abstract: the vehicles have undeniably altered the way in which transportation systems and the environment are designed and constructed, often at the expense of pedestrians. in the majority of crashes between pedestrians and motor vehicles, the pedestrian is trying to move in an environment designed primarily for automobile use. this paper explains how some common roadway design practices can have negative impacts on pedestrian travel and safety, as well as the policies that have led to these design practices. it also discusses other major factors that affect pedestrian safety such as street connectivity, site design, land use and access management. at the end, it discusses the necessity to institutionalize these changes by reviewing, amending, and adopting policies and design guidelines to better accommodate pedestrian travel. it is important to be proactive, as well as responsive to pedestrian safety problems.

keywords: pedestrian safety, planning, road design, countermeasures.

1. pedestrian safety problem background

pedestrian crashes and the resulting deaths and injuries are a serious problem on our roadways. research show that 4,641 pedestrians were killed in traffic crashes, representing 12 percent of all roadway-related fatalities (national highway traffic safety administration, 2004). in urban areas, pedestrian deaths typically represent 25 to 40 percent of traffic fatalities. approximately 70,000 pedestrians were injured on roadways in 2004, and many of these were severe injuries. while reducing pedestrian crashes has recently gained increasing priority among some state and local agencies as well as the u.s. department of transportation (dot), more efforts and programs are needed to develop and implement effective strategies to reduce pedestrian-related injuries and deaths.

many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors. the roadway design can contribute to unsafe behaviors by pedestrians and motorists. for example, excessively-wide streets encourage higher 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.
In a society that values choice and freedom, people should be able to walk safely, whether for fun and recreation, errands, getting to work or school, shopping, or other reasons. Many Americans want to be able to walk more if given the opportunity to do so. Yet, many street environments are often inhospitable and unsafe for walking.

![Figure 1. Unsafe pedestrian walking](image)

Pedestrian safety and mobility must be elevated to a top priority for the situation to improve substantially. The engineers, planners, and other public officials in state and local agencies can leave an important 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 (adapted from *A Guide for Reducing Collisions Involving Pedestrians*):

- 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.

2. TRANSPORTATION DESIGN AND POLICY ELEMENTS THAT IMPACT PEDESTRIAN SAFETY

Several design practices and policies conceived to improve motor vehicle mobility are now recognized as barriers 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:

- Street design.
- Street connectivity.
- Site design.
- Land use.
- Access management.

2.1. 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. The system results in street designs that do not serve pedestrians well for several reasons:
- **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 conditions.

- **They are wide or have multiple lanes that are difficult to cross**: Since arterial roads are designed to facilitate smooth and efficient motor vehicle flow, they often have multiple lanes in each direction to accommodate high motor vehicle traffic volumes and also multiple turn lanes. The number of lanes a pedestrian must cross has a direct effect on the complexity of the crossing task and the pedestrian crash risk.

- **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: the majority of pedestrian crashes and most fatalities occur on higher speed arterials.

- **They have complex intersections**: Typically, wide arterial streets have intersections that are even wider due to the addition of multiple turn lanes. This requires pedestrians to cross longer distances and watch for more cars in more lanes, an often challenging and dangerous task. Left turn arrows can also be confusing to pedestrians.

- **They create long delays for pedestrians at intersections**: Wide intersections and 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.

- **They provide little “friction” to protect pedestrians**: Much of the traffic engineering philosophy of the last few decades has been aimed at stripping roads of “friction” (for example, removing trees, etc.) in order to facilitate motor vehicle traffic flow. This creates an unsafe, and unattractive environment for pedestrians.

### 2.2. 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 larger collector and arterial streets that convey heavy motor vehicle traffic. A lack of street connectivity leads to intersections that are few in number, but often large in size, that are more difficult for pedestrians to navigate. Many local streets have curvilinear or cul-de-sac designs that:

- Limit pedestrians’ ability to travel in the most direct path.
- May be disorienting.
- Increase the distances to destinations.
- Increase pedestrian exposure time to other vehicles on the road.
- Discourage walking because of the added travel distance to destinations.

### 2.3. Site Design

Many existing developments do not provide direct, clear, and convenient access for pedestrians. Pedestrians wishing to access a site may have to determine their own path and navigate through driveways, parking lots, landscaping, and other buildings in order to reach the
destination. This often leads to confusion and conflicts between pedestrians and motorists, resulting in more pedestrian crashes.

2.4. Land Use

The practice and evolution of land use planning is long, complex, and generally beyond the scope of this document; however, an acknowledgement of certain issues pertaining to pedestrian safety is in order. Land use practices that took shape after World War II have typically favored the segregation of land uses (e.g., commercial and employment areas, schools, and residences) and the concentration of commercial activities along auto-dominated arterial corridors. This has produced the following unintended consequences:

- Trip origins and destinations are often far apart.
- Longer travel distances lead to fewer people walking and more driving.
- More people driving creates more hectic motor vehicle traffic conditions not conducive to safe pedestrian environments—those who do walk are exposed to long distances and high levels of risk when they walk along or try to cross busy high-speed arterial streets.
- The premise that most trips will be made by automobile leads to street designs intended to accommodate only the automobile, built to handle large volumes of motor vehicle traffic; when this occurs, pedestrians are often minimally accommodated only as an afterthought, if at all.
- Many of the destinations and commercial activities along a roadway corridor are also designed to serve motorists, fostering strip development with ample parking to capture passing motorists. As most of these destinations are located on arterials, they are hard for pedestrians to access.

2.5. Access Management

According to AASHTO, access management “involves providing (or managing) access to land development while simultaneously preserving the flow of traffic on the surrounding roadway system in terms of safety, capacity, and speed” (AASHTO, 2001). It has widely been used to improve the efficiency and flow of motor vehicle traffic by limiting the number of driveways and intersections on arterials and highways. These intersections are often difficult and unsafe for pedestrians to cross due to their size and large numbers of turning vehicles. Pedestrians wishing to cross at an intersection may have to walk long distances out of their way.

Figure 2. Poorly designed driveway
3. METHODS TO IMPROVE PEDESTRIAN SAFETY

In addition to improving the compliance of all roadway users with traffic controls and laws, there are several measures that can be taken to improve conditions for pedestrians within these transportation conventions previously discussed. Improved pedestrian safety can be achieved in a variety of ways, including:

3.1. Street Design Improvements

To make streets safer for pedestrians, planners, designers, engineers, and officials need to focus on:

- Slowing vehicle speeds.
- Reducing street crossing distances for pedestrians.
- Improving the visibility of pedestrians and motorists.
- Increasing the level of caution taken by pedestrians and motorists.
- Providing pedestrian facilities (sidewalks, crossing islands, etc.) where the needs and potential crash reductions are the greatest by establishing a routine system to identify gaps in the network along streets and highways, particularly in urban and suburban areas.

Achieving one or more of these objectives not only reduces the risk of pedestrian crashes, but also usually improves safety for motor vehicle drivers and passengers. Sometimes a design issue may result in a complication or delay to other roadway users, and transportation officials will have to make a choice to balance the competing interests. To achieve these objectives, some policies may require rethinking or reprioritization. These include:

a) Achieving a Desired Level of Service

Some effective pedestrian safety measures may increase motor vehicle travel time and have a slight negative impact on motor vehicle LOS. A rebalancing of the transportation system where pedestrian LOS and safety are included may sometimes mean a change in expectations about the priority that motor vehicle LOS is given in design and decision-making.

b) Accommodating Special Vehicles

The conflict between vehicle accommodation and pedestrian safety is usually considered a design decision, but it is also a values (policy) decision. An intersection can be designed with a smaller radius than is typically used for a particular design vehicle, thereby increasing pedestrian safety by reducing crossing distance/exposure. The motor vehicle driver can still make the turn, but the truck will have to maneuver into an inside lane to complete the turn. Communities with streets designed around the concept of “bigger is better” are communities that often provide poor pedestrian service and typically have poor pedestrian safety records. This does not mean trucks, school buses, and fire trucks cannot use the streets—they are accommodated; they just usually need to travel at a lower speed and take care in making turns. Transportation professionals are asked to carefully weigh these factors when making street design decisions.
c) **Street Connectivity Improvements**

Increasing street connectivity creates a safer, more pedestrian-friendly street system by:

- Reducing walking distances.
- Offering more route choices along quiet local streets.
- Dispersing motor vehicle traffic with more two-lane, neighborhood commercial streets, which relieves motor vehicle traffic from arterials to makes streets safer for pedestrians to walk along.
- Reducing the need for wide, difficult to cross streets and intersections by providing more connections.

3.2. **Site Design Improvements**

Both small-scale and large-scale developments should be directly accessible from the sidewalk through a safe and convenient sidewalk or pathway. Many communities are achieving better pedestrian safety records by requiring businesses and developments to locate close to the street (with parking provided in the back) in more pedestrian-oriented site developments that balance auto access with pedestrian needs and facilities. This does not mean that auto access is denied; it is just managed more appropriately.

These site design goals are achieved by enacting local zoning ordinances, which must be enforced. These principles contribute greatly to the safety, comfort, and aesthetics of the walking experience.

![Design of driveways that contributes to safe walking environment](image)

**Figure 3.** Design of driveways that contributes to safe walking environment

3.3. **Land Use Improvements**

Land use planning has often been considered a discipline separate from transportation planning, street design, and traffic engineering, and insufficient emphasis has been placed on the coordination of the two planning processes. However, the relationship between land use and transportation is evident, and the responsibility to coordinate between the two is imperative. Some changes to land use patterns that may positively influence pedestrian safety include:

- Encouraging mixed-use development (such as allowing small-scale retail in neighborhoods or placing schools in the center of neighborhoods) to help create destinations within walking distance of where people live and work.
- Designing new neighbourhoods in a cluster pattern with many destinations accessible on foot to residents.
3.4. Access Management Improvements

One of the most important access management techniques includes reducing conflicts at driveways to improve the walking environment. Some driveways can be closed—increasing the safety of both pedestrians and motorists—without impeding access to local businesses. Access management tools should not be used to reduce public street connections, especially pedestrian connections to the transportation network. Other access management goals can work in favor of pedestrians within the context of other important planning and policy issues, including:

- Constructing medians to control turning movements.
- Encouraging clustered development and mixed land uses.
- Improving street and neighborhood connectivity.
- Converting auto-oriented strip development into more accessible land use patterns more suitable for pedestrians.

4. CONCLUSION

Reduction or elimination of the risks faced by pedestrians is an important and achievable policy goal. Pedestrian collisions, like other road traffic crashes, should not be accepted as inevitable because they are, in fact, both predictable and preventable. Walking in an environment that lacks pedestrian infrastructure and that permits use of high-speed vehicles increases the risk of pedestrian injury. The risk of a motor vehicle colliding with a pedestrian increases in proportion to the number of motor vehicles interacting with pedestrians.

Pedestrian safety measures improve walking environments and contribute to urban renewal, local economic growth, social cohesion, improved air quality and reduction in the harmful effects of traffic noise. They also have supplementary benefits for other road users, such as motorists and cyclists. Implementation of safety measures requires commitment and informed decision-making by government, industry, nongovernmental organizations and international organizations.

5. REFERENCES