

Lecture 5.34

5.1 Road Accidents

Introduction to Road Safety and Traffic Crashes

A road accident, formally termed a road traffic crash, is defined as an unintended collision involving at least one moving vehicle on a public roadway that results in damage, injury, or fatality.

In developing nations like India, rapid motorization combined with mixed traffic conditions has led to alarmingly high accident rates. Road crashes result in substantial loss of human lives, severe long-term disabilities, and massive economic loss, amounting to nearly 3% of India's GDP annually.

- Unintended collision involving vehicles, pedestrians, or fixed objects
- High burden of fatalities and injuries in developing countries
- Economic loss estimated at 3% of national GDP
- Civil engineer's role in creating forgiving road infrastructure

Classification of Road Accidents by Severity

Traffic engineering authorities classify road accidents into distinct categories based on the severity of the outcome. This standardization ensures consistent statistical reporting across jurisdictions.

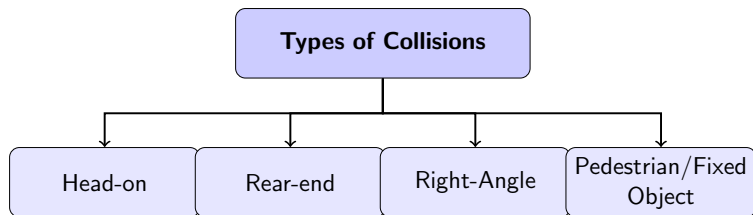
Accidents are broadly classified into Fatal Accidents (resulting in death within 30 days of the event), Grievous/Major Injury Accidents (causing hospitalization or permanent disability), Minor Injury Accidents (requiring first aid without hospitalization), and Property Damage Only (PDO) Accidents where no physical injuries occur.

Classification	Description
Fatal Accidents	Death occurs immediately or within 30 days due to crash injuries
Grievous Injury	Severe trauma, fractures, or long-term hospitalization
Minor Injury	Superficial wounds requiring basic medical treatment
PDO	Non-injury crashes resulting in vehicle/infrastructure damage

Types of Vehicular Collisions

Collisions are categorized according to the impact geometry between vehicles or objects. The specific type of collision provides crucial clues regarding underlying traffic flow problems and roadway defects.

Common collision types include Head-on Collisions (occurring on undivided two-lane roads), Rear-end Collisions (caused by tailgating or sudden braking), Side-swipe or Angle Collisions (common at intersections and lane merges), Single-vehicle Rollovers, and Collisions with Pedestrians or Fixed Objects.



Human Factors in Accident Causation

Human error is contributing factor in over 80% to 90% of all road traffic crashes. Drivers, riders, and pedestrians frequently display behaviors that compromise safety.

Key human factors include overspeeding beyond safe geometry limits, driving under the influence of alcohol or drugs, distracted driving (mobile phone usage), driver fatigue/drowsiness, aggressive driving, and non-compliance with traffic signals and seatbelt/helmet laws.

- Overspeeding: Reduces reaction time and increases stopping distance exponentially
- Distracted Driving: Cognitive and visual impairment from mobile phone use
- Driving Under Influence (DUI): Impaired reflexes and distorted distance judgment
- Fatigue & Drowsiness: Common during long-distance night commercial driving

Vehicular Factors in Road Accidents

Mechanical defects and inadequate vehicle maintenance significantly increase crash risk, especially under adverse weather or high-speed driving conditions.

Defects such as brake failure, sudden tire blowouts, defective headlights or taillights, steering system malfunctions, and structural overload in commercial freight vehicles are major vehicular contributors to road crashes.

- Brake Failure: Inability to stop in emergency situations due to fluid/pad wear
- Tire Blowouts: Loss of vehicle control at high speeds from worn treads or improper pressure
- Lighting Defects: Reduced night visibility and missing conspicuity markings
- Vehicle Overloading: Compromises braking distance, center of gravity, and stability

Roadway and Geometric Factors

Inadequate geometric design directly exposes road users to heightened accident hazards. Roads must be engineered to match driver expectations and physical vehicle limits.

Deficiencies such as inadequate sight distance at sharp horizontal curves, improper superelevation, narrow lanes or unpaved shoulders, skidded or slippery pavement surfaces, poor intersection alignment, and lack of clear lane markings directly induce traffic crashes.

- Sight Distance Deficiencies: Insufficient Stopping Sight Distance (SSD) at crests/curves
- Improper Superelevation: Vehicle skidding or rollover on sharp horizontal curves
- Slippery Pavement: Low skid resistance during wet weather conditions
- Hazardous Roadside Objects: Trees, utility poles, and steep unshielded embankments

Environmental and Meteorological Factors

Environmental conditions alter pavement surface characteristics, driver visibility, and vehicle handling, creating transient hazards on the roadway network.

Adverse conditions include dense fog or mist causing extreme visibility reduction, heavy rainfall leading to hydroplaning/aquaplaning, night-time headlight glare from oncoming vehicles, and extreme ambient temperatures affecting tire integrity.

- Dense Fog/Smog: Drastically reduces visibility, causing multi-vehicle pileups
- Heavy Rain & Aquaplaning: Loss of tire-pavement friction due to water film build-up
- Headlight Glare: Temporary blindness experienced on un-lit undivided roads
- Wind Gusts: Stability loss for high-sided commercial vehicles on open bridges

Vulnerable Road Users (VRUs) and Mixed Traffic Risks

Vulnerable Road Users—including pedestrians, bicyclists, and two-wheeler riders—account for more than half of all road fatalities in India due to their lack of protective structural shielding.

In Indian highway corridors, mixed traffic conditions (where slow-moving animal carts, bicycles, high-speed buses, and heavy trucks share the same carriageway) create extreme speed differentials, significantly heightening conflict points and fatality rates.

- High Vulnerability: VRUs lack physical protection during impact events
- Heterogeneous Traffic: Severe speed differentials increase conflict frequency
- Inadequate Facilities: Absence of dedicated footpaths, cycle tracks, and safe crossings
- Urban Fringe Hazards: Uncontrolled ribbon development along national highways

Haddon's Matrix for Accident Analysis

Haddon's Matrix is a multi-dimensional framework used by safety engineers to systematically evaluate crash causes and interventions across three time phases and three system factors.

The framework analyzes Human, Vehicular, and Environmental factors across Pre-crash (prevention), Crash (injury reduction during impact), and Post-crash (emergency response and rehabilitation) phases to identify all possible points of intervention.

Phase	Human Factor	Vehicular Factor	Environmental Factor
Pre-crash	Driver training, awareness	Maintenance, brakes	Road design, signs
Crash	Seatbelt/helmet use	Airbags, crash zones	Crash barriers, clear zones
Post-crash	First aid knowledge	Extrication ease	Emergency response

Socio-Economic Consequences of Road Crashes

Road accidents inflict severe economic losses on families and society, often pushing vulnerable households into poverty when the primary wage earner is lost or permanently disabled.

Economic costs are classified into Direct Costs (medical treatment, vehicle repair, property restoration, emergency service deployment) and Indirect Costs (loss of productive output, legal expenses, administrative costs, and socio-emotional suffering).

- Direct Economic Costs: Emergency medical care, vehicle replacement, infrastructure repairs
- Indirect Economic Costs: Loss of workforce productivity, legal litigation fees
- Social Consequences: Household impoverishment and psychological trauma
- Cost-Benefit Justification: High economic return of safety engineering projects

Summary of Road Accidents

This lecture introduced the fundamentals of road accidents, highlighting their classification, primary causative factors, and multi-faceted impacts.

Achieving a reduction in crash frequency and severity requires a thorough understanding of human, vehicular, roadway, and environmental interactions. Civil engineers play a pivotal role in designing safe, forgiving roadway environments.

- Road accidents are classified by severity into fatal, grievous, minor, and PDO categories
- Collision types reflect specific geometric or operational traffic deficiencies
- Human factors cause majority of crashes, but roadway design dictates crash outcomes
- Haddon's Matrix provides a systematic 3x3 framework for analyzing crash interventions
- Understanding crash fundamentals prepares engineers for data collection and safety audits