Pedestrian Safety

An Online Continuing Education Course for Engineers

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Pedestrian Safety

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I. Introduction

A. Pedestrian Safety Problem Background

This document can be used as a reference for improving pedestrian safety through street redesign and the use of engineering countermeasures, as well as other safety-related treatments and programs that involve the community in its entirety.

In 2015, 5,376 pedestrians were killed in traffic crashes, representing 14 percent of all roadway-related fatalities (National Highway Traffic Safety Administration, 2016). On average, a pedestrian was killed every 2 hours and injured every 7 minutes. Greater priority has recently been given to reducing pedestrian crashes among some state and local agencies, as well as the U.S. Department of Transportation (DOT); however, more efforts and programs are needed to develop and implement effective strategies to reduce pedestrian-related injuries and deaths.

Safety literature reveals a variety of risk factors that influence pedestrian crashes and severity. For example, pedestrian crash risk increases on wide roads (four lanes or more), and with higher motor vehicle speeds and volumes. Intersections are more difficult to cross when pedestrians encounter wide crossing distances, wide turning radii, or multiple turn lanes. Other high-risk factors include drug/alcohol use by motorists and pedestrians, lack of nighttime roadway lighting, and the lack of walkways along roads. Older pedestrians are much more susceptible to serious or fatal injuries because of their frailty, while young children are more likely to be struck by a motor vehicle after darting into the street.

Many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors. Certain roadway design features can contribute to unsafe behaviors by pedestrians and motorists. For example, excessively wide streets encourage higher motorist speeds. High-volume multilane roads with a lack of safe crossings at regular intervals can contribute to pedestrians crossing streets at unsafe locations, particularly those who cannot or will not walk great distances to signalized locations. Land use decisions can also result in areas that are unsafe for pedestrians. For example, separating residential areas from shopping areas with high-volume multilane roads forces some pedestrians to cross streets in places that may not be safe. These types of issues must also be addressed in long-term solutions for pedestrian safety.

According to the American Association of State Highway and Transportation Officials (AASHTO), in their document "A Policy on Geometric Design of Highways and Streets" (Green Book)

> "*Pedestrians are a part of every roadway environment, and attention should be paid to their presence in rural as well as urban areas… pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas*" (AASHTO, 2016)

And in The National Cooperative Highway Research Program's (NCHRP) Report 500, Volume 10, "A Guide for Reducing Collisions Involving Pedestrians":

> "*Walking is a basic human activity, and almost everyone is a pedestrian at one time or another… Even though pedestrians are legitimate roadway users, they are frequently overlooked in the quest to build more sophisticated transportation systems. Whether building new infrastructure or renovating existing facilities, it should be assumed that people will walk, and plans should be made to accommodate pedestrians.*"

Unfortunately, many of our nation's streets and highways were primarily built to facilitate the smooth flow of motor vehicles. Yet, walking is the fundamental mode of human mobility; everyone is a pedestrian at some point in every journey that they take. This includes walking to a bus or walking to a parking lot. It includes people of all ages, from children to older adults, as well as pedestrians with visual and mobility impairments.

It is important to recognize that although many people choose to walk instead of driving as their only or primary mode of transportation, many others do not have the choice of driving. Per 2015 Census figures, nearly 10 percent of U.S. households do not own a vehicle. Also, 13 percent of U.S. citizens do not have a valid driver's license. This includes children under age 16, as well as many older and physically-impaired adults. This portion of our population should not be prevented from safe and reasonable opportunities to walk.

In a society that values choice and freedom, people should be able to walk safely, whether for errands, commuting to work or school, shopping, or recreation. Many Americans want to be able to walk more if given the opportunity to do so. Yet many street environments are often inhospitable or unsafe for walking.

Pedestrian safety and mobility must be elevated to a top priority for a substantial improvement to the situation. The engineers, planners, and other public officials in state and local agencies can leave a significant legacy of improved walking conditions and fewer pedestrian crashes and injuries for future generations.

There are several objectives that transportation professionals should address to improve pedestrian safety and mobility:

- Reduce the speed of motor vehicles
- Reduce pedestrian risks at street crossing locations
- Provide sidewalks and walkways separate from motor vehicle traffic
- Improve awareness of and visibility between motor vehicles and pedestrians
- Improve pedestrian and motorist behaviors

A variety of strategies are available to improve pedestrian safety. A comprehensive approach involving the "three E's" (Engineering, Education, and Enforcement), as well as making pedestrian-conscious land-use decisions, is recommended. Engineers, educators, planners, and enforcement officials all play a role in helping to identify and implement effective safety improvements.

II. Planning and Designing for Pedestrian Safety

A. Understanding Pedestrian Characteristics

Good pedestrian safety planning must include an understanding of the characteristics of pedestrians. Armed with this information, those involved in pedestrian safety planning can more effectively understand how new and existing facilities must operate, as well as how pedestrians will act when faced with certain conditions. Applying a practical understanding of pedestrian characteristics will provide insights when considering appropriate safety solutions and will particularly help ensure that facilities are inviting to pedestrians.

Important characteristics include understanding why and where pedestrians walk, what types of design features create a safer pedestrian environment, and what types of behavioral decisions pedestrians are likely to make. In addition, pedestrians also consist of specific populations with different characteristics, including children (who may be impulsive or unpredictable), persons with mobility impairments (who may require specific visibility devices or facility features), and senior citizens (who may require additional time for roadway crossings).

B. Transportation Design and Policy Elements that Impact Pedestrian Safety

Several design practices and policies created to improve motor vehicle mobility are now recognized as impediments to a safe pedestrian environment. There are many factors that affect the safety and mobility of the pedestrian transportation network. The major planning, design, and policy elements that impact pedestrian safety include:

1. Street design
2. Street connectivity
3. Site design
4. Land use
5. Access management

C. Street Design

The traditional street system is based on a simple hierarchy: most trips originate on local streets; travelers are then ferried via collector streets to arterials, which are intended to carry large amounts of motor vehicle traffic long distances at higher speeds. This system assumes that most trips occur by motor vehicle, so most of the facilities are designed primarily for motor vehicle travel. The system results in street designs that do not serve pedestrians well for several reasons:

1. They lack pedestrian facilities: Some collector and arterial streets are built with inadequate or no sidewalks or walkways, discouraging or limiting safe pedestrian movement along streets. Continuous lighting may not exist to provide adequate nighttime pedestrian conditions.

2. They are wide or have multiple lanes that are difficult to cross: Since arterial are designed to facilitate smooth and efficient motor vehicle flow, they often have multiple lanes in each direction to accommodate high motor vehicle traffic volume and multiple turn lanes. The number of lanes a pedestrian must cross has a direct effect on the complexity of the crossing task and the pedestrians' crash risk. The pedestrian must find an adequate gap in motor vehicle traffic, a task that increases exponentially with the number of lanes.

3. They have high speeds: Wide streets encourage and allow higher vehicle speeds, which relate directly to more severe injuries (to motorists and pedestrians) when a crash occurs; most pedestrian crashes and most fatalities occur on higher speed arterials.

4. They have complex intersections: Typically, wide arterial streets have intersections that are even wider due to the addition of multiple turn lanes. They also often have large turning radii to allow larger vehicles such as trucks and busses, to make turns easily and quickly. This requires pedestrians to cross longer distances and watch for more cars in more lanes, often a challenging and dangerous task. Skewed intersection designs and high vehicle right and left turn volumes at an intersection can also add complexity to the crossing task. Left turn arrows can also be confusing to pedestrians.

5. They create long delays for pedestrians at intersections: Wide intersections are those with multiple turn lanes create a long wait for pedestrians. At times, crossing prohibitions may be designated for one or more crosswalks to facilitate turning movements. If a crosswalk is closed, the pedestrian is left with three choices: cross illegally with no signal protection, walk a long distance around the intersection, or walk to another location to cross.

6. They provide little "friction" to protect pedestrians: Much of the traffic engineering philosophy of the last few decades have been aimed at stripping roads of "friction" (for example, removing trees, etc.) to facilitate motor vehicle traffic flow. This creates a barren, unsafe, and unattractive environment for pedestrians, often with high vehicle speeds.

D. Street Design Policies that have Affected Pedestrians

Achieving a Desired Level of Service

Level of Service (LOS) for motor vehicle traffic is usually measured in letter grades A through F. LOS A describes free-flowing unimpeded motor vehicle traffic; LOS F is near gridlock. LOS D is typical of congested urban areas where streets are full, and motor vehicle traffic is moving relatively slowly. It is not uncommon for intersections to operate at LOS F during the peak periods of traffic.

The measurements and calculations needed to predict or determine LOS are quantitative. However, the desired LOS is often a political decision (or policy), based on how much congestion decision-makers assume the public will tolerate. Those communities that have aimed to have motor vehicle traffic flow smoothly often have characteristically wide roads with minimal pedestrian accommodations. Consequently, they often experience higher crash rates for all roadway users, as both motorists and pedestrians suffer from the less safe conditions created to achieve these higher levels of vehicle mobility.

Accommodating Special Vehicles

Roadway design is usually predicated on the concept of the "design vehicle." The design vehicle is the largest vehicle that can be expected to be used on the road often enough to justify designing the roadway to accommodate that vehicle. Large design vehicles are commonly trucks and busses, include trash collection trucks, moving vans, school busses, and fire trucks. A typical design vehicle for local streets is known as a SU (Single Unit delivery truck), such as those used by UPS.

The most critical application of this concept is at intersections, where the radius is made large enough so the design vehicle can make a right turn without encroaching into the opposing lane. This can have a major negative effect on pedestrian safety and comfort because a large radius allows passenger vehicles to make right turns at higher speeds and requires pedestrians to cross longer distances. Large radii at intersections can contribute to a higher pedestrian crash risk as pedestrians are often hit by turning vehicles.

E. Street Connectivity

Within the context of the previously described street hierarchy, local streets typically do not connect well to each other, arterial streets, or destinations such as transit stops or stores. This leads to a larger collector and arterial streets that convey heavy motor vehicle traffic. This discontinuous pattern of local streets limits travel choices for pedestrians to higher-risk arterial streets that reduce both comfort and safety. A lack of street connectivity leads to intersections that are few – but often large in size- that are estrians to navigate. Many local streets have curvili

1. Limit pedes
2. Maybe disor
3. Increase the
4. Increase pede d
5. Discourage w tinations

Fewer people walking estrians along and crossing streets

These street designs h creasing driving distance and time, and s.

F. Site Design

Many existing developr access for pedestrians. Pedestrian ave to determine their own path and navigate through drivew ng lots, landscaping, and other buildings to reach the