

# ***Traffic Safety Design Recommendations***

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## *Traffic Safety Design Recommendations*

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# ***Accident Types and Safety Counter Measures***

## **1. Overturn**

### **1.1 Possible Cause: Roadside features**

#### **Safety Counter Measures:**

- Extend culverts
- Provide traversable culvert end treatments
- Install/improve traffic barriers "Guardrail"
- Flatten side slopes and ditches
- Relocate drainage facility
- Provide adequate recovery zone
- Provide wider lanes

### **1.2 Possible Cause: Inadequate shoulders**

#### **Safety Counter Measures:**

- Upgrade shoulder surface
- Remove curbing / obstruction
- Widen lane/shoulder

### **1.3 Possible Cause: Roadway Geometry**

#### **Safety Counter Measures:**

- Improve pavement drainage
- Eliminate edge drop off
- Improve super elevation/crown

### **1.4 Possible Cause: Traffic control devices**

#### **Safety Counter Measures:**

- Install reflectorized pavement lines/raised markers
- Install delineation / reflectorize safety hardware
- Improve roadway lights
- Add special signing (e.g., chevrons)
- Upgrade barrier system
- Install warning signs
- Improve alignment/grade
- Reduce speed limit if justified by *Spot Speed Study*
- Provide adequate drainage
- Install Rumble strips

## **2. Fixed Objects**

### **2.1 Possible Cause:** Obstruction too close to roadway

#### **Safety Counter Measures:**

- Install Delineation / reflectorize safety hardware
- Remove/relocate obstacles
- Install breakaway features to light poles, signposts, etc
- Protect objects with guardrail
- Install crash cushions

### **2.2 Possible Cause:** Inadequate lighting

#### **Safety Counter Measures:**

- Improve roadway lighting
- Install Delineation / reflectorize safety hardware

### **2.3 Possible Cause:** Inadequate pavement marking

#### **Safety Counter Measures:**

- Install reflectorized pavement lines/raised markers and Delineators

### **2.4 Possible Cause:** Inadequate signs, delineators and guardrails

#### **Safety Counter Measures:**

- Install reflectorized paint, and / or reflectors on the fixed object
- Add special signing
- Upgrade barrier system

### **2.5 Possible Cause:** Inadequate road geometry design

#### **Safety Counter Measures:**

- Install warning signs / delineators
- Improve alignment / grade (Flatten horizontal and vertical curves)
- Provide proper superelevation (***Perform Ball-Bank Study***)
- Provide wider lanes

### **2.6 Possible Cause:** Slippery surface

#### **Safety Counter Measures:**

- Reduce speed limit if justified by ***Spot Speed Study***
- Provide adequate drainage

### 3. Run-Off-Road

#### 3.1 Possible Cause: Slippery pavement / ponded water

##### Safety Counter Measures:

- Reduce speed limit on approaches if justified by Spot Speed study
- Provide "SLIPPERY WHEN WET" signs
- Provide adequate drainage
- Groove existing PCC pavement
- Overlay existing AC pavement with ACFC
- Improve roadway cross slope

#### 3.2 Possible Cause: Roadway design inadequate for traffic conditions

##### Safety Counter Measures:

- Install / improve traffic barriers
- Close curb lane
- Flatten slopes/ditches
- Relocate islands
- Improve alignment/grade
- Provide proper superelevation (Perform Ball-Bank Study)
- Provide truck escape ramp
- Widen lanes / shoulders

#### 3.3 Possible Cause: Poor delineation

##### Safety Counter Measures:

- Install roadside delineators
- Install advance warning signs
- Improve/install pavement markings

#### 3.4 Possible Cause: Poor visibility

##### Safety Counter Measures:

- Increase sign size
- Improve roadway lighting

#### 3.5 Possible Cause: Improper channelization

##### Safety Counter Measures:

- Improve channelization

## 4. Sideswipes or Head on

### 4.1 Possible Cause: Inadequate road design and / or maintenance

#### Safety Counter Measures:

- Perform necessary road surface repairs
- Sign and mark unsafe passing areas
- Provide roadside delineators
- Improve alignment/grade
- Provide wider lanes
- Provide passing lanes (Perform No - Passing Study)

### 4.2 Possible Cause: Inadequate shoulders

#### Safety Counter Measures:

- Improve/Widen shoulders

### 4.3 Possible Cause: Excessive vehicle speed

#### Safety Counter Measures:

- Reduce speed limit if justified by Spot Speed Study
- Install median devices
- Install center line rumble strips

### 4.4 Possible Cause: Inadequate pavement markings

#### Safety Counter Measures:

- Install/improve centerlines, lane lines and edge lines
- Install reflectorized markers

### 4.5 Possible Cause: Inadequate channelization

#### Safety Counter Measures:

- Install/improve channelization
- Install acceleration and deceleration lanes
- Provide turning bays

### 4.6 Possible Cause: Inadequate signing

#### Safety Counter Measures:

- Provide advance direction and warning signs
- Add illuminated name signs

## **5. Rear End Collisions at Unsignalized Intersections**

### **5.1 Possible Cause:** Pedestrian crossing

#### **Safety Counter Measures:**

- Install / improve signing or marking for pedestrian crosswalks
- Relocate crosswalk

### **5.2 Possible Cause:** Driver not aware of intersection

#### **Safety Counter Measures:**

- Install / improve warning signs
- Install signs
- Install/improve street lighting

### **5.3 Possible Cause:** Slippery surface

#### **Safety Counter Measures:**

- Provide "SLIPPERY WHEN WET" signs
- Reduce speed limit on approaches if justified by *Spot Speed study*
- Groove existing PCC pavement
- Overlay existing AC pavement with ACFC

### **5.4 Possible Cause:** Large number of turning vehicles

#### **Safety Counter Measures:**

- Prohibit turns
- Increase curb radii
- Create left or right turn lanes

## **6. Right Angle Collisions at Unsignalized Intersections**

### **6.1 Possible Cause:** Restricted sight distance

#### **Safety Counter Measures:**

- Install warning signs
- Install stop signs
- Install yield signs
- Restrict parking near corners
- Reduce speed limit if justified by *Spot Speed Study*
- Remove sight obstructions
- Install signs
- Install/improve street lighting
- Channelize intersection

### **6.2 Possible Cause:** Large total intersection volume

#### **Safety Counter Measures:**

- Install signals (*Perform Volume Count On All Approaches*)

### **6.3 Possible Cause:** High approach speed

#### **Safety Counter Measures:**

- Reduce speed limit if justified by *Spot Speed Study*
- Install rumble strips

## **7. Right Angle Collisions at Signalized Intersections**

### **7.1 Possible Cause:** Poor visibility of signals

#### **Safety Counter Measures:**

- Install advanced warning devices
- Install visors
- Install back plates
- Reduce speed limit on approaches if justified by *Spot Speed study*
- Remove sight obstructions
- Add additional signal heads
- Install 12-inches signal lenses
- Improve location of signal heads
- Install overhead signals



**7.2 Possible Cause:** Inadequate signal timing

**Safety Counter Measures:**

- Adjust amber phase
- Provide all red clearance phases
- Add multi-dial controller
- Install signal actuation
- Retime signals (*Perform Volume Count On All Approaches*)
- Provide progression through a set of signalized intersections

## **8. Collisions at Driveways**

**8.1 Possible Cause:** Right turning vehicles

**Safety Counter Measures:**

- Restrict parking near driveways (*Perform Turning Count*)
- Increase the width of the driveway
- Increase curb radii
- Provide right turn lanes
- Widen through lanes

**8.2 Possible Cause:** Large volume of through traffic

**Safety Counter Measures:**

- Move driveways to side street (*Perform Volume Count For Through Traffic*)
- Construct local service road
- Reroute through traffic

**8.3 Possible Cause:** Large volume of driveway traffic

**Safety Counter Measures:**

- Signalize driveway (*Perform volume count for driveway traffic*)
- Provide acceleration and deceleration lanes
- Channelize driveway (*Perform gap study*)

**8.4 Possible Cause:** Restricted sight distance

**Safety Counter Measures:**

- Restrict parking near driveway
- Reduce speed limit if justified by *Spot Speed study*
- Install/improve street lighting
- Remove sight obstructions

## **9. Pedestrian / Bicycle**

### **9.1 Possible Cause:** Limited sight distance

#### **Safety Counter Measures:**

- Remove sight obstructions
- Install/improve pedestrian crossing signs and markings
- Reroute pedestrian paths

### **9.2 Possible Cause:** Inadequate protection

#### **Safety Counter Measures:**

- Add pedestrian refuge islands

### **9.3 Possible Cause:** Inadequate signal/signs

#### **Safety Counter Measures:**

- Install/upgrade signals/signs

### **9.4 Possible Cause:** Inadequate signal phasing

#### **Safety Counter Measures:**

- Change timing of pedestrian phase
- Add pedestrian "WALK" phase

### **9.5 Possible Cause:** Inadequate pavement marking

#### **Safety Counter Measures:**

- Supplement marking with signing
- Upgrade pavement markings

### **9.6 Possible Cause:** Inadequate lighting

#### **Safety Counter Measures:**

- Improve lighting

**9.7 Possible Cause:** Drivers has inadequate warning of frequent mid-block crossings

**Safety Counter Measures:**

- Prohibit parking
- Install warning signs
- Reduce speed limit on approaches if justified by *Spot Speed study*
- Install pedestrian barriers

**9.8 Possible Cause:** Lack of crossing opportunity

**Safety Counter Measures:**

- Install traffic/pedestrian signals (*Perform Gap study*)
- Install pedestrian crosswalk and signs

**9.9 Possible Cause:** Excessive vehicle speed

**Safety Counter Measures:**

- Reduce speed limits if justified by *Spot Speed study*
- Install proper warnings signs

**9.10 Possible Cause:** Pedestrians/bicycles on roadway

**Safety Counter Measures:**

- Eliminate roadside obstructions
- Install curb ramps
- Install sidewalks
- Install bike lanes/paths

**9.11 Possible Cause:** Long distance to nearest crosswalk

**Safety Counter Measures:**

- Install pedestrian crosswalk
- Install pedestrian actuated signals

**9.12 Possible Cause:** Sidewalk too close to traveled way

**Safety Counter Measures:**

- Move sidewalk laterally a way from roadway

**9.13 Possible Cause:** School crossing area

**Safety Counter Measures:**

- Establish safe route and awareness program
- Use school crossing guards
- Install crosswalks and traffic signals

## **10. Bridges**

**10.1 Possible Cause:** Alignment

**Safety Counter Measures:**

- Install advance warning signs
- Improve delineation/markings
- Realign bridge/roadway

**10.2 Possible Cause:** Narrow roadway

**Safety Counter Measures:**

- Improve delineation/markings
- Install signing/signals
- Widen structure

**10.3 Possible Cause:** Visibility

**Safety Counter Measures:**

- Improve delineation/markings
- Install advance warning signs
- Remove obstruction

**10.4 Possible Cause:** Vertical clearance

**Safety Counter Measures:**

- Improve delineation/markings
- Install advance warning signs
- Provide heights restrictor/warning device
- Rebuild structure/adjacent roadway grade

**10.5 Possible Cause:** Slippery surface (wet/ice)

**Safety Counter Measures:**

- Provide special signing
- Provide adequate drainage
- Improve skid resistance
- Resurface deck

**10.6 Possible Cause:** Rough surface

**Safety Counter Measures:**

- Rehabilitate joints
- Resurface deck
- Regrade approaches

**10.7 Possible Cause:** Inadequate barrier system

**Safety Counter Measures:**

- Improve delineation/markings
- Remove hazardous curb
- Upgrade bridge rail
- Upgrade bridge approach rail connections
- Upgrade approach rail/terminal

## **11. Collisions at Railroad Crossings**

**11.1 Possible Cause:** Restricted sight distance

**Safety Counter Measures:**

- Install advance warning signs
- Remove sight obstructions
- Install train actuated signals
- Install gates
- Reduce grades

**11.2 Possible Cause:** Poor visibility

**Safety Counter Measures:**

- Increase size of signs
- Improve roadway lighting

**11.3 Possible Cause:** Inadequate pavement markings

**Safety Counter Measures:**

- Install advance markings to supplement signs
- Install stop bars
- Install / improve pavement markings

**11.4 Possible Cause:** Rough crossing surface

**Safety Counter Measures:**

- Improve crossing surface

**11.5 Possible Cause:** Sharp crossing angle

**Safety Counter Measures:**

- Rebuild crossing with proper angle

**11.6 Possible Cause:** Improper pre-emption, Timing of traffic signals, Railroad signals or gates

**Safety Counter Measures:**

- Retime traffic signals
- Retime railroad signals and gates

## **12. Nighttime**

**12.1 Possible Cause:** Poor visibility or lighting

**Safety Counter Measures:**

- Install/improve warning signs
- Install/improve delineations/markings
- Install/improve street lighting

**12.2 Possible Cause:** Poor sign quality

**Safety Counter Measures:**

- Upgrade signing
- Provide illuminated reflectorized signs

**12.3 Possible Cause:** Inadequate channelization or delineation

**Safety Counter Measures:**

- Install pavement markings
- Improve channelization/delineation

### **13. Wet Pavement**

**13.1 Possible Cause:** Slippery pavement

**Safety Counter Measures:**

- Provide "SLIPPERY WHEN WET" signs
- Reduce speed limit on approaches if justified by *Spot Speed study*
- Provide adequate drainage
- Groove existing PCC pavement
- Overlay existing AC pavement with ACFC

**13.2 Possible Cause:** Inadequate pavement markings

**Safety Counter Measures:**

- Install raised/reflectorized pavement markings

## *Intersection Safety Design Recommendations*

In 2000, more than **2.8 million** intersection-related crashes occurred, representing **44 percent** of all reported crashes. About 8,500 fatalities (23 percent of total fatalities) and almost one million crashes with injuries occurred at or within an intersection. The cost to society for intersection-related crashes is approximately **\$40 billion** a year.

About **one-half** of these fatal crashes involved drivers who were **80 years and older**. Older drivers are more likely to receive traffic citations for failing to yield, turning improperly, and running stop signs and red lights.

Intersections are disproportionately responsible for **pedestrian** deaths and injuries. Almost **50 percent** of combined fatal and non-fatal injuries to pedestrians occur at or near intersections.

Despite improved intersection design and more sophisticated applications of traffic engineering measures, the annual toll of human loss due to motor vehicle crashes has not substantially changed in more than 25 years.

***Improving the engineering intersection is the first step toward reducing accidents.***

***The most important thing to remember when improving safety at intersections is that countermeasures that improve vehicle traffic flow or reduce vehicle crashes should not compromise pedestrian safety.***

***Reducing Fatalities And Injuries At Intersection Can Be Accomplished Through A Combination Of Efforts, Including The Careful Use Of:***

1. **Good road design.**
2. **Traffic engineering.**
3. **Comprehensive traffic safety laws and regulations.**
4. **Consistent enforcement efforts.**
5. **Sustained education of drivers and pedestrians.**
6. **Willingness among drivers and pedestrians to obey traffic safety laws.**



### ***Major Types Of Vehicle Crashes At Intersections Are:***

1. **Side (Crossing) collisions** are when one vehicle strikes the side of another, these are the most severe type of crashes. They can result from vehicles attempting to drive straight through or turning within an intersection. Each year, more than **one-third** of all deaths to vehicle occupants occur in side-impact crashes. These are the most serious kind of collisions, which occur most frequently at intersections.
2. **Rear-end collisions** are common at intersections. They can be the result of poor street design or inadequate traffic engineering measures, but usually are the result of dangerous driver behavior, such as speeding, following too closely, and braking too late. **Seventy-five percent** of all rear-end crashes involve a vehicle that is either stopping or has already stopped. More than half of these kinds of crashes occur at or near intersections.
3. **Vehicles changing lanes improperly** or crossing a road's center line are less common at intersections than crossing and rear-end collisions.
4. **Pedestrian and bicycle collisions** occur most frequently in urban areas, particularly with older and younger age groups.

### ***Major Causes of Intersection Crashes Are:***

1. **Poor physical design** of both the intersections and their approach roadways. A major aspect of safety design is restricted sight distances.
2. **Inadequate traffic engineering.** In some cases, traffic control devices-such as signs-are improperly used, placed in the wrong locations, too small to be seen, or have suffered damage or deterioration.
3. **Driver licensing and education** often fails to train drivers to safely negotiate intersections. Some drivers do not respect the rights and safety needs of pedestrians.
4. **Drivers disregard for the clear messages of traffic control devices at intersections.** Devices such as stop signs, signals and pavement markings, speed limit signs, and repeatedly violate traffic laws. Driver distractions, such as cell phone use and inattention and drug and alcohol use, are additional human factors that cause accidents with death and injuries.

***Actions To Achieve Substantial Reductions In Crash Accidents Are:***

1. Alter key features of the physical design of a highway or street.
2. Analyze the reasons for traffic conflicts at intersections.
3. Engage in innovative and strategic thinking to delicately balance the requirement for efficient traffic movement and congestion reduction, and at the same time, the need to protect vehicle occupants and pedestrians from the consequences of dangerous vehicle maneuvers and unwise pedestrian behavior.
4. Provide sustained and consistent law enforcement efforts.
5. All levels of government must play a central role by providing improved funding and cooperation with highway and vehicle engineers, health care authorities, law enforcement, national safety organizations, and local citizen safety groups.

***Consider The Following Decisions When Improving Intersection Pedestrian Safety Design And Operation:***

1. **Eliminate** vehicle and pedestrian conflicts.
2. **Reduce** unavoidable vehicle and pedestrian.
3. **Design** intersections so that when collisions do occur, they are not as severe.
4. **Add** turn lanes at intersections. Providing turn lanes for left-turning vehicles can reduce accidents by about 32 percent and decrease personal injury accidents by as much as 50 percent.
5. **Improve** signals. Increase the size of signal heads from 8 to 12 inches to increase their visibility; provide separate signals over each lane, install higher intensity signal lenses, and change the length of signal cycles, including the yellow clearance interval and the all-red phases.
6. **Utilize** non-traditional intersection design such as roundabouts or traffic circles.
7. **Upgrade** pavement condition and quality to better drain the road and resist skidding.
8. **Improve** drivers' sight distance. Restrict parking near intersections and move stop lines back from intersections.

9. **Rehabilitate** and supplement signs. Enforcing laws that prohibit dangerous intersection driving is a necessity to even well-designed and regulated intersections. Consistent and sustained enforcement efforts have been proven to lower both intersection violations and crash rates, sometimes to a dramatic extent.

### ***Pedestrian Safety at Intersections***

More than one in five pedestrian deaths is the result of a collision with a vehicle at an intersection. An average of **5,475** pedestrians died in traffic crashes annually between **1990 and 2000**.

#### ***The Year 2000 National Highway Traffic Safety Administration Pedestrian Crash Facts Are As Follows:***

- **4,739** pedestrians were **killed** in traffic crashes (**one** pedestrian is killed **every 111 minutes**).
- **78,000** pedestrians were **injured** in traffic crashes (**one** pedestrian is injured **every seven minutes**).
- Most pedestrian crashes occurred in urban areas (**71 percent**), at nonintersection locations (**78 percent**), in normal weather conditions (**91 percent**) and at night (**64 percent**).
- Almost **one-fourth (23 percent)** of all **children** between the ages of **five and nine years** who were killed in traffic crashes were pedestrians.
- **Children** under the age of **10** are not yet capable of crossing a roadway alone. Young children have not fully developed an awareness of the direction of sound (e.g., an approaching car), peripheral vision, focus and concentration levels, or proper judgment of a car's speed and distance until after the age of 10.
- **Older pedestrians** (ages 70 and above) accounted for 17 percent of all pedestrian fatalities and 6 percent of all pedestrians injuries.
- **42 percent** of all young pedestrian fatalities (under age 16) occurred between 4 p.m. and 8 p.m.
- **Alcohol** involvement-either for the driver or for the pedestrian-was reported in 47 percent of the traffic crashes that resulted in pedestrian fatalities.

## ***Pedestrian Safety Problems at Intersections:***

Traffic improvements that include widening streets, adding lanes, and using traffic engineering solutions that **increase vehicular efficiency can decrease pedestrian safety.**

Pedestrians have not been accorded equal status with vehicles at intersections. Roadways have been designed and constructed primarily to **accommodate vehicular traffic rather than pedestrians.**

About **one-third of fatal** collisions with pedestrians is the result of pedestrians disobeying intersection traffic control or making dangerous judgments in attempting to cross a street.

The design and improvement of roadways often **fail to meet the needs of pedestrians of all ages** and capabilities for safely crossing intersections, including older persons, young children and those with impaired vision or difficulty in walking.

Traffic engineers **must not use walking speed that is too fast** for many pedestrians in determining the necessary time for pedestrians to cross the street.

Crash data consistently show that collisions with pedestrians occur far more often with turning vehicles than with straight-through traffic. **Left-turning vehicles** are more often involved in pedestrian accidents than right-turning vehicles, partly because drivers are not able to see pedestrians to the left as well.

Pedestrians involved in crashes are more likely to be killed as vehicle speed increases. The fatality rate for a pedestrian hit by a car at **20 mph is 5 percent.** The fatality rate rises to **80 percent when vehicle speed is increased to 40 mph.**

**Right turn on red (RTOR)** contributes to pedestrian crashes because it creates reduced pedestrian opportunities to cross intersections without having to confront turning vehicles.

**Pedestrian visibility** to drivers is much poorer during hours of darkness, especially in areas where there is **poor lighting** on the road. This is a common shortcoming of rural and suburban intersections.

**Methods to reduce pedestrian injuries and fatalities at intersections are:**

1. **Improving visibility.** Pedestrians need to make themselves more visible during evening and nighttime hours.
2. **Coordination among engineers, educators and enforcement personnel** to improved pedestrian safety at intersections.
3. **Application of enforcement on:**
  - Motorist compliance with pedestrian safety laws.
  - Pedestrian compliance.
  - Reducing speeding through intersections.
4. **Education.** Develop a sustained, comprehensive public awareness campaign that reaches both motorists and pedestrians.
5. **Pedestrian signal timing/pedestrian signals:**
  - Re-assess the adequacy of pedestrian-signal timings.
  - Consider pedestrian-only phasing in a traffic signal cycle.
  - Ensure that the pedestrian signal is visible and all push-buttons are accessible. Signals may be supplemented with audible messages for visually impaired persons.
6. **Install "Stop for Pedestrians" paddle signs** at the roadway centerline, at crosswalks without signals in central business districts and other areas of high pedestrian activity to reinforce the right-of way of pedestrians.
7. **Identify and decrease road and traffic hazards:**
  - Repair/re-stripe crosswalks and stop lines.
  - Improve lighting.
  - Provide additional signage where necessary.
  - Install barriers such as fences, shrubs, or uncomfortable median surfaces to discourage pedestrians from crossing at unsafe locations.
  - Provide a wide refuge island on a median with fencing.
  - Make crosswalk improvements such as:
    - A ladder pattern that is more visible to motorists.
    - Crosswalks with flashing lights embedded in the roadway pavement.
    - Flashing "Pedestrian Crossing" signs that alert oncoming traffic to pedestrians in the crosswalk.

**Reference** Federal Highway Administration (FHWA)  
American Association of State Highway and Transportation Officials (AASHTO)  
Institute of Transportation Engineers (ITE)