2003) and Lee & Moudon (2004) summarized much research on the relationships between built environment features and walking activity, particularly focused on the macro-scale environmental variables study fields such as transportation and urban planning.

According to these reviews, environmental variables associated with walking activity, non-motorized transportation and urban planning include proximity, connectivity, block length, access to programs and facilities, population and housing density, land uses, sidewalk continuity (Saelens et al., 2003; King et al., 2003; Frank et al., 2005; Hoehner et al., 2005; Krizek & Johnson, 2006; Lee & Moudon, 2004; Boer et al., 2007). Additional built environment features that have been empirically related with walking and other forms of physical activity include urban sprawl (Ewing et al., 2003), public transit (Hoehner et al., 2005), and intersection density (Frank et al., 2005; Alfonzo et al., 2008).
Factors that affect people’s choice of using motorized or non-motorized transport are based primarily on two fundamental aspects of the way land is used: (1) proximity (distance) and (2) connectivity (directness of travel) (Frank, 2000). Other factors, such as travel expense, environmental quality, and aspects of convenience and access (e.g., parking availability) are also likely to be influential in walking activity (Saelens et al., 2003). Proximity refers to the distance between trip origins and destinations. Proximity is determined by two land use variables: density (compactness of land uses) and land use mix (the distance between or intermingling among different types of land uses) (Saelens et al., 2003). Living in a high-density area with mixed land uses is more convenient for a resident to walk to shopping, dining in a restaurant, and visiting neighbors than in a low-density with single land use area.

Among all the macro-scale environmental variables considered affecting walking activity, connectivity is the most abstract one and also the key component for good neighborhood or urban design (Dill, 2004). Block length is also an important criterion in measuring connectivity. Shorter the length of a block is, it has higher connectivity. Many new communities have incorporated maximum block length standards to increase connectivity (Handy et al., 2003). Block length is usually measured between street centerlines. The basic hypothesis behind the measure is that shorter block length means more intersections and thus shorter travel distances and a greater number of routes between locations (Dill, 2004). Block size is similar with the block length, but using block size measured by area or perimeter as a standard may be more flexible than block length for each side.

Frank et al. (2000) used the block density as a proxy measure for connectivity, which is considered a good proxy for street connectivity. Intersection density is measured as “the number of intersections per unit of area” (Dill, 2004, pg. 467). A higher number
would indicate more intersections and, presumably, higher connectivity. Street density is measured as the number of linear miles of streets per square mile of land. A higher number would indicate more streets and, presumably, higher connectivity (Dill, 2004). Table 2.1 below illustrates the macro-scale environmental variables affecting walking activity in the literature.
<table>
<thead>
<tr>
<th>Number of blocks</th>
<th>Grain and pattern of development (including density)</th>
<th>Density</th>
<th>Density</th>
<th>Connectivity</th>
<th>Fine grained land uses</th>
<th>Density</th>
<th>Safety</th>
<th>Population density</th>
<th>Presence of continuous and well maintained sidewalks</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Land use</td>
<td>Land use</td>
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<td>Public open space</td>
<td>Connectivity</td>
<td>Strengths of centers</td>
<td>Land use attributes</td>
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<td>Attractor destinations</td>
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<td>Safety</td>
<td></td>
<td>Number of central activities</td>
<td>Block segments along arterials</td>
<td>Crime</td>
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<td>Pedestrian separation or buffering from traffic</td>
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<td>Land use density</td>
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<td></td>
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<td></td>
<td>Building and land-use diversity</td>
</tr>
</tbody>
</table>
2.3.2 Micro-Scale Environmental Variables

In addition to macro-level variables typically considered in planning and transportation fields, the literature review also points out numerous environmental variables that may affect walking, other fields such as urban design, architecture, landscape architecture, park planning, environmental psychology, and literatures from visual preference and visual assessment also contribute to it (Ewing, 2000; Ewing et al., 2005). At the micro-scale, the relevant environmental variables of walkability are typically about route characteristics relating to quality and path context. Southworth (2005) identifies six criteria of walkability: connectivity, linkages to other modes, fine-grained and varied land use patterns, safety, quality of path, and path context (e.g. visual interest, landscaping, spatial definition, etc.). Among these, connectivity, linkages to other modes and land use patterns are part of macro-scale environmental variables which have been discussed before. At the micro-scale, the relevant environmental variables of walkability are route characteristics relating to quality and path context. The following section of the literature review specifically focuses on micro-scale environmental variables that affect pedestrian perceptions and walking experience.

A micro-scale environmental variables review matrix was created after extensive research on landscape architecture and urban design literature in the end of this section. This matrix was used to derive the most common micro-scale environmental variables in pedestrian oriented urban spaces. And this matrix also benefit from design elements matrix created by Ozdil (2008).

2.3.2.1 Roadway

Many studies have indicated that various factors associated with roadways might influence pedestrians walking activity. The basic idea of this is that wider street draws
faster traffic speed, which decreases the sense of safety. So a narrower street is more pedestrian-friendly and walkable (Southworth and Ben-Joseph, 2003). Southworth and Ben-Joseph (2003) suggested 24 feet as the ideal roadway width. Using the same logic, some research focused on the number of traffic lanes instead of the width of traffic zone (roadways, street parking and bike lanes). They claimed that fewer traffic lanes are also beneficial for pedestrians because street crossing distance is reduced (Harkey and Zegeer, 2004). In addition, various researchers have pointed out that traffic calming factors also increase the pedestrian safety, because these factors reduce traffic speed as well (Boarnet, 2003; Ewing, 2005).

Improvements to the design of pedestrian crossings, such as the quality of signage and signals, raised pedestrian crossings, existence of median islands, and curb extensions (Bicycle Federation of America, 1998) can make it safer and easier for pedestrians to cross street. Also, special pavement for crossings and one-way traffic may also be helpful (Harkey and Zegeer; Lamont, 2001).

2.3.2.2 Buffer Zone

Buffer zone, usually indicates the space between walking zone and traffic zone, is a key factor that affects walking activity, because it protects pedestrians from the negative impact of fast-moving traffic (Jacobs, 1993; Boarnet, 2003; Guttenplan, 2001; Landis et al, 2001). More specifically, buffer zone is defined as the space between the edge’s of sidewalk and thorough-traffic lane, including three major street elements, street landscape, on-street parking, and bike lanes (Park, 2008).

Lynch and Hack (1984) discuss the benefits of on-street parking: “Curb parking can be ameliorated by occasional projections of the planting strip, to break the line of cars and to provide a safe launching pad for crossing the street” (Lynch and Hack, 1984,
pg. 265). Some other studies also suggest “angled on-street parking” (Calthorpe and Poticha, 1993, pg. 17). However, very limited research claimed that bike lanes can help walking activity of pedestrians, but they would add additional three to four feet into a buffer zone so that the traffic speed may decrease.

2.3.2.3 Building Setbacks and Property

Building setbacks have also been mentioned in walkability literature (Lamont, 2001), but whether a building setback is good or bad for pedestrians is yet to be determined with rigorous research. Façade transparency has been discussed by many researchers in walkability literatures (Jacobs, 1999; Lamont, 2001; Boarnet, 2003). Fenestration is the design and placement of windows and other openings in a building. The general idea is that transparent glass is more enjoyable than blank wall by pedestrians near the building façade (Urban Design Guidelines, City of Tampa Bay). Also pedestrians prefer an entrance to a building facing the street rather than parking lots (Calthorpe and Poticha, 1993; Knaap et al., 2005). Mixed land use was also considered to provide more walking pleasure than vacant lots and unoccupied buildings (Lamont, 2001; Boarnet, 2003). Commercial uses are usually considered the most favorite land use type for pedestrians to walk.

2.3.2.4 Street Trees and Street Furniture

The importance of street trees associated with walking activity is mentioned in many studies (Jacobs et al., 2002; Ewing, 2000; Boarnet, 2003). Jacobs et al. (2002) points out two benefits of street trees: shading from sunlight, and providing a physical and psychological buffer from fast-moving traffic. Some research also indicates that street trees can effectively reduce wind velocities (Lynch and Hack, 1984). Ewing’s visual
preference survey found that “trees along the street” was one of the top five determinants influencing bus users’ route choice to bus stops (Ewing, 2000, pg. 24). Street furniture, such as street lighting, trash cans, benches, bollards, post boxes, phone boxes and public art, have also been mentioned in many research (Ewing, 2000; Boarnet, 2003). Street lighting, especially pedestrian level lighting, makes a bright and well-lit street environment and can increase sense of security of pedestrians (Harkey and Zegeer, 2004). However, there is no or few discussion about how other street facilities influence pedestrians.

2.3.2.5 Street Scale and Enclosure
Design literature also refers to “intimate human scale,” which is typically determined by street width (building-to-building distance) (Jacobs, 1993, p278). The “human scale” definition is based on whether a pedestrian on one side of the sidewalk can recognize the facial expression of pedestrian on the other side. As part of this theory building height is also considered as an important factor in street scale in literature. Blumenfeld’s study claims that three-story (or 30-foot) building, (along with a 36 foot building width and a 72-foot street width) is the maximum dimension for human scale. To evaluate building scale, Knaap et al. suggests measuring both “average height of buildings” and “average width of buildings” (Knaap et al., 2005, pg. 24). Jacobs also suggests that the ratio between building height and street width is important. He claimed that the best ratio is 1:3.3, such as a 20-foot building height coupled with a 66-foot building to building distance, while 1:2 (or less) gives a strong sense of enclosure, and 1:5 (or more) shows a weak sense of enclosure (Jacobs, 1993). He also mentioned “the spacing of buildings along a street”; he believed that “tighter spacing” creates “street definition.” Knaap et al. suggested measuring the percentage of block face without building façades to measure “street
enclosure” (Knaap et al., 2005, pg. 24). Lamont called the same concept “streetwall quality” (Lamont, 2001). Table 2.2 below summarizes factors reviewed above as well as additional factors affecting walkability that are found throughout the literature review is a literature review.
Table 2.2 Micro-scale Environmental Variables Literature Review Matrix

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</tr>
</thead>
<tbody>
<tr>
<td>Visual Complexity</td>
<td>Street crossings</td>
<td>Trees along streets</td>
<td>Street parking</td>
<td>Building Frontage</td>
<td>Windows facing the street</td>
<td>Availability of facilities</td>
<td>Streetlights</td>
<td>On-street parking</td>
</tr>
<tr>
<td>Uses and Activities</td>
<td>Weather</td>
<td>Cleanliness of sidewalk</td>
<td>Traffic speed</td>
<td>Air quality</td>
<td>Street lighting</td>
<td>Street trees per length of road</td>
<td>Street trees</td>
<td>Building setback</td>
</tr>
<tr>
<td>Microclimate</td>
<td>Pleasantness</td>
<td>Safety</td>
<td>Sidewalk width</td>
<td>Character of the street</td>
<td>Sidewalk buffers</td>
<td>Streetscape</td>
<td>Number of stores and shopping center</td>
<td>Front porches</td>
</tr>
<tr>
<td>Boundaries</td>
<td>Safety</td>
<td>Availability of Recreation Facilities</td>
<td>Sidewalk &amp; pavement quality</td>
<td>Trees and green spaces</td>
<td>Street width</td>
<td>Views</td>
<td>Curb Cuts</td>
<td>Retail type</td>
</tr>
<tr>
<td>Seating</td>
<td>Visual interest along the path</td>
<td>Seating</td>
<td>Handicap</td>
<td>Public art</td>
<td>Curb bulb-outs</td>
<td>Lighting</td>
<td>Benches</td>
<td>Buffers (landscape)</td>
</tr>
<tr>
<td>Planting</td>
<td>Terrain</td>
<td>Bike lanes</td>
<td>Outdoor seating</td>
<td>Lighting</td>
<td>Paving treatment</td>
<td>Noise</td>
<td>Topography</td>
<td>Sidewalk condition</td>
</tr>
<tr>
<td>Public Art</td>
<td>ADA</td>
<td>Greenery</td>
<td>Visual complexity</td>
<td>Street trees</td>
<td>Slope</td>
<td>Shade and rain cover</td>
<td>Street trees</td>
<td></td>
</tr>
<tr>
<td>Fountains</td>
<td>Signage</td>
<td>Public outdoor displays</td>
<td>Seating</td>
<td>Street furniture</td>
<td>Street width</td>
<td>Weather/Climate</td>
<td>Signage</td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>Air qualities</td>
<td>Signage</td>
<td>Graffiti</td>
<td></td>
<td></td>
<td></td>
<td>On-street and off-street parking</td>
<td></td>
</tr>
<tr>
<td>Vendors</td>
<td>Lighting</td>
<td></td>
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<td></td>
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<td></td>
<td>Sidewalk availability</td>
<td></td>
</tr>
<tr>
<td>Paving</td>
<td>Facades</td>
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<td></td>
<td>Sidewalk buffer</td>
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</tr>
<tr>
<td>Information &amp; Signs</td>
<td>Building Frontage</td>
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<tr>
<td>Maintenance &amp; Amenities</td>
<td>Availability and size of crosswalk</td>
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</table>
2.4 Measuring Walkability

Associations between elements of physical/built environments and physical activities have been broadly studied in the United States. Measures of built environment development play important roles in these studies. In the last few decades, more comprehensive measures of the built environment have been developed, allowing better assessment of the impacts of built environment to walkability. Brownson and his colleagues (2009) claimed that three categories of data are being mostly used in the current research: (1) perceived measures obtained by telephone interviews or self-administered questionnaires; (2) observational measures obtained using systematic observational methods (audits); and (3) archival data sets that are often layered and analyzed with GIS.

2.4.1 Perceived (self-reported) Environment Measures

In perceived environment measures - evidences on the association between environmental variables and physical activity behaviors - are usually derived from self-reported data on individuals' perceptions of their environments (Humpel, 2002). In previous research, data have usually been collected through phone interviews and by self-reports (in person or by mail) (Brownson et al., 2009).

Two studies were conducted by Pikora et al. (2003) and Ramirez et al. (2006). Indicators in their evidence-based frameworks were generally similar, including the following key environmental elements: functional, safety, aesthetic, and destination. Some social factors were also included, such as crime rate and social capital. In the more than 100 studies of perceived built environment that have been conducted, questionnaires play an important role, ranging from 7 to 68 questions (Brownson et al., 2009).
In order to test the reliability, Landis (2001) suggested rating of test-retest tool as follows: 1.0–0.8 (almost perfect agreement); 0.8–0.6 (substantial agreement); 0.6–0.4 (moderate agreement); 0.4–0.2 (fair agreement); and 0.2–0.0 (poor agreement). Results of these studies indicated that vast majority of the questions and scales fell in the substantial or almost perfect range of agreement (Brownson et al., 2009).

When it comes to the validity, only a few studies have comprehensively addressed evaluating validity for the measures. Three types of validity that are the most relevant include: (1) content validity; (2) construct validity; and (3) criterion-related validity (Cerin, 2006). Content validity focuses on to which extent the measures represent the appropriate attributes. Current studies largely relied on experts’ opinions and empirical indicators. Construct validity is “the degree to which a measure behaves in a way consistent with theoretical hypotheses and is predictive of some external attribute”. One example is that researchers examined individual and block group-level associations separately for residential density and land-use mix with walking (Cerin, 2006, pg. 36). Criterion-related validity (sometimes considered as a subset of construct validity) is “the degree to which a measure is predictive of some gold-standard measure of the same attribute”. Some published studies have compared perceived measures with data obtained by observation and/or with measures derived from GIS. And some of them have used GIS data as reference (Brownson et al., 2009). One major challenge in perceived-environment data collection has been the low response rates of surveys. Response rates can be negatively affected by long questionnaires. Therefore, the questionnaire should be short enough to ensure high response rate (Brownson et al., 2009).
2.4.2 Observational Measures

Observational measures are instruments and protocols to measure the actual physical environment as it is directly observed (Moudon, 2003). Southworth (2005) described micro environment as the most problematic and least developed walkability criteria which can only be measured with street level information. A systematic observation of the physical environment at micro-scale (street level) including presence and qualities of features (e.g., number and quality of public spaces, sidewalk quality) hypothesized to affect walking activity (Brownson et al., 2009). In-person observation should select sites, define and choose samples. Researchers walk or drive through a neighborhood and code characteristics within a standardized form. Street segment is the typical unit of observation. Several observational measures tools have been developed in recent years, such as the Walking Suitability Assessment Form and the Environmental Assessment of Public Recreation Spaces (EAPRS) tool. Personal digital assistant devices have also been developed for data collection (Brownson et al., 2009).

Most observation instruments include one or more measures of: land use (e.g., presence and type of housing, retail); streets and traffic (e.g., traffic volume, presence of traffic calming); sidewalks (e.g., presence and continuity of sidewalks); bicycling facilities (e.g., presence of bike lanes); public space/amenities (e.g., presence of street furniture or benches); architecture or building characteristics (e.g., building height); parking/driveways (e.g., presence of parking garages); maintenance (e.g., presence of litter); and indicators related to safety (e.g., presence of graffiti) (Brownson et al., 2009). Comparing to measures such as land use and street characteristics, observational measures report reliability by item or domain, measures of physical disorder/tidiness/safety-related features tend to be less reliable.
2.4.3 GIS-based Measures

GIS-based measures simply refer to measures of the built environment derived primarily from existing data sources that have some spatial reference, which provides great convenience for characterizing the built environment. In addition, it is believed to be the most common way to generate objective measures of built environment (Brownson et al., 2009). The GIS-based measures generally including variables such as population density, land-use mix, street pattern, sidewalk coverage, vehicle traffic, crime, public transit, slope, and greenness/vegetation. In addition, some studies combined multiple indicators into one single variable or index (Frank, 2005). It is critical to know how to obtain, manage, and analyze GIS-based data to conduct the studies. Researchers should eliminate the potential mismatch between the variables conceptualized and actual data.

2.5 User Perception

Measuring walkability is not only done through the assessment of physical macro- and micro-scale environmental variables (objectively); gathering personal perceptions (subjectively) is also an important method. Perception is the term stated by environmental psychologists to “the complicated processing, integration, and interpretation of complex, often meaningful stimuli” people encounter in everyday life (Bell et al., 2001, pg. 57). Essential dimension of urban design is eliciting user’s awareness and appreciation of environmental perception in particular of perception and experience of “place” (Carmona et al., 2003). User perceptions are also informed by their activity and physical setting, feed into the image or sense of a place. Thus, the design of an area can affect user’s perception, for example: (1) they can walk many routes in a well-connected street, (2) the art work along the street make walking experience more enjoyable, (3) the
legibility can affect how easily people understand the area. These concepts are important to create responsive places which people may engage with and enjoy more.

Ewing and Handy (2009) have described five qualities that are mostly frequently mentioned in environmental perception research: imageability, enclosure, human scale, transparency and complexity. Imageability refers to those features which help create an image of a particular place. Enclosure refers to the space created by the physical environment. Buildings, streets and sidewalks, and greenery such as trees can all provide definition of space. Ewing and Handy (2009) found that human scale was much more difficult to define than imageability and enclosure qualities. Transparency is the ability to project life within the indoor environment by an outdoor environment. It is a perceptual quality that allows a person to imagine what activities are taking place outside the direct line of sight. For example, "courtyard, sign and buildings that convey specifics uses (school and churches) add to transparency" (Ewing and Handy, 2009, pg. 78). Complexity is another quality that adds to the perception of the physical environment. This quality relates to the variation found within the environment and the ability of a person to internalize the information. Too little information creates boredom and too much creates information overload. Complexity is created by variations in the development pattern through varied setbacks, building orientations, and constructed buildings. Street furniture, signage, and the presence of and the activity of people all help to create complexity (Ewing and Handy, 2009).

2.6 Walkability in Downtown Fort Worth

This study uses 9 blocks (0.45 mile) of Main Street in downtown Fort Worth to understand the environmental variables affecting walkability. Fort Worth is one of the fastest-growing cities in America, and the fastest growing city in North Texas. The
downtown area is the heart of Fort Worth, where cowboys, culture and convention-goers intersect. With its low-rise, brick-lined, David Schwarz-designed cityscape, it’s a nod to Fort Worth’s cattle-trail past that impresses out-of-towners with its folksy charm (Philpot and Darling, 2014). The main users of downtown Fort Worth are office workers and downtown dwellers during weekdays, conventioneers, bar-hoppers, restaurant patrons, concert- and movie-goers, and families the rest of the time. There is retail as well as movie theaters, restaurants, as well as Bass Hall for the Performing Arts. Sundance Square Plaza is the new 1-acre gathering place in the heart of downtown (Philpot and Darling, 2014).

The Downtown Urban Design Standards and Guidelines (2009) focus on promoting a walkable urban form of development consistent with the character suited for a downtown. The focus on form promotes buildings that conform to tested urban design principles and that adapt to changing conditions over time. Downtown Fort Worth is often ranked among the best in America due to its walkable, vibrant, mixed-use urban center in the region focusing on exceptional design of both private and public places. The new Sundance Square Plaza should only help bolster that reputation. With it come new restaurants, an outdoor stage, fountains and a new space for festivals and performances. Cowboy-themed restaurants and shops reflect the city’s Western heritage, but downtown also has a very contemporary vibe, with everything from sushi spots, brewpubs and sports bars to live music and theater spaces (Philpot and Darling). Such qualities of downtown are suggestive of promoting walkability, so it would important to understand how environmental variables affect walkability in downtown Fort Worth.
2.7 Chapter Summary

Literature review was conducted on various topics during the course of this research. The topics primarily studied were history and background on walkability research, environmental variables found to be influential in walkability, measuring walkability, user perception as an area of research, and walkability in downtown Fort Worth. Literature was reviewed to identify both macro- and micro-scale environmental variables. Two matrices of these environmental variables were generated from the past research to inform the research methods in this study. One matrix is for macro-scale environmental variables and the other is matrix for micro-scale environmental variables. As a result of this chapter, research methods and variables are further refined. Furthermore, the study of history and background on Fort Worth in relation to walkability allows the researcher to further examine various portions of downtown Fort Worth as a study site for the walkability research. Chapter 3 describes the research methods used, and Chapter 4 reviews the analysis and findings obtained from these research methods. The conclusions to this research are shown in Chapter 5.
Chapter 3

Research Methods

3.1 Introduction

This chapter describes the procedures and methods utilized in this research. The research primarily benefited from quantitative methods to understand the impact of environmental variables on walkability. The quantitative method is explaining phenomena by collecting numerical data that are analyzed using mathematically based methods (Deming and Swaffield, 2011). The research concentrated on primary (original) data collection methods. Where it is found applicable, the researcher benefited from secondary and archival data. The following sections cover the procedures followed in this research as well as brief coverage of study population and site selection. Following pages also details three methods used in the research. walkthrough surveys (Lynch, 1959; Gupte, 2009), passive observation (Francis, 2002), and review of archival and secondary data in the form of GIS. Data later are analyzed using descriptive statistics and data triangulation methods as (Cohen and Manion, 1986). Chapter 3 describes the implementation of these research methods for evaluating the walkability of Main Street in downtown Fort Worth, TX.

3.2 Research Design

The major goal of this research is to test the effects of both macro-and micro-scaled environmental variables in three segments of Main Street Fort Worth. The main hypothesis of this research is that there could be a certain combination of macro- and micro-scale environmental variables that encourage or discourage pedestrians to walk on Main Street Fort Worth.
3.2.1 Site Selection and Application

“Few downtowns have achieved the cohesion between cowboy culture and urban sophistication that Fort Worth has. City and community leaders support a number of rehabilitation and improvement projects that help bring in more businesses, create a more walkable environment and ease traffic congestion.” (Baker, 2014, pg. 19)

Main Street, the main axis of downtown Fort Worth, is chosen for the study area. This particular place has been selected because of its strong pedestrian traffic and walkable characteristics observed by the researcher. Along with cities recognition as one of the most walkable places in North Texas. Main Street in downtown is always busy with people walking in and out of cafes, restaurants and retails, jogging and biking on sidewalks. Interestingly, the demographic mix is multi-generational and multi-racial due to the international offices and tourist destinations in the vicinity.

3.2.2. Study Population

An essential dimension of urban design is eliciting user's awareness and appreciation of environmental perception, in particular of perception and experience of "place" (Carmona et al., 2003). User perceptions are formed by their activity and physical setting, feed into the image or sense of a place. The survey method used for this research incorporated the idea of walking with the interviewee along the Main Street in downtown Fort Worth to note their observations and comments. Convenient sampling methods are used to recruit participants in this research. Snowball sampling technique is utilized to recruit participants primarily from the student body from area colleges (such as UTA, TCU). Study population of this research is a group of adults who have design background (either bachelor’s or master’s programs in architecture, landscape architecture, or urban planning) and a group of adult who have no design background. A
total of twenty-five participants took the walkability walkthrough survey on Main Street Fort Worth. Out of these twenty participants, 65% were males and 35% were females. About 80% of the survey participants were students, while the remaining 35% was distributed among scientist (10%), social worker (5%), and engineer (5%).

3.2.3 Data Collection

Data collection for this research included three methods: walkthrough surveys, passive observation, and study the archival and secondary data using GIS. The data obtained from these three sources were triangulated using the data triangulation technique to provide an in-depth evaluation of the walkability of Main Street Fort Worth. Two steps were taken prior to the data collection process:

List of significant environmental variables: The first step for this study was to derive a list of significant macro-scale and micro-scale environmental variables. The design literature review matrices (see Tables 2.1 and 2.2) were further analyzed according to the number of their appearances in the matrix. Table 3.1 shows the results of this analysis. This newly generated environmental variables matrix was used for passive observation. The environmental variables from the matrix were also used to prepare the survey questionnaire.
Table 3.1 Most Common Environmental Variables from the Literature Review

<table>
<thead>
<tr>
<th>Top Macro-Scale Environmental Variables</th>
<th>Top Micro-Scale Environmental Variables</th>
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<tbody>
<tr>
<td>Land-use (8)</td>
<td>Street Trees (7)</td>
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<tr>
<td>Density (7)</td>
<td>Lighting (4)</td>
</tr>
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<td>Connectivity (6)</td>
<td>Seating (4)</td>
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<tr>
<td>Accessibility (5)</td>
<td>Signage (4)</td>
</tr>
<tr>
<td>Crime (4)</td>
<td>Building Front porches (3)</td>
</tr>
<tr>
<td>Street pattern (2)</td>
<td>Public Art (3)</td>
</tr>
<tr>
<td>Motor vehicle volume and speed (2)</td>
<td>Microclimate (3)</td>
</tr>
<tr>
<td>Public open space (1)</td>
<td>Street furniture (3)</td>
</tr>
<tr>
<td>Proximity (1)</td>
<td>Terrain and slope (3)</td>
</tr>
<tr>
<td>Strengths of centers (1)</td>
<td>On-street parking (2)</td>
</tr>
<tr>
<td>Block size (1)</td>
<td>Visual complexity (3)</td>
</tr>
<tr>
<td>Presence of sidewalk and lateral separation (1)</td>
<td>Buffers (2)</td>
</tr>
<tr>
<td>Number of blocks (1)</td>
<td>Noise (2)</td>
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<td>Number of intersections (1)</td>
<td>ADA (2)</td>
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<td></td>
<td>Sidewalk condition (2)</td>
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<td>Safety (2)</td>
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<td>Windows facing the street (1)</td>
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<td>Overhead structure (1)</td>
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<td></td>
<td>Food (1)</td>
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</table>

3.2.3.1 Walkthrough Survey

Lynch and Rivkin (1959) conducted an experiment on the streets of Boston to learn what an ordinary individual perceives in the landscape. For the purposes of the experiment, a group of random citizens was chosen. An interviewer took a short walk with
an interviewee along a selected block in Boston. The survey method used for this research incorporated the idea of walking with the interviewee along the Main Street in downtown Fort Worth to note their observations and comments. This research also used similar survey techniques with a group of adults who have design background (either bachelor’s or master’s programs in architecture, landscape architecture, or urban planning) and a group of adults who have no design background. Participants are asked to walkthrough three segments of Main Street and to answer the survey questions. The researcher makes an appointment with each participant and meets them on Main Street, Fort Worth at a previously determined location. Individuals or small groups are followed by the researcher if they are not familiar with downtown Fort Worth. Participants get survey questionnaire sheets and they fill the survey questions while they are walking through Main Street. The survey questions are about how they feel about environmental variables that affect their walking experience. The participants answered questions based on their observations of the Main Street and on their design knowledge.

Convenient sampling methods are used to recruit participants in this research. Snowball sampling technique is utilized to recruit participants primarily from the student body from area colleges (such as UTA, TCU). The researcher also reached out to potential candidates who work in downtown Fort Worth offices. Recruitment for the study is done primarily in person, via email and/or by phone. Every participant had to be eighteen years or older to be in compliance with the Internal Review Board (IRB) at the University of Texas at Arlington (See Appendix B for IRB Approval). The student group was recruited using personal contacts. No course credits or incentives were given for participation in the survey (See Appendix B for IRB Approval Letter & Appendix C for Informed Consent Document).
Appointments were set with the students and professionals at their convenience. Each participant was asked to arrive at Fort Worth Convention Center at the scheduled time. Each received a three-page survey and oral instructions. All participants were asked to walk the three segments of the Main Street and provide answers on the survey questionnaire.

Figure 3.1 Walkthrough Survey Map
The survey is a combination of close-ended and open-ended questions. Close-ended questions allow for comparisons of specific answers by giving only certain choices from which to pick (Peterson, 2000). The survey questionnaire consists of two sections: Section A asks demographic questions. Section B questions are rated using a modified Likert scale, a widely used rating scale, named after developer Rensis Likert (Peterson, 2000). The original Likert scale has five categories consisting of two parts: a declarative statement and a list of response categories. The response categories used for this survey are: strongly disagree, disagree, neutral, agree, and strongly agree. The survey was designed to determine the users’ perspectives of each micro-scale environmental variables in creating a successful walking experience for pedestrians. The micro-scale environmental variables were identified from the previous literature which has been collected and organized in the matrix in the last chapter.

3.2.3.2 Passive Observation

Most of the evidence on the association between environmental variables and walking activity has been collected using self-observation or interviews in cross sectional studies. A systematic observation of the physical environment including presence and qualities of features (e.g., number and quality of public spaces, sidewalk quality) hypothesized to affect walking activity (Brownson et al., 2009). One of the primary methods to evaluate walkability is to study the quality of paths. With that aim, passive observation is used to identify and document micro-scale environmental variables of the Main Street and determine their functionality in context of the downtown Fort Worth.

Passive observation of each segment began by walking the linear distance of the Main Street and documenting its micro-scale environmental variables. Main Street was
recorded photographically to highlight both positive and negative issues contributing to the experience of walkability and accessibility. Three spots were chosen in each segment and observed for these elements and their usage. As the micro-scale environmental variables were identified, their functional descriptions were documented in the matrix. These variables were recorded for their quantities. A detailed description of the variables was noted with systematic site visits. The data collected from passive observation was charted using spreadsheets.

Data collection took place on weekdays as well as on weekends. Observations were recorded mostly during the mornings, afternoons, and early evenings in March. The main tools used in the research process were detailed micro-scale environmental variables matrix and a digital camera. Field notes that were made while observing Main Street, and its users were charted (see Appendix A).

3.2.3.3 Archival and Secondary Data Review

Geographic Information Systems (GIS) is one of the methods to objectively measure features of the built environment that may influence physical activity. GIS data provides an opportunity for researchers to construct measures of environmental attributes and to develop indices of walkability for cities, regions or local communities (Leslie et al., 2005). Literature review from last chapter indicates that many macro-scale environmental variables of the built environment are associated with walkability. These can be measured and categorized by using GIS technology. The walkability research to be used in this study is comprised of physical characteristics that have previously been identified as key macro-scale environmental variables in transportation and planning literature. Study archival and secondary data provide better understanding of the district level
walkability and accessibility in downtown Fort Worth. This data information is usually obtained from city authorities and census databases.

3.2.4 Data Triangulation

The data findings from the three research methods were analyzed using data triangulation. Triangulation is defined as an “attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint” (Cohen and Manion, 1986). Data triangulation is used to indicate that more than two methods are used in a study with a view to double- or triple-check results. This also is called “cross examination”. Researchers can be more confident with a result if different methods lead to the same result. By using three methods to get the answer to one question, the hope is that two of the three methods may produce similar answers; if three clashing answers are produced, the investigator knows that the question needs to be reframed, methods reconsidered, or both. Triangulation is a powerful technique that facilitates the researcher in validating data through cross-verification from more than two sources (Cohen and Manion, 1986).

The four basic types of triangulation are data triangulation, investigator triangulation, theory triangulation, and methodological triangulation (Denzin, 1978). Data triangulation is commonly used and involves time, space, and persons. The data collected from the three data collection methods adopted in this research is triangulated using data triangulation. The conclusions of this research are based on the results of the three methods.
3.3 Bias and Errors

There are some sources of variation inherent in public opinion studies, such as question wording, context effects that can introduce error or bias. Walkthrough surveys conducted in different dates so the weather and temperature was different, it may also influence the result. Some of the archival and secondary data are not up to date, so it may cause inaccuracy of findings. Users’ perception plays a significant role in walkthrough survey, different group of participant may cause different result.

3.4 Chapter Summary

This research adopted three data collection methods: walkthrough surveys, passive observation, and archival and secondary data to assess environmental variables impacting walkability within the context of downtown Fort Worth. The data obtained from these three methods are first analyzed independently and then triangulated using the data triangulation method. 9 blocks of Main Street has been chosen for this study and they were divided into three segments for data collection purposes. A concise matrix of micro-scale environmental variables derived from literature review was used a base for the passive observation and survey while the matrix of macro-scale environmental variables was used a base for GIS analysis. Walkthrough survey of this research is for random citizens and design students. Passive observation was conducted at Main Street on weekdays during daylight hours. Main Street was recorded photographically during passive observation. Data collected on the environmental variables was charted using spreadsheets. The findings and analyses of the research are explained in Chapter 4, with the conclusions in Chapter 5.
Chapter 4
Analysis and Findings

4.1 Introduction

In this chapter, an overview of the research methods and findings from the first section of the survey are demonstrated. The analysis of the walkability data is described with respect to the individual environmental variables. An overview of the findings is given, and the chapter ends with a summary.

4.2 Overview of Research Methods

Three research methods have been used in this research: walkthrough surveys, passive observation, and review of archival and secondary data. Walkthrough surveys were conducted using a three-page survey questionnaire and an introductory cover sheet describing the research (see Appendix A). Pretesting was done with a group of individuals—friends having a background in architecture, landscape architecture, and urban design—who are similar to the targeted study participants. The pretest group said the survey questions were easy to answer, relevant to the topic, and took less than twenty minutes to complete along with the 0.5-mile walk. Therefore, the pretest indicated that the survey questions were relevant to walkability of urban spaces (Peterson, 2000).

Analysis from the surveys yields specific results that can be charted, so the data collected was compiled into spreadsheets. Passive observations were made during daylight hours on weekdays and weekends in March 2015. Data from the archival and secondary data were also analyzed to generate findings.

Finally, data triangulation method was used to analyze the findings from these three research methods. Design elements and the respective findings from the three methods are described in the Walkability Data Analysis section of this chapter.
4.3 Survey and Observation Findings

A four-part walkthrough survey is created for each three block segment of Main Street identified in this research. As it is highlighted earlier first part of the questionnaire focused on the profile of the participants. The second part composed of 20 Likert scale questions measuring effect of environmental variables on walkability. The third part included open-ended questions on walkability (See Appendix A).

Walkthrough surveys are conducted within a one-month period in the spring of 2015. Surveys are conducted based on the availability of the participants, so there were different samples from weekdays and weekends as well as morning and afternoon. There are five profile questions in Part 1 of the questionnaire and their findings are elaborated here. Out of the total survey invitations sent to potential survey participants, a positive response rate of 72% was obtained. A total of 25 users took the walkthrough survey. 80% of the survey participants were students, while 20% of survey participants were not students. 70% of the survey participants has design education background (landscape architecture, architecture or urban planning), while 30% of survey participants have no design background. 65% of the survey participants were males and 35% were females. The survey participants were from age group 18-24 (30%), 25-34 (55%), 35-44(15%). There were no respondents over 45 years old in this research.

Findings from the walkthrough surveys, passive observation, and the review of archival and secondary data are combined and presented here for each environmental variable. More specifically, findings from walkthrough surveys and passive observation are demonstrated the micro-scale environmental variables and findings from archival and secondary data are demonstrated macro-scale environmental variables of Main Street Fort Worth.
The walkthrough survey asked participants to rate statements on environmental variables (Part 2) based on a modified Likert scale for each of the three segments. As it is highlighted in the previous chapters, the 20 statements in this part are structured based on the most common environmental variables documented in the literature review. The survey included five categories Likert scale options: strongly disagree, disagree, neutral, agree and strongly agree. After the initial analysis, these 5 categories were reduced to 3: disagree, neutral, and agree to simplify the review of the results.

4.3.1 Fenestration

Fenestration in this research has been defined as the arrangement, proportioning and design of windows and doors as well as the openings that they provide from the sidewalks. The survey respondents are asked whether fenestration in this segment provided good walking environment. The bar chart below (Figure 4.1) displays the role of fenestration along the façade that provides a good walking experience for pedestrians. According to the survey findings, a maximum number of participants in segment 1 (Convention Center/9th Street to 6th Street) disagreed with the statement about the fenestration in that segment. On the contrary, a majority of participants appreciated the fenestration in segment 2 (6th Street to 4th Street).
Fenestration along Main Street was observed by researcher. In segment 1, there are a few restaurants with well-designed fenestration which provide people visual interaction while looking outside or looking inside of restaurants. However, the fenestration of the travel agency and parking garage is dull and drab in this segment, and is not interesting enough to enhance the pedestrian walking experience. Fenestration along segment 2 is found to be better than segment 1. Researcher attributes this to the physical qualities of this segment as well as diversity in design and color choices. Researcher’s observation revealed that segment 3 (4th Street to Weatherford Street/Tarrant County Courthouse) a number of retail, businesses and museums have different sizes and shapes of windows, which make the façade and fenestration interesting for pedestrians. The Worthington Renaissance Fort Worth Hotel building is located in between First Street and Second Street of segment 3. This building has a few blank façades along this segment (see Figure 4.2), which deterring pedestrian walking experience.
4.3.2 Overhead Structures

Participants’ response to the overhead structures effecting walkability is varied for each segment of Main Street. According to personal observation as well as survey findings, segment 2 and segment 3 have adequate overhead structures providing adequate weather protection and provide a good walking experience (see Figure 4.3).
The survey respondents are asked whether overhead structure in this segment provided good walking environment. The overhead structures in segment 1 are considered inadequate for weather protection or do not contribute to a good walking experience, according to participants. There are two to six overhead structures for each segment of Main Street Fort Worth. Figure 4.4 displays an overhead structure at segment 1, which has poor design and condition. Figure 4.5 shows the canopy in Sundance Square at segment 2, which is well-designed and is in good condition. This canopy provides some protection from the weather and provides a good walking experience for the pedestrians.
4.3.3 The scale and proportion of the buildings to the streets

The scale and proportion of the buildings to the streets vary for each segment of the Main Street Fort Worth. About 80% of the survey participants agreed that the scale
and proportion of buildings in segment 2 creates a good walking experience for pedestrians (see Figure 4.6). On the contrary, only 50% agreed (20% disagreed and 30% were neutral) about the scale and proportion of the buildings on the streets in segment 1. In segment 1, the number of high-rise buildings (more than 7 floors) is much more than low-rise buildings (less than 3 floors) (see Figure 4.7). However, buildings in segment 2 and 3 are dominated by 3 to 5 floor buildings with retail components in the first level, which seemed to provide more walkable environment for pedestrians (see Figure 4.8).

![Figure 4.6 Survey result of the scale and proportion of buildings to streets](image)

<table>
<thead>
<tr>
<th></th>
<th>Segment1</th>
<th>Segment2</th>
<th>Segment3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>20%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Neutral</td>
<td>30%</td>
<td>15%</td>
<td>40%</td>
</tr>
<tr>
<td>Agree</td>
<td>50%</td>
<td>80%</td>
<td>55%</td>
</tr>
</tbody>
</table>
Figure 4.7 High-rise buildings in segment 1

Figure 4.8 Low-rise buildings in segment 3
4.3.4 Presence of retail

The survey respondents are asked whether the presence of retail in this segment provided good walking environment. A majority of the survey participants agreed with the survey statement in regards to the presence of retail. The participants observed that there is almost no retail along the segment 1 of Main Street Fort Worth. The most retail and businesses are located in segment 2 and segment 3. The survey findings are reflected in the Figure 4.9, below.

![Survey result of presence of retail](image)

Figure 4.9 Survey result of presence of retail

Researcher observed that the retail stores in segment 2 and segment 3 are mainly souvenir shops, snack shops, cigar and wine shops, jewelry and watch shops, etc. Most of the retail shops are well designed and have window displays, which seem to enhance pedestrian's walking experience (See Figure 4.10).
4.3.5 Presence of restaurant with outdoor seating

The number of restaurants with outdoor seating is almost equal in three segments of Main Streets. Segment 2 has five restaurants with outdoor seating that faces the Main Street. The survey respondents are asked whether the presence of restaurant with outdoor seating in this segment provided good walking environment. Most of the survey participants like the outdoor seating at these restaurants. A few participants who work around the downtown area state that they frequent these restaurants. 80% of the
participants felt that the presence of restaurants with outdoor seating creates a lively atmosphere for pedestrians to walk in segment 2 and segment 3 (see Figure 4.12). 25% of participants disagreed the statement regarding restaurant with outdoor seating in segment 1, with the presence of just three restaurants.

![Figure 4.11 Survey result of presence of restaurant with outdoor seating](image)

<table>
<thead>
<tr>
<th></th>
<th>Segment1</th>
<th>Segment2</th>
<th>Segment3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>25%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Neutral</td>
<td>10%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Agree</td>
<td>65%</td>
<td>80%</td>
<td>80%</td>
</tr>
</tbody>
</table>

![Figure 4.12 Restaurant with outdoor seating in segment 1](image)

The passive observation findings further strengthen the survey results on the presence of restaurants. Segment 1 has three popular restaurants: Del Frisco's...
Steakhouse, Little Red Wasp, Ruth's Chris Steak House and Six 10 Grille. Segment 2 has three restaurants. All of these restaurants have outdoor seating, but the presence of awnings makes them more inviting. Further, they seem to be scaled appropriately for the narrow pathway leading to their access (see Figure 4.13).

Figure 4.13 Restaurant with outdoor seating in segment 2

4.3.6 Signage

The survey respondents are asked whether signage in this segment provided good walking environment. The survey findings reveals that all three segments of the Main Street have the necessary signage (see Figure 4.14). It was observed that there was enough signage at all segments of Main Street studied in this research. Informational signage along Main Street consists of historical markers such as the ones displayed in Figure 4.15. There is a LED signage in Sundance Square in segment 2 provides the current event information in downtown area and the location of restaurants and shops (see Figure 4.16). Other type of signage on Main Street includes the signage of heritage
trails in segment 3, the 3D map shows the location of historical buildings (see Figure 4.17).

Figure 4.14 Survey result of signage

Figure 4.15 Informational signage along Main Street
Figure 4.16 LED signage in Sundance Square in segment 2

Figure 4.17 Signage of heritage trails in segment 3
4.3.7 Seating

The survey respondents are asked whether the seating in this segment provided good walking environment. The survey findings showed that a majority of the participants agreed on the presence of sufficient seating in segment 2 and segment 3. (see Figure 4.18). However, only 40% of participants agreed on the presence of sufficient seating in segment 1. Also, a few participants noted that the seats are uneven distributed in some segments, such as in segments 2, all the seating are located in Sundance Square while the rest area in this segment has no resting place.

![Figure 4.18 Survey result of seating](image)

It was observed that three segments on Main Street have some seating spaces to accommodate pedestrians. However, some blocks are lacking of seating and deteriorating the walkability of the Main Street, people have to sit on the planting containers (see Figure 4.19). Exceptions to this were the Sundance Square in segment 2, where extra seating is available (see Figure 4.20).
One of the issues related to seating, observed at segment 1, was the location of seating. People seemed dislike the location of the seating too close to the trash cans (See Figure 4.21). There were few different types of seating in each segment on Main
Street. Some of them were comfortable and popular among the users, but some seemed old and had poor condition so people did not want to use them.

![Figure 4.21 On street seating in segment 2](image)

4.3.8 Lighting

The survey findings, as demonstrated in Figure 4.22 below, clearly indicate that a majority of the participants agreed on the adequacy of lighting in all segments of the Main Street studied in this research. Though all the surveys were conducted in the daylight hours, the survey participants who have design background could use their expertise and knowledge to understand the equipment and street furniture associated with this evaluation.
Passive observation showed that the lighting in all the three segments of Main Street is adequate for walking after sunset. Each block has six street lights (See Figure 4.23) and street lights at most segments are located at a distance of 35 feet to 40 feet from each other. Most of the survey participants who had visited Main Street after daylight hours also felt that Main Street is adequately lit at night.
4.3.9 Street trees

Survey findings show that only 25% of the participants agree that the street trees in the segment 1 provides a good walking experience for pedestrians (see Figure 4.24). Some participants note that the first block of this segment has no street tree and that it has too much open space. 80% of the participants agreed that the street trees in segment 2 provides a good walking experience, but few statement indicate that street tree in this segment are not big enough to provide shade. For segment 3, 75% of the people agree that the street trees here provided a good walking experience.
Passive observation findings also supported the survey findings. It was observed that segment 2 and segment 3 have bigger and better street trees compared to segment 1. The first block of segment 1 looks very open without the presence of any street trees. Also, some street trees in this segment are not properly maintained, because as the tree trunk expands, the grate can choke it (see Figure 4.25). As stated earlier, the street trees in segment 2 and segment 3 are well maintained and have bigger size to provide shade to pedestrian (see Figure 4.26). Such maintenance were issues found to be detrimental for the walking experience in this segment.
Figure 4.25 Tree grate in segment 1

Figure 4.26 Street trees in segment 3
4.3.10 Greenery

Greenery in the urban environment include different type of vegetation near the buildings or street such as green belts, shrubs, ornamental flowers, etc. The survey respondents are asked whether greenery in this segment provided good walking environment. Figure 4.27 shows that the majority of the survey participants agreed about the survey statement on greenery. The participants commented that the condition of greenery on Main Streets is varied, and that the greenery in segment 3 is the best within all segments. 20% of participants blamed the choice of vegetation for not providing balanced greenery in segment 1.

![Survey result of greenery](image)

Participants also suggest that more followers would improve the overall greenery in this segment. Figure 4.28 shows the comparison of greenery in three segments.
Passive observation also showed that the greenery in segment 3 is pleasant and well maintained. As stated earlier, the greenery in segment 1 is bare and not well maintained. Some of the survey participants felt they did not enjoy walking in segment 1 due to the lack of greenery. However, the greenery in segment 2 shows better conditions than segment 2, since there are more vegetation types and color difference. Segment 3 has the most diverse greenery and well maintained landscape, which creates a good walking atmosphere for pedestrians. People seem to enjoy the greenery in segment 3.

4.3.11 Curb-cuts, ramps, and rails

According to the survey findings, 75% of participants agreed to the efficient designs of the curb cuts and ramps and found them to adhere to ADA standards in each segment and it also promotes walkability (see Figure 4.28).
Passive observation showed that one ramp (Figure 4.29) is provided at each green and open space in segment 1. Curb ramps, wherever necessary, are provided according to the ADA standards in all segments. One of the survey participants said ramps and curb ramps were present wherever required (see Figure 4.30). The participant said that he was extremely happy with the accessibility throughout the Main Street.
Figure 4.29 Ramp to green space in segment 1

Figure 4.30 Curb-cut in segment 2
4.3.12 Pavement

The survey respondents are asked whether pavement this segment provided good walking environment. The survey findings on pavement on Main Street shows that the majority of the survey participants agreed about the survey statement on pavement. As seen from the charts below, a majority of the participants at all three segments of Main Street agreed that the pavement is efficient for walking.

![Survey result of pavement](image)

The pavement material on Main Street in almost all sections is red brick (new or old), which matches most of the historic buildings in the downtown area. Figure 4.32 shows the pavement material at segment 1. Some decorative pavers, such as the one shown in Figure 4.33, are seen around Sundance Square in segment 2. Observations revealed that the pavement is well maintained throughout the 10 block segment of Main Street studied in this research.
Figure 4.32 Pedestrian pavement in segment 1

Figure 4.33 Pavement in Sundance Square Plaza in segment 2
4.3.13 The dimension of sidewalk

![Survey result of the dimension of sidewalk](image)

A majority of the survey participants agreed to the survey statement on the dimension of sidewalk. The passive observation showed that there were wide enough spaces (10'-15') for pedestrian to walk in the sidewalk. The survey findings are reflected in the Figure 4.34, above. Passive observation showed most outdoor restaurants having planter boxes and fences to define the edges of sidewalk, it seems to ease walking experience. Observation revealed that no major furniture and signage intrusion existed in the sidewalks as well.

4.3.14 Safety

According to the survey findings, more than 75% of participants agreed to the statement about safety in each segment of the Main Street studied in this research (see Figure 4.28). It is important to remember here that survey is conducted in daytime.
Passive observation showed the landscape buffer on Main Street created a good walking environment for pedestrian and most them feel safe walking in each segment. It was also observed there were homeless people in segment 1.

4.3.15 The speed or volume of vehicles

The survey respondents are asked whether the speed or volume of vehicles negatively influences walking experience in this segment. The survey findings showed that a majority of the participants disagreed on the statement about the speed or volume of vehicles. (see Figure 4.37). Some participants indicated that vehicles traffic in downtown area is too much and they suggested vehicles should slow down (see Figure 4.36).
4.3.16 Noise

The survey respondents are asked whether the noise negatively influences walking experience in this segment. The noise level varies for each segment of Main Street. About 55% of the survey participants agreed that the noise does not affect their walking activity in segment 1 (see Figure 4.46). On the contrary, only 30% and 35% of survey participants agreed about noise in segment 1 and segment 3 does not affect their
walking activity, because Ninth Street and Weatherford Street have more traffic and make more noise in these two segments.

![Survey result of noise](image_url)

**Figure 4.38 Survey result of noise**

### 4.3.17 People

The survey respondents are asked whether the presence of people positively influences walking experience in this segment. A majority of survey participants agreed that the presence of people in the segment 2 and segment 3 creates a lively atmosphere for other pedestrians along the Main Street. However, the survey participants did not feel the same about segment 1. For various reasons, segment 1 had less people than other segments at most times, which is reflected in the survey findings (see Figure 4.39).
Figure 4.39 Survey result of people

The passive observation findings were similar to the survey results: people were seen in segment 2, especially in Sundance Square, and segment 3 at all times. Out of these two segments, segment 2 had the maximum number of people at all times during the passive observation (see Figure 4.40). The presence of retail, business, restaurants and pubs in this segment have made this segment the most used. Large populations congregate in Sundance Square Plaza during most times of day due to the presence of open space, water feature, ample seating with or without canopy, and many restaurants.
4.3.18 Art work

Seen from the survey findings below, survey participants found the art work on Main Street contributed to a good walking environment. The majority of participants at all segments noted this. Art work along segment 1 is located at the first block (see Figure 4.42). This is a traditional sculpture with memorial wall and seating around. Thirty percent of participants noted that the inappropriate location of the artwork does no good to enhance the pedestrian walking experience along the segment.
Eighty-five percent of the survey participants appreciated the art work in segment 2. They remarked that the painting on the wall made the space memorable (see Figure 4.43). The passive observation findings echoed these survey results.
Figure 4.43 Art work in segment 2

Figure 4.44 shows a piece of art work in segment 3. The artwork is a sleeping panther sculpture located in the green space. However, survey results show that the art work is enjoyed only when people walk into the green space of segment 3, because this art work is small and hiding under some trees. Passive observation shows that people seem to ignore this art work when they passing it.

Figure 4.44 Art work in segment 3

Overall, the participants commented that the art work in the Main Street is scarce. Only few art work, and they are invisible due to the size or surrounding environment.
4.3.19 Historical characteristics

The survey respondents are asked whether historical characteristics this segment provided good walking environment. A majority of the survey participants agreed to the survey statement on historical characteristics (see Figure 4.45). Most historical buildings on Main Street are well protected and have many historical characteristics.

![Figure 4.45 Survey result of historical characteristics](image)

Historical characteristics are not only found in buildings, but also also exist as signage, sculpture, etc. All of these historical characteristics shows cultural aspect of Main Street and creates a lively walkable environment for pedestrian.
Figure 4.46 Historical building in segment 1

Figure 4.47 Historical building in segment 3
4.3.20 Overall aesthetic quality

Survey findings show that more than 90% of the participants agreed that the overall aesthetics quality provides a good walking experience for pedestrians in segment 2 and segment 3 (see Figure 4.48). For segment 1, 60% of the people agree that the overall aesthetics quality here provided a good walking experience. 10% disagreed with it because they felt that this segment was visually boring. Participants also suggest that by adding street furniture, the overall aesthetics quality in this segment would improve.

It was also observed during passive observation that segment 2 and segment 3 had higher aesthetics quality than segment 1. The researcher attributes higher aesthetic quality to overall visual quality, art works, as well as maintenance and upkeep of not only landscape but also historic buildings. A few facilities that require maintenance were observed in segment 1.
4.4 Analysis of Archival and Secondary Data

Findings from the walkthrough survey and passive observation have already been discussed in the previous section. As is highlighted earlier these environmental variables are defined as micro-scale environmental variables. After thorough review it is also realized that these variables have significance in the contextual level (district level). In the following section, macro-scale environmental variables summarized from literature have been studied by reviewing and analyzing archival and secondary data. Based on the availability of data those macro-scale environmental variables that are considered in this research are: sidewalk connectivity, land use, crime, bike routes.

4.4.1 Sidewalk connectivity

Due to the small block size and high sidewalk connectivity, downtown Fort Worth always being considered a walkable downtown. Figure 4.49 shows each block in downtown Fort Worth is about 200-250 feet and all are well-connected.
Figure 4.49 Sidewalk connectivity
4.4.2 Land use

Land use in downtown Fort Worth is well-mixed; pedestrians can easily walk from one part to another. Parking is mostly located in the east part of Main Street, only two to three blocks away. So, pedestrians can park their cars in a parking lot and enjoy walking in downtown Fort Worth.
4.4.3 Crime

From Figure 4.51, most crime happened in segment 2 of Main Street in Sundance Square area, courthouse area, and transportation hub area.
4.4.4 Bike route

Figure 4.52 shows the bike routes in downtown Fort Worth and the locations of bike racks. Even though there is no bike route on Main Street, a few people were observed riding bikes by researcher.
4.5 Summary Findings

A total of twenty-five participants took the walkability walkthrough survey on Main Street Fort Worth. Out of these twenty participants, 65% were males and 35% were females. About 80% of the survey participants were students, while the remaining 35% was distributed among scientist (10%), social worker (5%), and engineer (5%).

The survey findings demonstrated a list of environmental variables that are considered crucial for the walkability of Main Street in downtown Fort Worth. The survey responses on the most-liked pedestrian space varied for almost each participant. The commonality among these responses was the recognizable feature of these spaces. Most pedestrian spaces were appreciated for their proximity to good restaurants.

The analysis of the walkability data demonstrated the findings for individual environmental variables on Main Street. These findings from the three research methods are shown below. The archival and secondary data were studied for walkability issues relative to sidewalk, land use, crime, and bike routes on Main Street.

Fenestration: It was inferred from the two research methods that fenestration impacts the walking experience of pedestrians. The fenestration along segment 2 is appreciated for its brickwork and window placements. The presence of first-floor restaurants with outdoor seating enhances the pedestrian experience. However, blank facades in segment 3 were criticized by all participants.

Overhead structures: Overhead structures in most segments provide adequate weather protection, according to the survey findings. Canopies in Sundance Square Plaza in segment 2 were appreciated by most participants.

Scale and proportion of the buildings to the streets: The scale and proportion of the buildings varied for each segment. Most buildings in segment 3 were 2 to 4 stories high with brick facades and ample windows; most participants favored the scale and
proportion of these buildings. High-rise office buildings are features of segment 1, survey participants criticized the scale and proportion of these buildings.

Presence of retail: Most participants noted that retail on Main Street contributed to a good walking environment for walking activity. Participants also mentioned that the presence of store windows facing the sidewalk would enhance their walking experience. There is almost no retail along the segment 1 of Main Street Fort Worth. Most retail shops are located in segment 2 and segment 3.

Presence of restaurants with outdoor seating: Most of the survey participants like the outdoor seating at these restaurants. A few participants who work around the downtown area state that they frequent these restaurants. 80% of the participants felt that the presence of restaurants with outdoor seating creates a lively atmosphere for pedestrians to walk in segment 1 and segment 2.

Signage: The survey results as well as passive observation showed that there is enough signage throughout Main Street. The signage is also aptly located.

Seating: Findings from the survey and passive observation showed that there is adequate seating in segment 2. However, some blocks lack seating and are deteriorating the walkability of Main Street, making people sit on planting containers. Sundance Square Plaza has enough seating, most participants appreciated it.

Lighting: Lighting is adequately provided on Main Street, as inferred from the survey findings and passive observation.

Street trees: Segment 2 and segment 3 have bigger and better street trees compared to segment 1. The first block of segment 1 looks very open without the presence of any street trees. Also, some street trees in this segment are not properly maintained either, while the street trees in segment 2 and segment 3 were well maintained and had bigger size to provide shade to pedestrian.
Greenery: Survey results and passive observations showed that the lush greenery in segment 3 creates a good walking experience for pedestrians, while the greenery in segment 1 does not benefit the walking experience.

Curb-cuts, ramps and rails: There are adequate curb cuts and ramps, as inferred by the surveys and passive observation.

Pavement: It was demonstrated through the survey findings and passive observation that the pavement is efficient for walking and also for wheelchair navigation. Mainly red brick or concrete pavers are observed throughout Main Street.

Dimension of the sidewalk: A majority of the survey participants agreed to the survey statement on the dimension of the sidewalk. The passive observation showed that there were wide enough spaces for pedestrians to walk on the sidewalk.

Safety: The survey results and passive observation showed the landscape buffer on Main Street created a good walking environment for pedestrians and most them feel safe walking in each segment.

The speed or volume of vehicles: The survey findings and observation showed that a majority of the participants disagreed on the statement about the speed or volume of vehicles. Some participants indicated that there is too much vehicle traffic in downtown and they suggested that vehicles slow down.

Noise: The noise is varied for each segment of Main Street. Most participants noted segment 1 and segment 3 were much nosier than segment 2, because 9th Street and Weatherford Street have more traffic and make more noise in these two segments.

People: Survey participants felt that the presence of people on segment 2 and segment 3 attracted other pedestrians to these places.

Art work: The survey results showed that the art work in segment 2 was appreciated by most participants, while the participants did not enjoy the art work in
segment 1. The most appreciated art work is well located to be seen and enjoyed by pedestrians. On the contrary, the criticized art work is wrongly located where they cannot be seen easily.

Historical characteristics: A majority of the survey participants appreciated the historical characteristics on Main Street. Most historical buildings on Main Street are well protected and have many historical characteristic.

Overall aesthetic quality: In segment 1, 60% of the people agreed that the overall aesthetics quality here provided a good walking experience. 10% disagreed with it because they felt visually boring in this segment. Participants also suggested that by adding street furniture the overall aesthetics quality of this segment would improve.

The overview of findings for each of the three segments, are shown as charts below (Figure 4.53). And the overall findings for the environmental variables on Main Street are shown in next section.
Figure 4.53 Overview of environmental variables findings by segment
4.6 Overall Walkability Findings of Main Street

Based on the research findings, the overall sense of walkability seems to be positive in regards to the downtown section of Main Street, Fort Worth studied in this research. These findings came from the walkthrough surveys that were given to participants and passive observation by the researcher. The presence of people positively influencing the walking experience garnered the highest rating in the agreeability measurement of the survey. This indicates that the presence of people on Main Street helps to make the walkability a better experience. Also, survey participants appreciated the pavement and the dimension of sidewalk. Both of these environmental variables provide a good walking environment on Main Street. It was demonstrated through the survey findings and passive observation that the pavement was efficient for walking; the curb-cuts, ramps, and rails seems to meet ADA accessibility standards for navigation, as well. The passive observation also showed that there were wide enough spaces for pedestrians to walk on the sidewalk on Main Street. Two other environmental variables that participants found agreeable were historical characteristics and aesthetic quality. Survey findings showed that a majority of the participants agreed that the historical characteristics and the overall aesthetic quality enhanced walkability in the downtown portion of Main Street. However, there are three environmental variables that had the lowest ratings in survey results: noise, fenestration and the speed or volume of vehicles. Those environmental variables decrease walkability on Main Street and need to be improved. The overall findings of the environmental variables on Main Street are shown as charts below (Figure 4.54).
Figure 4.54 Overall findings of environmental variables on Main Street
4.6 Chapter Summary

This chapter on research analysis and findings started with an overview of the research methods. The profile information of the survey participants was displayed first, and then the participants’ perceptions of the urban transit mall were noted. Descriptive statistics and frequencies, bar charts, photographs, and descriptions were used to convey the walkability analysis of Main Street Fort Worth. Under the walkability analysis section, each environmental variable was discussed individually and the findings from the three methods on those environmental variables were noted. Photographs taken during passive observation were used here along with bar charts to explain all the findings. The open-ended question was then discussed with participants’ comments. The conclusions derived from these research findings are demonstrated in Chapter 5.
Chapter 5

Conclusion

5.1 Introduction

After analyzing the data from research findings, this research identifies the key environmental variables that affect walkability of Main Street Fort Worth. This chapter looks at these key environmental variables and demonstrates the value of this research to landscape architects. Topics for future research are suggested.

5.2 Research Summary

The purpose of the study was to evaluate the walkability of Main Street Fort Worth by documenting and analyzing its environmental variables.

This research raised three questions:

- What are the environmental variables that affect walkability?
- How do these environmental variables impact the walking experience of pedestrians in the context of Main Street Fort Worth?
- What are the walkability lessons learned from Main Street Fort Worth?

The objectives of this study were to determine the environmental variables which are most critical to the walkability of Main Street Fort Worth, how these environmental variables impact the walking experience of pedestrians, and to analyze the improvements needed on Main Street Fort Worth to enhance its walkability. Three research methods were used for this study. To achieve these research objectives, a comprehensive design and planning literature review was conducted to determine the crucial environmental variables, which impact the walkability of urban spaces. The methods included walkthrough surveys, passive observations, and review of archival and secondary data. An environmental variables matrix created from the literature review was analyzed and
used to frame Likert scale survey questions. The matrix was also used for identifying variables that were recorded in passive observations on Main Street Fort Worth. The analyses and findings from the three research methods are triangulated using data triangulation to determine the conclusions of this research. The lessons learned from the Main Street case after using these research processes are presented in next section.

5.2.1 What are the environmental variables that affect walkability?

The first research question of this research was: what are the environmental variables that affect walkability? According the literature review, the most common macro-scale environmental variables that affect walkability are: land use, density, connectivity, accessibility, crime, street pattern, proximity, block size, number of block, and number of intersection. The most common micro-scale environmental variables that affect walkability found from literature review are: street trees, lighting, seating, signage, building front porches, public art, microclimate, street furniture, terrain and slope, on-street parking and visual complexity. The environmental variables listed above are used to study the walkability of the downtown portion of the Main Street, Fort Worth.

5.2.2 How do these environmental variables impact the walking experience of pedestrians in the context of Main Street Fort Worth?

The second research question of this research was: how do these environmental variables impact the walking experience of pedestrians in the context of Main Street Fort Worth? After conducted passive observation, walkthrough survey and studied archival and secondary data, each environmental variable was discussed individually and the findings from the three methods on those environmental variables were noted. The research on Main Street Forth Worth illustrated that the selected set of environmental
variables adopted in this research has varying impacts in various segments of the downtown portion of Main Street, Fort Worth. In summary, among the environmental variables reviewed in this research the presence of people positively influencing the walking experience garnered the highest rating in the agreeability measurement. This finding seems to support Whyte’s (1980) earlier finding on the importance of the presence of people in public spaces. The research results also illustrated that the presence of retail, presence of restaurant with outdoor seating, signage, the dimensions of sidewalks, overall aesthetic quality and historical characteristics also enhanced walking experience of pedestrians on Main Street. However, noise, speed or volume of vehicles showed negatively impacted walking experience of pedestrians on Main Street. Respondents also seem to feel not too strongly about the arrangements, proportion and design of windows and doors (fenestration). The research also suggested that seating options seem to be limited in downtown portion of the Main Street.

5.2.3 What are the walkability lessons learned from Main Street Fort Worth?

This research aimed at identifying the environmental variables, which are most critical to the walkability of pedestrians along Main Street Fort Worth. The survey findings along with the passive observation and the review of secondary and archival data seem to reveal five lessons. These lessons include some key environmental variables identified from the findings.

5.2.3.1 Buffer Zone

As pointed out by many previous studies, traffic impact discourages pedestrians walking. A multi-lane street can cause fasting-moving traffic which is not desirable. A street with fewer through-traffic lanes is better than a street with more lanes. Traffic
impacts can be reduced by buffer zones. The width of the buffer zone, which is the space between the edge of the outer traffic lane and edge of the sidewalk, is important. Unlike stationary elements such as lawn strips, on-street parking slows down traffic and provides more customers, pedestrians, and “eyes on the street.” Also, according to Downtown Urban Design District Standards and Guidelines of the City of Fort Worth, ornamental wood may be used as a buffer but wood requires consistent maintenance to retain its aesthetic appeal (City of Fort Worth, 2009). Low-growing shrubs can also provide parking lot screening.

5.2.3.2 Sidewalk Environment

This research was suggestive that three sidewalk elements are more important than others. The basic idea is providing more street trees, brighter lighting, and special pavement to improve walkability. As it is highlighted in Downtown Urban Design District Standards and Guidelines, street trees can be located in the Furnishing Zone (space between traffic zone and pedestrian way) next to the street, within 2 to 3 feet of the curb (City of Fort Worth, 2009). A well-lit street can also improve walkability and this could be achieved in many different ways. More and lower street lightings improve luminosity. Lighting should be designed in a manner to avoid disturbances and glare onto adjacent properties. Pedestrian lights can be located approximately at the mid-point between street trees. Commercial streets are typically well illuminated, because light from the windows is often intense, and helps to fill the gap between streetlights, whose effectiveness drops sharply as one move away from the sources. Special pavements, other than common concrete pavement, may also increase path walkability. Main Street’s special pavements were mostly colored and patterned concrete and brick.
5.2.3.3 Fenestration and Façade

Like the buffer zone dividing the traffic zone and the pedestrian zone, the setback between the sidewalk and buildings is also important. According to Downtown Urban Design District Standards and Guidelines, buildings should face the street or other public spaces with a setback of no more than 5 feet from the back of the sidewalk (City of Fort Worth, 2009). Unlike the buffer zone between the traffic zone and pedestrian zone, less of a barrier between the buildings and sidewalks seems more desirable to provide more visual access from the outside to the inside of the building at the ground level (façade transparency) and more visual access from the inside to the outside space from the second and third stories (upper-level windows). Larger and more transparent windows with lower window sills increase both types of visual access. Garage façades as well as blind façades can be softened with landscaping such as trailing plants or vines, different colors or architectural features. In Main Street, the majority of retail shops have well-designed windows and doorways, which provide a good walking environment for pedestrians.

5.2.3.4 Scale and Enclosure

Some blocks on Main Street have two-to-four story, mixed-use buildings. Survey findings showed that pedestrians prefer to walk in this type of area rather than in a high-rise office area. The ratio of building-to-building distance to building height is important, or more accurately, the building-to-building distance relative to the average building skyline height, which is influenced by vacant lots and surface parking lots. Jacobs(1993) claimed that the ratio between building height and street width is important; the best ratio is 1:3.3, such as a 20-foot building height coupled with a 66-foot building-to-building distance, while 1:2 (or less) gives a strong sense of enclosure, and 1:5 (or more) shows a weak
sense of enclosure (Jacobs, 1993). Also, using overhead structures such as awnings and canopies can help create a human scale as well as improve the image of individual buildings, businesses and the entire streetscape.

5.2.3.5 Building Uses

The research results were also suggestive that walking-conducive commercial uses, such as gift shops and snack shops can be popular uses in places like Main Street Fort Worth. Boutique stores or restaurants with outdoor seating on the first floors of buildings can promote walkability. Although there are hardly any examples of this, residential use on the first floor would be better than non-commercial uses, such as vacant lands, parking lots and industrial uses. Buildings with ground-level commercial space and second- and third floor residential space seem to make sense from a walkability perspective in the case of Main Street Fort Worth.

5.3 Additional Suggestions for Downtown Portion of Main Street

Walkthrough survey and passive observation findings showed that segment 1 has lower walkability than the other two segments. There are some suggestions for segment 1. First, adding street trees in the first block of segment 1. By doing this, traffic zone and green space can be separated effectively. Furthermore, the existing trees and greenery beds were not maintained well in this segment. Second, adding more seating space may be considered in segment 1. Many survey participants stated that seating in this segment is very limited. Third, the scale of the proportion of buildings should be reconsidered, because there are a few high-rise office buildings that are off the human scale and not creating a good walking environment. The store windows should be
enhanced to increase the pedestrian walking experience. Also, segment 1 could do with more art work to improve the overall aesthetic quality.

Segment 2 has higher walkability but fenestration of this segment also needs to be thought of. Also, the addition of artwork and water features would enhance the pedestrian walking experience in this segment. There is a derelict parking lot in this segment that could be removed and possibly transformed into another green space. A pedestrian scale could be achieved in segment 2 by provision of canopies and planters. The tall buildings in this segment create a hindrance to the overall scale and proportion.

Within three segments, segment 3 was most liked by the survey participants. The only suggestion, which came from the findings and analysis, was the appropriate placement of art work. The sleeping panther sculpture in the green space is not visible enough. Addition of art work or water features in this segment would enhance the pedestrian walking experience. The black façades of the Worthington Renaissance hotel in segment 3 could be redesigned or decorated with planters and vines to enhance the pedestrian walking experience.

5.4 Implications for Landscape Architecture

Landscape Architecture is the profession which applies artistic and scientific principles to the research, planning, design, and management of both natural and built environments. The resulting environments shall serve useful, aesthetic, safe and enjoyable purposes (Rogers, 1997). This research illustrates to landscape architects that there are comprehensive sets of environmental variables covered in the scholarly literature that seem to be effective in promoting walkability. It is also realized as a result of this research that different sets of environmental variables can have varying implications depending of the physical context of walkability.
Research also made researcher realize that the relationship between architects, landscape architects, and urban planners is significant in planning, designing and managing streetscapes like Main Street in downtown Fort Worth. In order to achieve a higher quality, walkable environment, a strong dialogue among these professional fields is needed. This research is suggestive of supporting the idea that walkability requires a comprehensive and multi-disciplinary foundation in complex urban environments. Therefore joint classes between the programs of architecture, landscape architecture, and urban planning should be planned in order to execute further urban design projects. The built environments are a result of multiple design professions and the exploration may benefit all design students.

Urban built environments such as the Main Street are designed by a team of architects, landscape architects, planners, urban designers and others. This study attempted to communicate the views of people without a design background as well as a diverse set of design professionals and landscape architects. Although architects, landscape architects and urban designers all have a varied perspective on environmental variables and walkability, it is realized that there is common thread among the disciplines. Understanding these environmental variables helps not only the pedestrian accessibility and enjoyment of Main Street, but also future projects such as promoting urban walkability on Main Street in downtown Fort Worth.

5.5 Future Research

This research concentrated on the impact of environmental variables affecting walkability in the downtown portion of Main Street in Fort Worth. Future research topics are:

1. What are the physiological or cultural factors that may affect walking activity?
2. How are the environmental variables on Main Street in downtown Fort Worth different from other downtown areas such as downtown Dallas?

3. What is the connection between environmental variables and social interaction?

4. What are the implications of macro-scale environmental variables on walkability in the case of downtown Fort Worth?
To Whom It May Concern,

I sincerely request your assistance in completing the attached questionnaire which is a part of my master's thesis for The University of Texas at Arlington, School of Architecture, and Program in Landscape Architecture. The survey is designed to evaluate the walkability of Main Street in downtown Fort Worth.

The Main Street is divided into three segments in this research, each segment has same three blocks and equal distance. The survey requires participants to walkthrough each of the three segments and fills each survey page. A total distance of 0.45 mile needs to be walked for the survey. The first part of questionnaire asks profession background, gender and age information for profile purposes only. The second part of questionnaire includes twenty liker scale questions to ask how much you agree or disagree with a particular statement. The third part of questionnaire includes two open-ended questions and requires your comments.

This survey will take approximately twenty minutes to complete the questionnaire while walking. I assure you that the identity of the respondents will be held in confidence. If you are interested in reading the final thesis, please email me at xitong.li@mavs.uta.edu.

I appreciate your valuable time and help.

Thank you,

Best regards,

Xitong Li
Graduate Student
Program in Landscape Architecture
School of Architecture
The University of Texas Arlington

817-307-5889
xitong.li@mavs.uta.edu
Main Street Survey Questionnaire (Segment 1)

Survey no.:_______

PART 1: PROFILE QUESTIONS

1. Are you a student? Yes ______ No ______

2. What is your education background? Landscape architecture _______ Architecture _______ Urban planning _______ Others, please specify _______ 18-24 _______ 25-34 _______ 35-44 _______ Above 55 _______

3. What is your profession? Landscape architecture _______ Architecture _______ Urban planning _______ Others, please specify _______ 18-24 _______ 25-34 _______ 35-44 _______ Above 55 _______

4. What is your gender? Male _______ Female ________ Not disclosed _______

5. Which age group are you in? 18-24 _______ 25-34 _______ 35-44 _______ Above 55 _______

PART 2: LIKERT SCALE QUESTIONS

Following are Likert Scale questions to study the impact of environmental variables on walking activity in Main Street, Fort Worth. Please circle the number that describes how you agree or disagree with the following statements for segment 1.

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

| 1. The fenestration (the arrangement, proportioning, and design of windows and doors) along the façade provides a good walking environment in this segment. | 1 2 3 4 5 |
| 2. Overhead structures like canopies and awnings create a good walking environment in this segment. | 1 2 3 4 5 |
| 3. The scale and proportion of the buildings in the streets creates a good walking environment in this segment. | 1 2 3 4 5 |
| 4. The presence of retail creates a good walking environment in this segment. | 1 2 3 4 5 |
| 5. The presence of restaurant with outdoor seating creates a good walking environment in this segment. | 1 2 3 4 5 |
| 6. The signage provides a good walking environment in this segment. | 1 2 3 4 5 |
| 7. The lighting provides a good walking environment in this segment. | 1 2 3 4 5 |
| 8. The street trees provide a good walking environment in this segment. | 1 2 3 4 5 |
| 9. The greenery provides a good walking environment in this segment. | 1 2 3 4 5 |
| 10. The curb-cuts, ramps, and rails are well designed to meet ADA (Americans with Disabilities Act) standards and create a good walking environment in this segment. | 1 2 3 4 5 |
| 11. The pavement provides good walking environment in this segment. | 1 2 3 4 5 |
| 12. The dimension of sidewalk creates a good walking environment in this segment. | 1 2 3 4 5 |
| 13. The treescape provides safe walking environment in this segment. | 1 2 3 4 5 |
| 14. The speed or volume of vehicles negatively influences walking experience in this segment. | 1 2 3 4 5 |
| 15. The noise negatively influences walking experience in this segment. | 1 2 3 4 5 |
| 16. The presence of people positively influences walking environment for walking in this segment. | 1 2 3 4 5 |
| 17. The historical characteristics of this segment provide a good walking environment. | 1 2 3 4 5 |
| 18. The overall aesthetics quality of this segment provides a good walking environment. | 1 2 3 4 5 |

PART 3: OPEN-ENDED QUESTIONS

21. Are there any other environmental variables or physical characteristics enhancing/detering your walking experience in this segment? Please explain in detail.

22. Is there anything else you want to share regarding this segment?
Main Street Survey Questionnaire (Segment 2)

Part 2: LIKERT SCALE QUESTIONS

Following are Likert scale questions to study the impact of environmental variables on walking activity in Main Street, Fort Worth. Please circle the number that describes how you agree or disagree with the following statements for segment 2.

1 = Strongly Disagree  2 = Disagree  3 = Neutral  4 = Agree  5 = Strongly Agree

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The fenestration (the arrangement, proportioning, and design of windows and doors) along the façade provides a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Overhead structures (like canopies and awnings) create a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. The scale and proportion of the buildings to the streets creates a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. The presence of retail creates a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. The presence of restaurants with outdoor seating creates a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. The signage provides a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. The lighting provides a good walking environment along this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. The street trees provide a good walking environment along this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. The greenery provides a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. The cutouts, ramps, and rails are well designed to meet ADA (American with Disabilities Act) standards and create a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. The pavement provides good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. The dimension of sidewalk creates a good walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. The street trees provides safe walking environment in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. The speed or volume of vehicles negatively influences walking experience in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. The noise negatively influences walking experience in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. The presence of people positively influences walking experience in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. The presence of all work creates a good walking environment for walking in this segment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. The historical characteristics of this segment provide a good walking environment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. The overall aesthetics quality of this segment provides a good walking environment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Part 3: OPEN-ENDED QUESTIONS

21. Are there any other environmental variables or physical characteristics enhancing/detering your walking experience in this segment? Please explain in detail.

22. Is there anything else you would like to share regarding this segment?
Main Street Survey Questionnaire (Segment 3)

Part 2: LIKERT SCALE QUESTIONS
Followings are Likert scale questions to study the impact of environmental variables on walking activity in Main Street, Fort Worth. Please circle the number that describes how you agree or disagree with the following statements for segment 3.

1 = Strongly Disagree  2 = Disagree  3 = Neutral  4 = Agree  5 = Strongly Agree

<table>
<thead>
<tr>
<th>1. The fenestration (the arrangement, proportioning, and design of windows and doors) along the façade provides a good walking environment in this segment.</th>
<th>1  2  3  4  5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Overhead structures like canopies and awnings create a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>3. The scale and proportion of the buildings to the streets creates a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>4. The presence of retail creates a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>5. The presence of restaurants with outdoor seating creates a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>6. The signage provides a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>7. The seating provides a good walking environment along this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>8. The lighting provides a good walking environment along this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>9. Street trees provide a good walking environment along this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>10. The greenery provides a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>11. The curb cuts, ramps, and rails are well designed to meet ADA (Americans with Disabilities Act) standards and create a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>12. The pavement provides a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>13. The dimension of sidewalk creates a good walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>14. The streetscape provides safe walking environment in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>15. The speed or volume of vehicles negatively influences walking experience in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>16. The noise negatively influences walking experience in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>17. The presence of people positively influences walking experience in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>18. The presence of art work creates a good walking environment for walking in this segment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>19. The historical characteristics of this segment provide a good walking environment.</td>
<td>1  2  3  4  5</td>
</tr>
<tr>
<td>20. The overall aesthetic quality of this segment provides a good walking environment.</td>
<td>1  2  3  4  5</td>
</tr>
</tbody>
</table>

Part 2: OPEN-ENDED QUESTIONS
21. Are there any other environmental variables or physical characteristics enhancing/detering your walking experience in this segment? Please explain in detail.

22. Is there anything else you want to share regarding this segment?
Appendix B

IRB Approval Letter
Institutional Review Board
Notification of Exemption

March 10, 2015

Xitong Li
Dr. Tamer Ozcil
School of Architecture

Protocol Number: 2015-0564

Protocol Title: STUDY OF ENVIRONMENTAL VARIABLES AFFECTING WALKABILITY:
LEARNING FROM MAIN STREET IN DOWNTOWN FORT WORTH

EXEMPTION DETERMINATION

The UT Arlington Institutional Review Board (IRB) Chair, or designee, has reviewed the above referenced study and found that it qualified for exemption under the federal guidelines for the protection of human subjects as referenced at Title 45CFR Part 46.101(b)(2).

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, either directly or through identifiers linked to the subject; and (ii) any disclosure of the human subjects’ responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, or reputation.

You are therefore authorized to begin the research as of March 9, 2015.

Pursuant to Title 45 CFR 46.103(b)(4)(iii), investigators are required to, “promptly report to the IRB any proposed changes in the research activity, and to ensure that such changes in approved research, during the period for which IRB approval has already been given, are not initiated without prior IRB review and approval except when necessary to eliminate apparent immediate hazards to the subject.” Please be advised that as the principal investigator, you are required to report local adverse (unanticipated) events to the Office of Research Administration; Regulatory Services within 24 hours of the occurrence or upon acknowledgement of the occurrence. All investigators and key personnel identified in the protocol must have documented Human Subject Protection (HSP) Training on file with this office. Completion certificates are valid for 2 years from completion date.

The UT Arlington Office of Research Administration; Regulatory Services appreciates your continuing commitment to the protection of human subjects in research. Should you have questions, or need to report completion of study procedures, please contact Alyson Stearns at astearns@uta.edu. You may also contact Regulatory Services at 817-272-3723 or regulatoryservices@uta.edu.
Appendix C

Informed Consent Document
UT Arlington
Informed Consent Document

PRINCIPAL INVESTIGATOR
Xitong Li, Department of Landscape Architecture, xitong.li@mavs.uta.edu

FACULTY ADVISOR
Tamer R. Ozdil, Department of Landscape Architecture, tozdil@uta.edu

TITLE OF PROJECT
Study of Environmental Variables Affecting Walkability: Learning from Main Street in Downtown Fort Worth

INTRODUCTION
You are being asked to participate in a research study about walkability of Main Street, Fort Worth. Your participation is voluntary. Refusal to participate or discontinuing your participation at any time will involve no penalty or loss of benefits to which you are otherwise entitled. Please ask questions if there is anything you do not understand.

PURPOSE
The purpose of this research is to study the impact of the environmental variables (physical characteristics such as trees, seating and sidewalk) on walking activity. The research is to identify the environmental variables and analyze the relationship between walking activity and build environment in Main Street, Fort Worth.

DURATION
Participation in this study will last approximately 20 minutes.
You will be asked to walkthrough three segments of Main Street, each segment will last approximately 7 minutes.

NUMBER OF PARTICIPANTS
The number of anticipated participants in this research study is 100.

PROCEDURES
1. You will read and sign the UT Arlington Informed Consent Document.
2. Walkthrough the segment 1 (Weatherford St to 3rd St) and fill the survey page 1.
3. Walkthrough the segment 2 (3rd St to 6th St) and fill the survey page 2.
4. Walkthrough the segment 3 (6th St to 9th St) and fill the survey page 3.

POSSIBLE BENEFITS
This research can help landscape architects and other design professionals in their future design projects to develop and choose more walkable urban design alternatives by predicting walking activity and providing suggestions on improvements of walkable urban spaces.

POSSIBLE RISKS/DISCOMFORTS
Since this is a walkthrough survey in Main Street, Fort Worth, there are no perceived risks or discomforts for participating in this research study. Should you experience any discomfort please inform the researcher, you have the right to quit any study procedures at any time at no consequence.

COMPENSATION
There is no compensation will be offered for participation in this study.

IRB Approval Date: MAR 09 2015
UT Arlington
Informed Consent Document

ALTERNATIVE PROCEDURES
There are no alternative procedures offered for this study. However, you can elect not to participate in the study or quit at any time at no consequence.

VOLUNTARY PARTICIPATION
Participation in this research study is voluntary. You have the right to decline participation in any or all study procedures or quit at any time at no consequence.

CONFIDENTIALITY
Every attempt will be made to see that your study results are kept confidential. A copy of this signed consent form and all data collected [including transcriptions/tapes if applicable] from this study will be stored in [specify location at UTA] for at least three (3) years after the end of this research. The results of this study may be published and/or presented at meetings without naming you as a participant. Additional research studies could evolve from the information you have provided, but your information will not be linked to you in anyway; it will be anonymous. Although your rights and privacy will be maintained, the Secretary of the Department of Health and Human Services, the UTA Institutional Review Board (IRB), and personnel particular to this research have access to the study records. Your records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above. The IRB at UTA has reviewed and approved this study and the information within this consent form. If in the unlikely event it becomes necessary for the Institutional Review Board to review your research records, the University of Texas at Arlington will protect the confidentiality of those records to the extent permitted by law.

CONTACT FOR QUESTIONS
Questions about this research study may be directed to Xitong Li at 817-307-5889 or xitong.li@mavs.uta.edu and Taner R. Ozdil at tozdil@uta.edu. Any questions you may have about your rights as a research participant or a research-related injury may be directed to the Office of Research Administration; Regulatory Services at 817-272-2105 or regulatoryservices@uta.edu.

As a representative of this study, I have explained the purpose, the procedures, the benefits, and the risks that are involved in this research study:

\[Signature\] 02/19/2015
Signature and printed name of principal investigator or person obtaining consent Date

CONSENT
By signing below, you confirm that you are 18 years of age or older and have read or had this document read to you. You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits, to which you are otherwise entitled.

SIGNATURE OF VOLUNTEER DATE

IRB Approval Date: MAR 09 2015
References


http://fortworthtexas.gov/PlanningandDevelopment/info/default.aspx?id=17890


Gupte, V.N. (2009). Designers’ Perspectives Of Walkability And Accessibility Of Dart’s Downtown Transitway Mall In Dallas, Texas


Conservation Foundation.
Biographical Information

Xitong Li was born in Yangzhou, China. He enrolled in the Program in Landscape Architecture at UT Arlington in August 2012 and is currently a MLA Candidate. He has received bachelor’s degree in Urban Landscape Design from Nanjing Forestry University. He is a recipient of the Enhanced Graduate Teaching Assistantship and is working in this capacity for three years at UT Arlington. He is an enhanced teaching assistant to Dr. Taner R. Özdi̇l, supporting various graduate courses including senior level studios.

His strong work ethic, curiosity, discipline and commitment to Landscape Architecture makes him a dedicated worker. Landscape Architecture is his passion and he is look forward to contributing to this exciting field after graduation.