Spatial Database for Assessing Americans with Disabilities Act (ADA) Compliance in Pedestrian Facilities

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1.0 INTRODUCTION

1.1 Project Background

Pedestrian facilities such as sidewalks play a critical role in transportation by providing public access to essential services such as schools and businesses. Sidewalks provide efficient advantages to keep pedestrians safe when traveling and they need to be designed to meet the needs of all its users. Historically speaking, pedestrian facilities were designed for the average user. In the past, planners and engineers did not maximize their designs for pedestrian safety and access. This causes some pedestrians to be at a dangerous disadvantage due to mobility difficulties brought about by individual mental or physical limitations. For example, pedestrians with a disability such as using a wheelchair would be put at risk when using sidewalks of the past. Such users could not get over curbs to sidewalks causing them to use the roadways, placing them in dangerous situations. People with disabilities that live in areas with these limited designs in accessible pedestrian facilities also face the risk of becoming isolated from the community. Poor designs in pedestrian facilities create barriers between persons with disabilities and the public community. Most people with disabilities do not have access to automobiles and depend upon others or have to walk as a mode of transportation. Unfortunately, these sidewalk designs still exist today and while they meet the needs of an average pedestrian, but limit how useful sidewalks are for more than the average user. Because sidewalks provide fundamental access to services for the public, this issue has gained attention by federal agencies and laws have been developed to raise awareness of these types of disadvantages.

The Americans with Disabilities Act (ADA) was enacted in 1990 by the United States Department of Justice (DOJ) to help raise awareness for people who have disabilities and their safety along pedestrian facilities. The ADA broadly protects the rights of individuals with disabilities in employment, access to State and local government services, places of public accommodation, transportation, and other important areas of American life (ADA Title II Regulations, 2010). Regarding this issue, the ADA requires pedestrian facilities and routes to be accessible to pedestrians with visual, cognitive, mobility, and other types of impairments (Wisconsin Guide to Pedestrian Best Practices, 2010). Organizations that plan, design, and construct pedestrian facilities are held responsible under the ADA to make them the most usable and accessible by pedestrians with disabilities. Following the ADA in 1991, U.S. Architectural and Transportation Barriers Compliance Board (Access Board) developed the ADA Accessibility Guidelines (ADAAG) which created physical standards and access guidelines in the design of pedestrian facilities. The ADA and ADAAG established accessibility as a civil rights issue and emphasizes the importance of creating facilities for pedestrian travel that accommodates all types of pedestrians (Wisconsin Guide to Pedestrian Best Practices, 2010). For example, the ADAAG requires curb ramps with detectable warning fields to be implemented into sidewalk designs to eliminate the curb barrier explained in the earlier wheelchair illustration. There are five titles under the ADA outlining protections in the following areas: Employment, State and Local Government Services, Public Accommodations, Telecommunications, and Miscellaneous Provisions.

There are two subparts under Title II. Title II, Subpart A is implemented by the DOJ and prohibits discrimination on the basis of disability by public entities (ADA Title II Regulations, 2010). Subpart A expresses that any State or Local public entities cannot permit discrimination against individuals with disabilities in any of the public entities services, programs, or activities. Title II, Subpart B is implemented by the United States Department of Transportation (USDOT) and prohibits discrimination against people with disabilities in public transportation provided by public entities (ADA Title II Regulations, 2010). Subpart B requires no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity, or be subjected to discrimination by any public entity (ADA Title II Regulations, 2010). Subpart B covers the extent that public transportation entities offer in their services, programs, and activities. Title III of the ADA requires that new or altered places of public accommodation be "readily accessible to and usable by" people with disabilities (ADA Title III Regulations, 2010). Title III of the ADA requires places of public accommodation to remove barriers to access when it is readily achievable to do so and to meet the requirements for new construction and alteration in the ADA Standards for Accessible Design (ADA Title III Regulations, 2010). The primary goal of Titles II and III is to allow equal participation for people with disabilities in the community they live in by requiring state and local entities to provide access accommodations to their

services at the maximum extent possible. If a barrier does exist that prevents equal participation, the facility must be altered to provide equivalent access to the maximum extent feasible.

Titles II and III of the ADA followed a similar legislation as two previous federal laws, the Architectural Barriers Act of 1968 and Section 504 of the Rehabilitation Act of 1973. The Architectural Barriers Act of 1968 is a Federal law that requires facilities designed, built, altered, or leased with Federal funds to be accessible (WisDOT Transition Plan, 2011). This Act is one of the first efforts to ensure access to the built environment. Shortly after the Architectural Barriers Act of 1968, Section 504 of the Rehabilitation Act of 1973 was promulgated as a Federal law to protect qualified individuals from discrimination based on their disability. Section 504 implements nondiscrimination requirements that apply to employers and organizations that receive financial assistance from any Federal department of agency (WisDOT Transition Plan, 2011). Title II of ADA extended this coverage to all state and local government agencies, regardless of whether or not they receive federal funding (WisDOT Transition Plan, 2011). This means that all Federal, State, and Local government agencies must provide pedestrian access for people with disabilities in compliance with ADA and Section 504 standards. These laws work together to achieve the goal that prohibits public agencies from discriminating against persons with disabilities by excluding them from services, programs, or activities. They require that agencies must provide pedestrian access for persons with disabilities to the agency's streets and sidewalks, whenever a pedestrian facility exists (FHWA Public Rights-of-Way Access Advisory, 2013). When pedestrian facilities exist, these federal laws require standards for accessibility to the facilities such as curb ramps, detectable warning fields, and maintained sidewalks.

As a provider of public transportation services and programs, the Wisconsin Department of Transportation (WisDOT) must comply with Titles II and III of the ADA and Section 504 of the Rehabilitation Act as they specifically apply to state transportation agencies. Title II of the ADA contains administrative requirements and outlines the steps public entities such as the WisDOT should take to achieve ADA compliance. A public entity should self-evaluate all of its policies and practices, and determine whether any of these adversely affect the full participation of people with disabilities in its services, programs, and activities. Public entities must remove any impediments to full and equivalent participation discovered during this analysis. If structural modifications are required, a transition plan must be developed or updated. A transition plan should list the physical barriers to accessibility including curb ramps and sidewalks, an outline of the methods used to remove these barriers, and a schedule for achieving compliance (ADA Title II Regulations, 2010). When an ADA transition plan is developed, its need and purpose is to identify compliance issues and incorporate them into the State's planning and design.

The WisDOT conducted a self-evaluation of its facilities and developed an ADA Transition Plan in 1992 detailing how the organization will ensure that all of its facilities and activities are accessible to all individuals. An ADA taskforce was developed around high level members of the WisDOT to identify all deficiencies while completing one of the most extensive disability accommodations and accessibility plans in this government's history. The purpose of the self-evaluation was to assess policies and practices along with identifying barriers in programs and activities that prevent persons with disabilities from access (WisDOT Transition Plan, 2011). This includes identifying barriers within the public right-of-way such as curbs, sidewalks, pedestrian crossings, pedestrian signals, and bus stops. The end result of the self-evaluation was to determine modifications in pedestrian facilities that would allow maximum accessibility to persons with disabilities. This was the foundation for the WisDOT ADA Transition Plan. The purpose of the transition plan is to set forth steps necessary to complete modifications identified through self-evaluation (WisDOT Transition Plan, 2011). An important aspect behind the development of the transition plan was to make it a living document that evolves with the changing community needs and regulations. As boundaries grow, so does the need to incorporate acquired facilities into self-evaluation/transition plan processes (WisDOT Transition Plan, 2011). Each year the WisDOT's transition plan must identify physical obstacles in their public facilities that limit the accessibility of its programs or activities to individuals with disabilities; describe in detail the methods that will be used to make the facilities accessible; specify the schedule for taking the steps necessary to upgrade pedestrian access to meet ADA requirements in each year following the transition plan; and indicate the official responsible for implementation of the plan (WisDOT Transition Plan, 2011). The transition plan is an evolving planning and monitoring tool that provides detailed information about the pedestrian network in Wisconsin and the next steps to follow ADA regulations to make all facilities accessible for

people with disabilities. It has become a vital document today that has received routine updates to keep the document current and relevant to changing ADA and ADAAG regulations.

On April 16th, 2014 the WisDOT held a meeting to discuss the Transition Plan and the ADA compliance of existing sidewalks and curb ramps throughout the state. They discovered that one of the largest issues inhibiting the WisDOT's ability to determine the ADA compliance of pedestrian facilities in their Transition Plan is the lack of a sidewalk and curb ramp inventory. As stated in the meeting, first-rate pedestrian planning represents a continual process of addressing community needs and concerns rather than just developing a set of policies or rules to be followed. Geographic Information Systems (GIS) can provide an approach to this unprecedented pedestrian planning by developing a detailed sidewalk and curb ramp inventory and compliance assessment. When an inventory is developed and kept-up-to-date, it can represent a continual commitment to addressing pedestrian needs and issues required by the ADA. Organizing and developing an inventory of existing sidewalks and curb ramps through GIS can lead to many advantages when planning and designing pedestrian facilities. The information collected in an inventory can help identify existing facilities, identify ADA accessibility deficiencies in facilities, identify areas where changes are needed, and determine/prioritize solutions to create the changes. Developing a database of sidewalks and curb ramps in GIS is an incomparable way to inventory and evaluate existing conditions in a short-term fashion. GIS will allow for a proficient ruling to accessibility issues rather than waiting for streets to be redesigned with the new ADA compliant pedestrian facilities. Analyses can be performed on the inventoried data to help determine compliance percentages, trends, and relationships. This will not only resolve safety concerns but will also help with prioritizing various facility improvements and development plans in the future.

A dilemma hindering the WisDOT's ability to develop a sidewalk maintenance program for the Transition Plan determining ADA compliance issues is the lack of a comprehensive sidewalk inventory and compliance assessment plan. The objective of this project is to develop an efficient model for a statewide comprehensive sidewalk inventory and compliance assessment to determine the percentage of present facilities ADA compliance. The ultimate goal is to allow walking as a viable mode of transportation and improve safety, accessibility, and pedestrian mobility in the state of Wisconsin. The model for this statewide sidewalk assessment project will be based on Iowa County, Wisconsin. Iowa County is located in southwest Wisconsin and consists of 1,318 total miles of highway. Of the 1,318 total miles of highway, 177 miles consist of State Trunk Highways (STH) and United States Highways (USH). This project will focus on sidewalks and curb ramps among cities and villages in Iowa County that the State Trunk Highways and United States Highways proceed through.

1.2 Objectives

The final objectives for the sidewalks and curb ramps inventory and compliance assessment include:

1) Develop a systematic inventory process the WisDOT can use to track public sidewalks and curb ramps along highways
2) Create a data storage scheme for sidewalks and curb ramps
3) Inventory all public sidewalks and curb ramps along State Trunk Highways and United States Highways in Iowa County
4) Perform a compliancy assessment of public sidewalks and curb ramps inventoried
    - ADA compliance of the public sidewalks and curb ramps along the different USH's and STH's in Iowa County
    - ADA compliance of the public sidewalks and curb ramps within the different municipalities in Iowa County
5) Illustrate and recommend updates of cities/villages that are less compliant

2.0 Conceptualization

This project strives to develop a model for a statewide inventory of public sidewalks and curb ramps for the WisDOT transition plan to determine compliance issues incorporated by the ADA policies and guidelines. The following chapter describes the conceptual processes and methodologies used to inventory and assess the compliance of public sidewalks and curb ramps for the Iowa County model.

It is in the WisDOT's interest to have an accurate inventory of all public sidewalks and curb ramps along USH's and STH's in Wisconsin, populated with information explaining its compliancy with ADA policies as well as their locations. The development of a public sidewalks and curb ramps inventory involves the main tasks of data acquisition, data storage, and data utilization. Following through with these tasks will allow for a complete and accurate inventory that the WisDOT can implement into their Transition Plan to apply GIS assessments/analyses, reports, updates, and maintenance on. This will effectively advance the management of public sidewalks and curb ramps, identify compliance issues, and determine less-compliant municipalities that need ADA compliant updates.

2.1 Data Acquisition Process

The conceptual design of data acquisition for the inventory must identify the methods of how the sidewalks and curb ramps are going to be inventoried. Determining the most functional fields and attributes for the sidewalk and curb ramp inventory is the first step in creating a useful database. Understanding the regulations of the ADA was useful when determining what fields and attributes are appropriate. Under the ADA, there are accessibility design standards for highways, streets, or walkways to include accessible sidewalks and curb ramps with detectable warning fields. In the case of this inventory, the Transition Plan panel board wanted to develop a data format that would allow for efficient data collection of particular fields and attributes that will determine the compliance of public sidewalks and curb ramps to the ADA. Determining the correct fields and attributes will allow for an understanding of what defects the inventory should include. The important fields and attributes related to the inventory explained by the panel board include:

- Structure Type Identification
- Detectable Warning Field (DWF)
- Defect Identification
- Highway Number(s)
- Cardinal Direction/Location
- Year of Imagery

To be efficient, they demanded to collect sidewalk and curb ramp information in an office setting through the use of WisDOT's aerial photography, State Highway Programs Photolog, and Google Maps Street View. Centerlines and endpoints would be collected through the aerial photography while the important fields and attributes would be visualized and collected using Photolog and Street View. Using the Photolog and Street View will allow for a close-up, 360 degree view of the sidewalks and curb ramps.

Structure Type Identification – Sidewalks

Understanding what structure type is present at the different locations is beneficial when inventorying public sidewalks. Each structure has different ADA compliance regulations that need to be followed. There are four different structure types for public sidewalks that the inventory is identifying. They are sidewalks, paths, overpasses, and underpasses. The most common structure along highways are sidewalks. Understanding if the sidewalk is an overpass or underpass will help determine the importance of the sidewalks compliance. Overpasses and underpasses are considered grade-separated crossings which allow for pedestrians and motor vehicles to cross at different levels. Grade-separated crossings can be either beneficial or costly depending on their designs and locations. Some grade separated crossings are very steep and are difficult for people with mobility impairments to negotiate. In addition, grade-separated crossings are extremely costly to construct and are often not considered pedestrian-friendly because pedestrians are forced to travel out of their way to use the underpass or overpass. The effectiveness of a grade-separated crossing depends on whether or not pedestrians perceive that it is easier to use than a street crossing (Wisconsin Guide to Pedestrian Best Practices, 2010). Including these attributes of sidewalk structure type in the inventory will help WisDOT know where they are located as well as possible defects present.

If an issue ever arises with these different sidewalk structure types, the WisDOT can use the inventory to query the certain structure type and determine their compliance level.

Structure Type Identification – Curb Ramps

Curb ramps allow pedestrians who travel without vision cues to detect the transition from sidewalk to street crossing without any obstacles. They allow for a blended transition from the sidewalk to the crosswalk in the street. Curb ramps are mandatory at every end-point of a public sidewalk by the ADA. Inventorying the curb ramp structure type will allow for an easy determination if a curb ramp exists or does not exist at the end-points of public sidewalks. The inventory will also have a georeferenced location for each sidewalk endpoint. There are two structure types of public sidewalk end-points, curb ramps or curbs. If a curb ramp exists, the structure type would be determined curb ramp, but if a curb ramp doesn't exist, the structure type would be a curb.

Figure 2.1.1 Photo of a non-compliant sidewalk end-point. This is considered a curb since there is no cut in the curb for a curb ramp. http://www.torranceca.gov/14844.htm

Figure 2.1.2 Photo of a compliant sidewalk end-point. This is considered a curb ramp that allows for a blended transition from the sidewalk to the crosswalk. http://www.torranceca.gov/14844.htm

Detectable Warning Field – Curb Ramps

Detectable Warning Fields (DWF) are mandatory through the ADA whenever a curb ramp exists. DWF's are a distinctive surface pattern detectable by cane or underfoot. They are used to alert people with vision impairments of their approach to streets or hazardous drop-offs (Wisconsin Guide to Pedestrian Best Practices, 2010). A DWF may not exist at all but usually are either a truncated dome or mesh stamp. Truncated domes have become the most compliant DWF for the ADA and will replace the previously accepted practice of placing an expanded mesh pattern at the bottom of a curb ramp. Inventorying which type of DWF that is present will allow for a better understanding of a curb ramp compliance level.

Figure 2.1.3 Photo of a partially compliant curb ramp. There curb ramp exists but there is no DWF present.

Figure 2.1.4 Photo of partially compliant curb ramp disregarding the cracks. The curb ramp exists and a mesh stamp DWF is present.

Figure 2.1.5 Photo of fully compliant curb ramp. The curb ramp exists and a truncated dome DWF is present.

While inventorying the public sidewalks and curb ramps, defects in the structures should be included as an attribute to inform its compliance level. Defects in public sidewalks and curb ramps formulate non-compliant ADA structures since they can cause hazards to pedestrians. The inventory will include a field to incorporate whether or not a defect exists in the sidewalk or curb ramp. There are also many types of defects that can make a structure non-compliant causing accessibility issues. What type of defect exists will also be included in the inventory. Defects to be considered while inventorying sidewalks and curb ramps include:

- Vertical Faults
- Horizontal Faults
- Obstructions
- Cracking
- Cleanliness
- Missing Segments/Abrupt Gaps

Figure 2.1.6 Photo of a vertical fault in a public sidewalk.

Figure 2.1.7 Photo of a horizontal fault where a public sidewalk meets a curb.

Figure 2.1.8 Photo of an obstruction (telephone pole) in a public curb ramp.

Figure 2.1.9 Photo of a public sidewalk with various cracks and grass growing through.

Figure 2.1.10 Photo of a public sidewalk that has received no maintenance and grass growing on top of

Figure 2.1.11 Photo of a public sidewalk that has an abrupt end resulting in a gap.

Highway Number(s)

The highway the structures are associated with is very important when inventorying public sidewalks and curb ramps. It allows for an understanding of which highway the structure is located on. With the highway number being included in the inventory, a compliance assessment can be performed on the highway level to determine the compliance of structures present with particular highways. A final result will show all the highways in the study area and their sidewalks and curb ramps compliance to the ADA based on their defects. There will also be times where highways overlap, which they will all need to be included. There is the primary highway the structures will be tied to and a secondary highway that overlaps with the primary. Including the secondary highway will inform the user that it is present, but the structures are not associated with it.

Cardinal Direction/Location

Including the cardinal direction will identify the direction of travel on the highway that is being inventoried. A highway will have two main travel directions, North and South or East and West. The cardinal direction will inform which side of the highway the structures are on since there is two travel directions associated with a highway. If the cardinal direction of a structure is North, the structure is on the North bound side of the highway. The structures on the South bound side of the highway will also be inventoried. This will result in an inventory of a highway with both directions of travel being included.

Year of Imagery

Including the capture year of the image will help users know the latest year the image was captured and what the structures consisted of that year. For this inventory, the WisDOT is looking to reference images from the summer of 2013. If there are no images from 2013, 2012 would be the next best reference and so on. Usually, imagery is updated every year so knowing which year was used can help determine what was present at that time. It can also inform users to determine if the inventory needs to be updated since the imagery being used could be outdated and inaccurate. The structures could have been changed since the last year the images were captured and the inventory will need to be updated. This will allow for an accurate inventory of what defects exist in the public sidewalks and curb ramps from year to year.

WisDOT Photolog

WisDOT's photolog is a desktop link to Wisconsin's highways and allows for continuous route viewing. Photologging is conducted by taking photographs of the approaching perspective view from a moving vehicle at equal increments of distance along highways (WisDOT Safety Data Resource Guide, 2008). The photolog consists of consecutive photographs from an approaching perspective view that are captured every 0.01 miles (100 photos

per mile) on existing highways in Wisconsin (WisDOT Safety Data Resource Guide, 2008). It allows for multi-camera views from the front and sides of a moving vehicle to provide a driver's eye view of the roadway from any desktop. The photolog tool will be applied in the projects ArcMap MXD along with the Photolog Highways shapefile. It will be used to obtain information about the adjacent environment on all Interstate, U.S. Highways, and State Trunk Highways in Wisconsin.

Google Street View

Google Street View is a similar technology as the WisDOT's Photolog. It is a web application featured in Google Maps. Google Street View allows for a continuous, 360 degree panoramic view of streets from a desktop. Since Street View has more zoom capability, it will be implemented when sidewalks and curb ramps are difficult to visualize in WisDOT's Photolog.

2.2 Data Storage Structures

Since the panel board is requesting the format and structure of the data to be integrated into their existing GIS, the data storage scheme needs to be built on Environmental Systems Research Institute (ESRI) software. The plan behind this method is to have the sidewalks and curb ramps data integrated with many of their other facility layers. With the use of ESRI software, separate personal geodatabase structure's need to be built, one for sidewalks and the one for curb ramps. A geodatabase is the common data storage and management framework for ArcGIS. These geodatabases will store the functional attribute and mapping information for the public sidewalks and curb ramps. The sidewalks layer will be a line feature and the curb ramps layer will be a point feature. Each line and point feature of the geodatabases will include their exact location and the important attributes mentioned earlier. Domains and subtypes will be incorporated amongst the fields in the sidewalk and curb ramp geodatabases. These domains and subtypes will allow for data integrity and efficient inventorying with minimal errors when collecting and entering information. Once these geodatabases are developed and include the entire sidewalk and curb ramp information, their tables will be imported into a Postgres Spatial Database, pgAdmin. Utilizing spatial operations in the pgAdmin database will allow for spatial queries to identify the relationships and determine answers to the research questions proposed.

2.3 Database Utilization

When the data acquisition and storage processes are completed, various outputs and reports will be available to analyze the compliance of sidewalks and curb ramps in Iowa County. Structured Query Language (SQL) will be utilized to query amongst the tables in the pgAdmin spatial database. Different SQL queries can pull infromation from different levels that range from the county level, municipality level, and highway level. The information that is pulled from the spatial database can inform WisDOT planners and developers where compliance issues are relevant. There are two main research questions the WisDOT is trying to determine on the highway level and municipality level.

1. ADA compliance of the sidewalks and curb ramps along the different USH's and STH's in Iowa County
2. ADA compliance of the sidewalks and curb ramps within the different municipalities in Iowa County

3.0 Implementation

3.1 Data Storage Structure

The first step of the implementation process was to develop a data storage structure to store the information that will be collected in the data acquisition process. This was done by developing separate personal geodatabases for both the sidewalks and the curb ramps in ArcCatalog. A polyline shape feature geodatabase was created for the sidewalks and a point shape feature geodatabase was created for the curb ramps. The separate geodatabases were created with specific tables including the fields and attributes explained in the conceptualization process. Domains and subtypes are incorporated into the geodatabases to provide efficient labeling of the structures. With these geodatabases developed, the spatial information for the different structures that will be collected during the data acquisition process can now be stored. The following figures explain the format of the fields included in the geodatabases.

Table 3.1.1 Table showing the field and attribute format of the sidewalk geodatabase. Explains the Field Name, Field Type, Field Length, and an Explanation of why and what to include for each field.

Sidewalk Personal Geodatabase (Polyline)			
Field Name	**Field Type**	**Field Length**	**Explanation**
GID*	-	-	The reference number assigned to the sidewalk placed. (Automatically Generated)
SHAPE_Length*	-	-	The length of the segment, automatically calculated by Arc.
Structure_ID	Short Int	2	Is the structure a sidewalk, path, overpass, or underpass. Paths=8 ft wide or greater
Defect_ID	Short Int	2	Does the sidewalk have any defects? Cracking, Obstructions, Missing Segment, or Faults (horizontal (gaps) and vertical (lips))
Year	String	4	What is the year of the imagery you are referencing for this information? Should be from 2010 – 2013.
Highway_Number	Short Int	3	What highway is the sidewalk located on? This should be the lowest number of all the highways the sidewalk is located on. If you have overlapping highways such as HWY 12 and 14, this field would be entered as 12.
Cardinal_Direction	Short Int	2	What cardinal direction are you traveling on the highway? North/South or East/West
Defect_Comments	String	250	An explanation of the specific defects. If you entered 0 in Defect_ID, you may leave null. If you entered 1 in Defect_ID, explain the defect(s).
Highway_Number_2	Short Int	3	This should be the second lowest number of all the highways the sidewalk is located on. If you have overlapping highways such as HWY 12 and 14, this field would be entered as 14. If there is no secondary highway, you may leave null.
Highway_Number_3	Short Int	3	Enter a third highway number if present. Can leave null if there is no third.
Flag	Short Int	2	Mark due to uncertainty or questions you would like to clarify.
Flag_Comments	String	50	Any comments regarding why you flagged the sidewalk.
Miles	Double		This is a field for field calculating the SHAPE_Length* from feet to miles

Table 3.1.2 Table showing the domains and subtypes for the fields in the sidewalk geodatabase.

OBJECTID	SHAPE_Length	Structure_ID	Defect_ID	Year	Hwy_Num	Card_Direct	Defect_Cmts	Hwy_Num2	Hwy_Num3	Flag	Flag_Cmts	Miles
		0=Sidewalk	0=No			0=N				0=No		
		1=Path	1=Yes			1=S				1=Yes		
		2=Overpass				2=E						
		3=Underpass				3=W						

Table 3.1.3 Table showing the field and attribute format of the curb ramp geodatabase. Explains the Field Name, Field Type, Field Length, and an Explanation of why and what to include for each field.

Curb Ramp Personal Geodatabase (Point)			
Field Name	**Field Type**	**Field Length**	**Explanation**
GID*	-	-	The reference number assigned to the curb ramp placed. (Automatically Generated)
SHAPE*	-	-	Shape feature. Software automatically generates the shape as a point feature
Exist_ID	Short Int	2	Is there a curb ramp present at this location? 0=Yes 1=No
Defect_ID	Short Int	2	Does the curb ramp have any defects? Cracking, Obstructions, Missing Segment, Lips at the entry way, Erosion
DWF_ID	Short Int	3	Which type of Detectable Warning Field does the curb ramp have?
Year	String	4	What is the year of the imagery you are referencing for this information? Should be from 2010 – 2013.
Highway_Number	Short Int	3	What highway is the sidewalk located on? This should be the lowest number of all the highways the sidewalk is located on. If you have overlapping highways such as HWY 12 and 14, this field would be entered as 12.
Defect_Comments	String	250	An explanation of the specific defects. If you entered 0 in Defect_ID, you may leave null. If you entered 1 in Defect_ID, explain the defect(s).
Cardinal Direction	Short Int	2	What cardinal direction are you traveling on the highway? North/South or East/West
Highway_Number_2	Short Int	3	This should be the second lowest number of all the highways the sidewalk is located on. If you have overlapping highways such as HWY 12 and 14, this field would be entered as 14. If there is no secondary highway, you may leave null.
Highway_Number_3	Short Int	3	Enter a third highway number if present. Can leave null if there is no third.
Flag	Short Int	2	Mark due to uncertainty or questions you would like to clarify.
Flag_Comments	String	50	Any comments regarding why you flagged the curb ramp.

Table 3.1.4 Table showing the different domains and subtypes for the fields in the sidewalk geodatabase.

OBJECTID	SHAPE_Length	Exist_ID	Defect_ID	DWF_ID	Hwy_Num	Card_Direct	Defect_Cmts	Hwy_Num2	Hwy_Num3	Flag	Flag_Cmts
		0=Yes	0=No	0=Truncated Dome		0=N				0=No	
		1=No	1=Yes	1=Mesh Stamp		1=S				1=Yes	
				2=None		2=E					
						3=W					

3.2 Database Creation

With the data acquisition and storage processes completed, the next step in the implementation process involved creating at Postgres database in pgAdmin software. The spatial database contains all of the fields included in the separate geodatabases. Each point and polyline feature was given an entry and all available attributes associated with those features were merged from their sources. This was done by dumping the shapefile tables into pgAdmin using the PostGIS Plugin and appropriate Spatial Reference ID. To successfully query amongst the tables in pgAdmin, an Entity-Relationship Diagram (ER Diagram) and Relational Model needed to be developed. The ER Diagram consists of the Entities, Attributes, and Relationships amongst the shapefile tables in the postgres database. The Relational Model represents the collection of relations amongst the shapefile tables in the postgres database.

Figure 3.2.1 Entity-Relationship Model of the different shapefile tables containing the entities and their relationships that will be queried in pgAdmin.

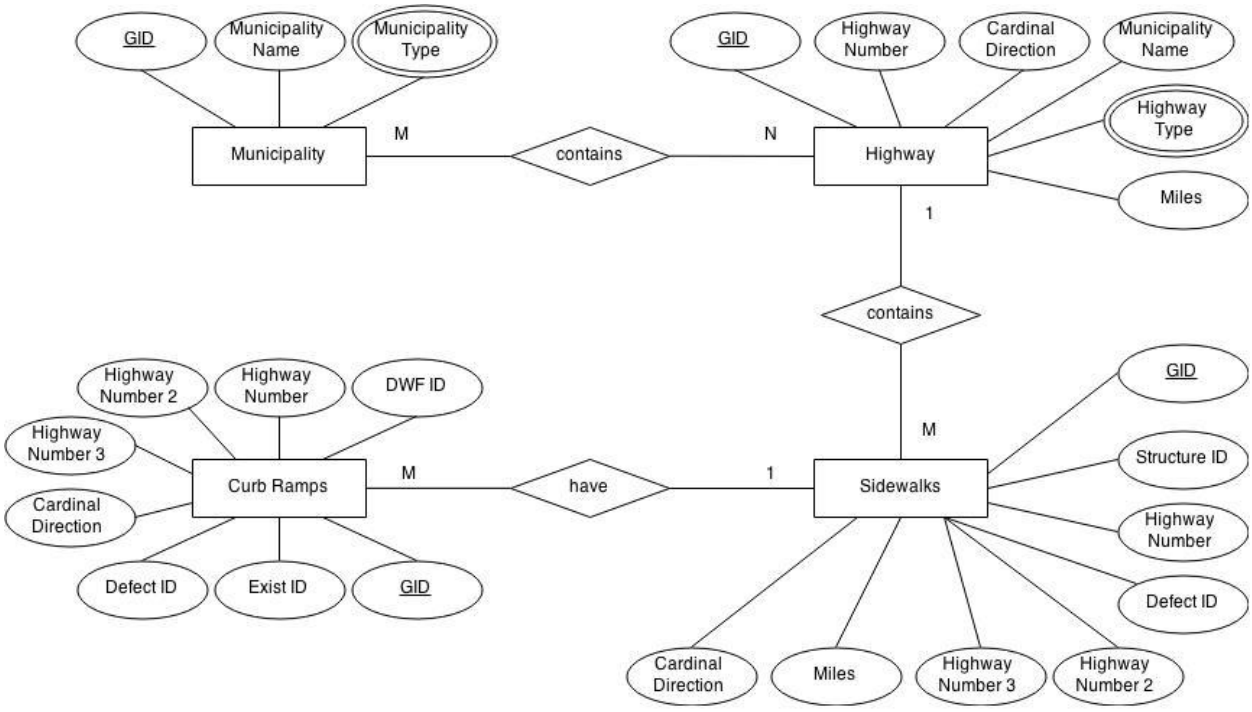
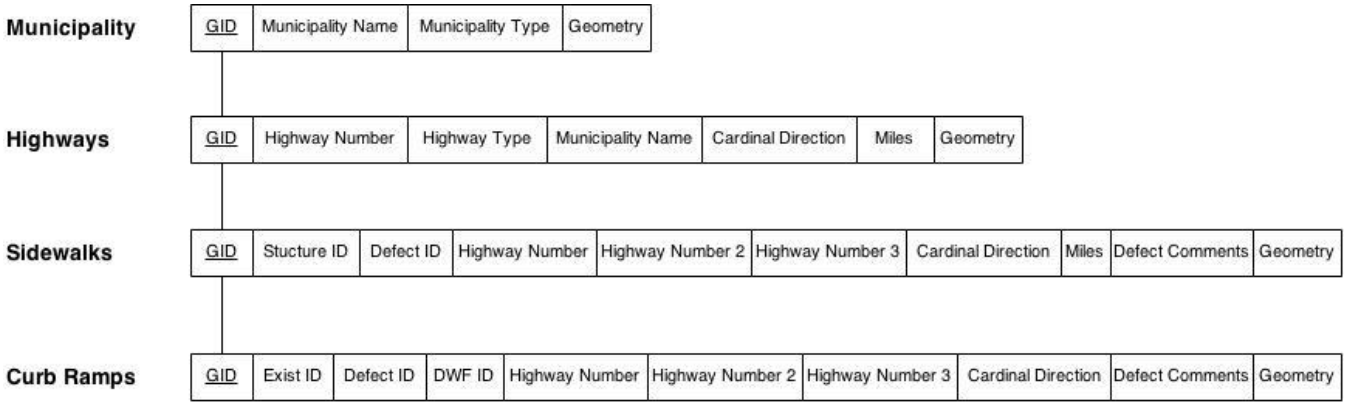


Figure 3.2.2 Relational Model describing the relationships of the entities from the different shapefile tables that will be queried in pgAdmin.



3.3 Database Utilization

Developing SQL queries in the pgAdmin database will analyze the data collected in this study to help develop answers to the research questions. SQL queries were established from the database to exhibit the number of compliant and non-compliant sidewalks and curb ramps from the inventoried data on Iowa County, Wisconsin. Each query accesses and joins tables to present specific information from both in a single table. The GID column, which contains unique identifiers for each record, was invaluable. This column was present in each of the shapefile attribute tables needed to answer the queries and therefore allowed for unobtrusive table joining. It is important to note that all sampling was done public sidewalks and curb ramps on United States Highways and State Trunk Highways that are within municipalities in Iowa County, Wisconsin. This is due to that fact public sidewalks and curb ramps tend to be only found within municipality limits. The WisDOT also only wanted to look at the higher priority roads, which are USH's and STH's.

To determine ADA compliance of sidewalks, sidewalk compliance is based on whether it has defects or not. If defects are present, the sidewalk is not ADA complaint. For ADA compliance of public curb ramps, curb ramp compliance is based on whether one exists, has no defects, and if the detectable warning field is a truncated dome. Mesh detectable warning fields and DWF that are not present are not ADA compliant. This means if a curb ramp exists and has no defects but has a mesh DWF or no DWF present, it is still not ADA complaint.

Count of Compliant Sidewalks on each USH and STH in Iowa County

The first query was written to establish the number of compliant sidewalks on each USH's and STH's. The *select distinct* accesses the distinct highway numbers and their street labels, which was either USH or STH. A *count* of defect ID's is also being selected. This table information from *highways_iowaco* was joined using *inner join* to the *sidewalks_iowaco* table, allowing for its table information to be accessed. The *where* statement does just that, accessing *sidewalks_iowaco*'s *defect_id* column to access information that has an ID of zero (0), which means it does not have a defect and is in compliance with ADA standards. The *group by* statement is then used to group the query results by column name.

```
select distinct highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy,
count(sidewalks_iowaco.defect_id)
from highways_iowaco
inner join sidewalks_iowaco on highways_iowaco.gid = sidewalks_iowaco.gid
where defect_id = '0'
group by highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy;
```

Count of Non-Compliant Sidewalks on each USH and STH in Iowa County

The second query is similar selecting from and joining the same tables as the first query. The main difference is the *where* statement where the *defect_id* is specified as one (1), meaning the sidewalk has defect(s) and does not comply with ADA standards. The output therefore reflects the count of defective sidewalks by USH and STH.

```
select distinct highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy,
count(sidewalks_iowaco.defect_id)
from highways_iowaco
inner join sidewalks_iowaco on highways_iowaco.gid = sidewalks_iowaco.gid
where defect_id = '1'
group by highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy;
```

Count of Compliant Curb Ramps on each USH and STH in Iowa County

The third query gives the number curb ramps in compliance with ADA standards on USH's and STH's. This query shares similar structure with the first two however a count and join are being selected from a new table *curbramps_iowaco* using it with the *highways_iowaco* table again. The *where* statement is selecting *defect_id*'s equal to zero (0), which indicates there is no defects in the curb ramp. Also in the *where* statement, it is selecting curb ramps with a truncated dome DWF (0) which is needed to comply with the ADA.

```
select distinct highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy,
count(curbramps_iowaco.defect_id)
from highways_iowaco
inner join curbramps_iowaco on highways_iowaco.gid = curbramps_iowaco.gid
where defect_id = '0', dwf_id = '0'
group by highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy;
```

Count of Non-Compliant Curb Ramps on each USH and STH in Iowa County

The fourth query gives the number of curb ramps that are not compliant with ADA standards on USH's and STH's. This is accomplished by changing the *where* statement to select *defect_id*'s equal to 1, and dwf_id equal to 1 or 2, which indicates noncompliance to the ADA.

```
select distinct highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy,
count(curbramps_iowaco.defect_id)
from highways_iowaco
inner join curbramps_iowaco on highways_iowaco.gid = curbramps_iowaco.gid
where defect_id = '1', dwf_id = '1', dwf_id = '2'
group by highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy;
```

Count of Compliant Sidewalks in each Municipality in Iowa County

Switching from the highway level to the municipality level, this query was written to establish the number of compliant sidewalks in each municipality with existing sidewalks along the USH's or STH's that pass through the municipality. The *select distinct* accesses the distinct municipality name and their municipality type, which is either a city, village, or township. A *count* of defect ID's is also being selected. This table information from *municipality_iowaco* was joined using *inner join* to the *sidewalks_iowaco* table, allowing for its table information to be accessed. The *where* statement does just that, accessing *sidewalks_iowaco*'s *defect_id* column to access information that has an ID of zero (0), which means it does not have a defect and is in compliance with ADA standards. The *group by* statement is then used to group the query results by column name.

```
select distinct municipality_iowaco.mname, municipality_iowaco.mtype
count(sidewalks_iowaco.defect_id)
from municipality_iowaco
inner join sidewalks_iowaco on municipality_iowaco.gid = sidewalks_iowaco.gid
where defect_id = '0'
group by municipality_iowaco.mname, municipality_iowaco.mtype;
```

Count of Non-Compliant Sidewalks in each Municipality in Iowa County

This query is similar selecting from and joining the same tables as the query just above. The main difference is the *where* statement where the *defect_id* is specified as one (1), meaning the sidewalk has defect(s) and does not comply with ADA standards. The output therefore reflects the count of defective sidewalks in each municipality.

```
select distinct municipality_iowaco.mname, municipality_iowaco.mtype
count(sidewalks_iowaco.defect_id)
from municipality_iowaco inner join
sidewalks_iowaco on municipality_iowaco.gid = sidewalks_iowaco.gid
where defect_id = '1'
group by municipality_iowaco.mname, municipality_iowaco.mtype;
```

Count of Compliant Curb Ramps in each Municipality in Iowa County

This query gives the number curb ramps in compliance with ADA standards within each municipality. This query shares similar structure with the first two however a count and join are being selected from a new table *curbramps_iowaco* using it with the *municiplaity_iowaco* table again. The *where* statement is selecting *defect_id*'s equal to zero (0), which indicates there is no defects in the curb ramp. Also in the *where* statement, it is selecting curb ramps with a truncated dome DWF (0) which is needed to comply with the ADA.

```
select distinct municipality_iowaco.mname, municipality_iowaco.mtype
count(curbramps_iowaco.defect_id, curbramps_iowaco.dwf_id)
from municipality_iowaco
inner join curbramps_iowaco on municipality_iowaco.mname = curbramps_iowaco.hwy_num
where defect_id = '0', dwf_id = ‘0’
group by municipality_iowaco.mname, municipality_iowaco.mtype;
```

Count of Non-Compliant Curb Ramps in each Municipality in Iowa County

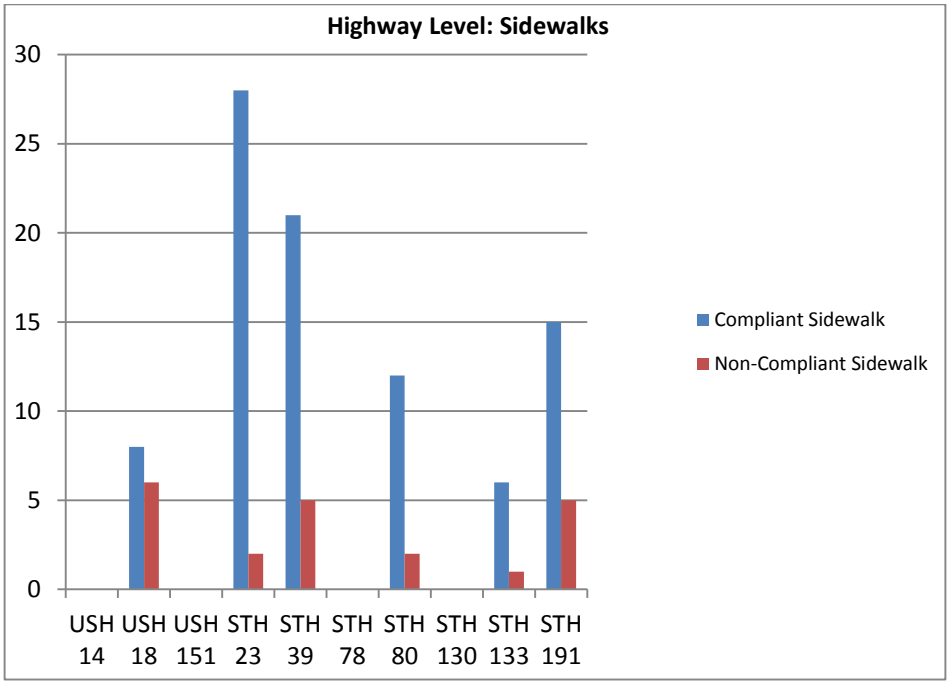
The last query gives the number of curb ramps that are not compliant with ADA standards with the municiplaities. This is accomplished by changing the *where* statement to select *defect_id*'s equal to 1, and dwf_id equal to 1 or 2, which indicates noncompliance to the ADA.

```
select distinct highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy,
count(curbramps_iowaco.defect_id)
from highways_iowaco
inner join curbramps_iowaco on highways_iowaco.gid = curbramps_iowaco.gid
where defect_id = ‘1’, dwf = ‘1’, dwf_id = ‘2’
group by highways_iowaco.st_labl_nm, highways_iowaco.st_prmy_sy;
```

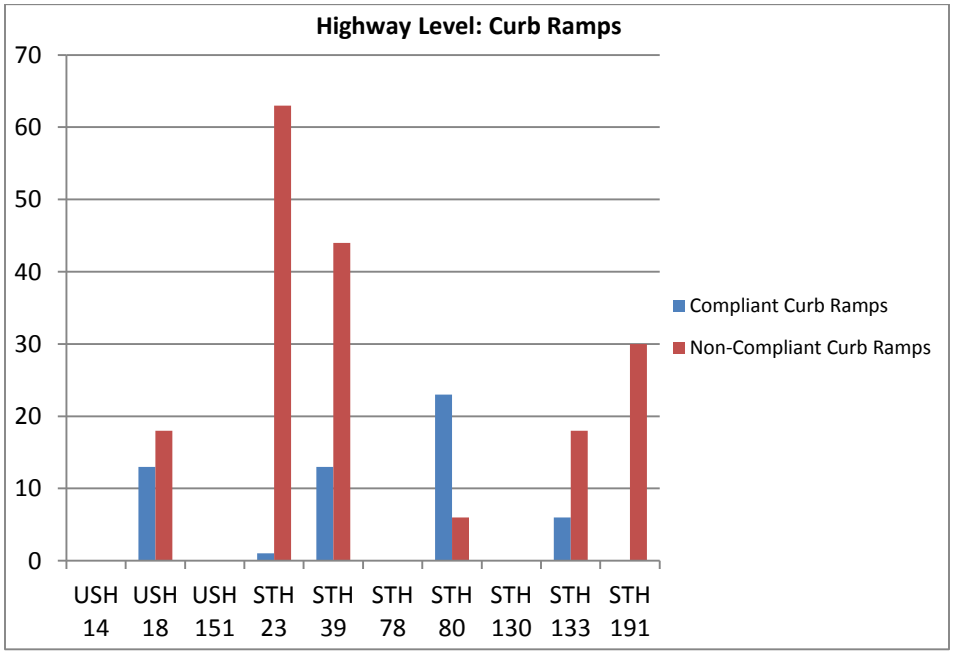
4.0 Results and Discussion

Utilizing the SQL queries in the pgAdmin database pulled the correct information to determine the ADA compliance of public sidewalks and curb ramps on the highway and municipality level in Iowa County. Graphs were developed to show the relationship between complaint and non-compliant sidewalks and curb ramps.

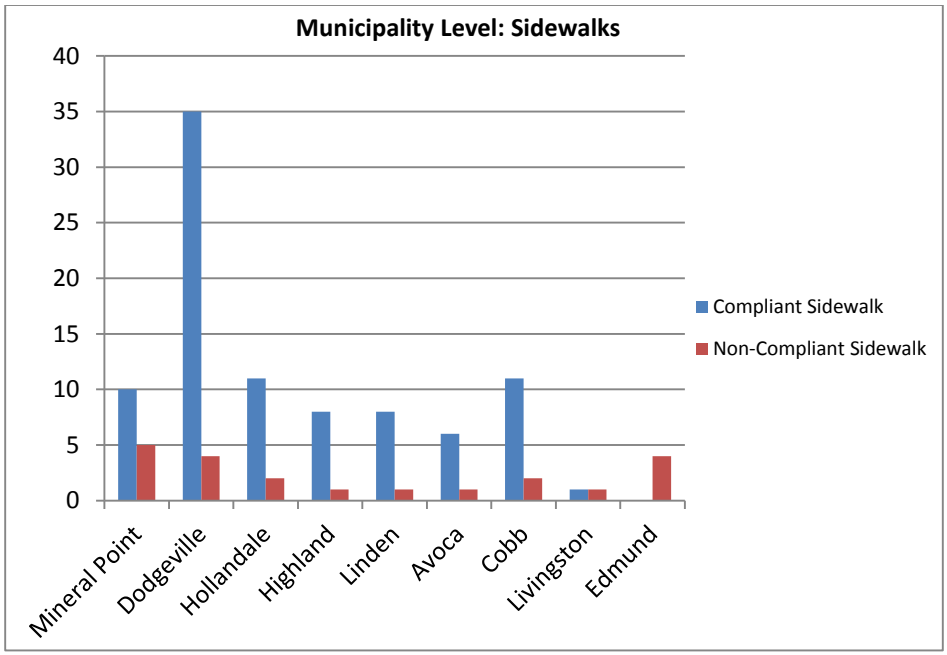
Count of Compliant and Non-Compliant Sidewalks on each USH and STH in Iowa County



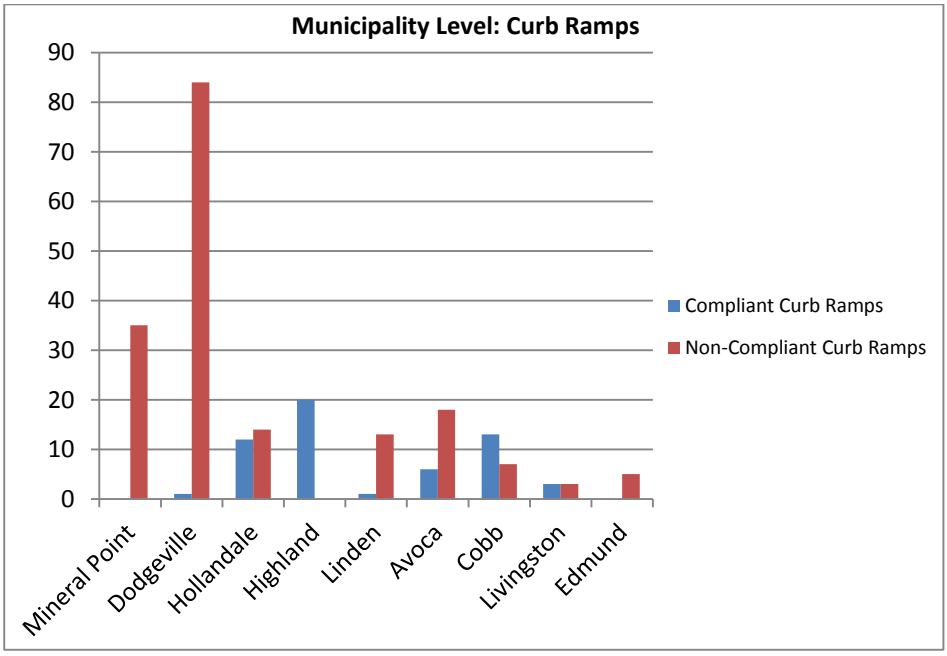
Count of Compliant and Non-Compliant Curb Ramps on each USH and STH in Iowa County



Count of Compliant and Non-Compliant Sidewalks in each Municipality in Iowa County



Count of Compliant and Non-Compliant Curb Ramps in each Municipality in Iowa County



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