Lecture 5.35

5.2 Accident Recording and Analysis

Need and Objectives of Accident Data Collection

Accident investigation and recording serve multiple vital purposes across engineering, law enforcement, legal proceedings, and policy formulation.

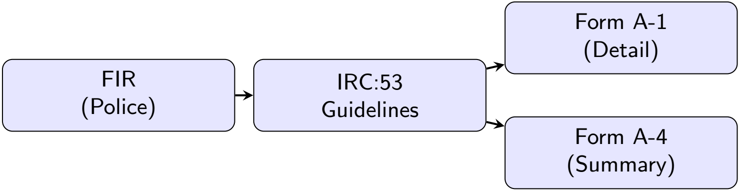
The primary engineering objectives include identifying high-accident locations ('black spots'), diagnosing specific roadway defects, evaluating the economic effectiveness of safety improvements, establishing legal responsibility, and supporting research into safer vehicle and road designs.

- Black Spot Identification: Locating clusters of crashes on the road network
- Cause Diagnosis: Determining whether human, road, or vehicle factors dominated
- Countermeasure Evaluation: Testing before-and-after effectiveness of engineering changes
- Policy & Research: Guiding national safety standards and legislation updates

Accident Reporting Systems and Primary Documents

In India, the initial recording of a road crash begins at the local police station via the First Information Report (FIR) under relevant sections of the Bharatiya Nyaya Sanhita (BNS) and Motor Vehicles Act.

For traffic engineering analysis, police records are translated into standardized accident reporting forms (such as Form A-1 for road crash data and Form A-4 for summary reports) recommended by the Indian Roads Congress (IRC:53).



Essential Data Elements Recorded in Crash Surveys

A comprehensive accident record must capture detailed information across multiple categories to enable precise statistical analysis and spatial reconstruction.

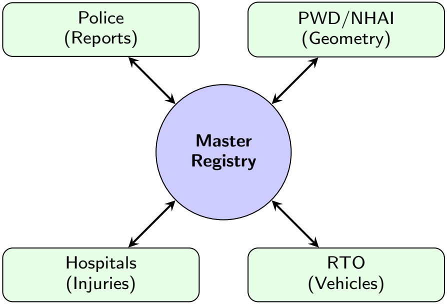
Key data elements include precise location (GPS coordinates, chainage kilometer stone, landmark), time and date, prevailing weather and lighting conditions, road classification, vehicle types involved, driver details (age, license status), pedestrian movements, and collision diagrams.

Category	**Examples of Data Elements**
Location Specifics	Landmark, chainage, GPS, node ID
Temporal Factors	Hour of day, day of week, season
Environmental Parameters	Surface moisture, lighting quality
Participant Data	Age, gender, experience, seatbelt/helmet

Inter-Agency Coordination and Data Sources

Accident data collection requires seamless coordination among multiple public agencies, each contributing specialized information to the master crash registry.

Primary contributing agencies include the Police Department (crash reports), Highway Authorities like NHAI/PWD (road inventory and traffic volume data), Health Departments and Hospitals (injury severity and medical outcomes), Motor Vehicle Inspectors (vehicle fitness), and Insurance companies.



Accident Rate Expressions: Volume-Based Rates

Comparing absolute crash counts between different road sections can be misleading due to variations in traffic volume. Therefore, engineers calculate exposure-adjusted accident rates.

For road sections, accident rates are expressed per Million Vehicle Kilometers (MVkm) of travel. For specific spots or intersections, rates are calculated per Million Entering Vehicles (MEV).

- Section Accident Rate formula: $R_{sec} = \frac{A \times 10^6}{365 \times T \times V \times L}$
- A = Total number of crashes in time period, T = Years
- V = Average Daily Traffic (ADT), L = Length of section in km
- Spot/Intersection Rate formula: $R_{spot} = \frac{A \times 10^6}{365 \times T \times V_{total}}$

Accident Rate Expressions: Population and Vehicle Fleet Rates

To compare road safety performance across different cities, states, or nations, demographic and vehicle-fleet exposure metrics are utilized.

Common macroscopic rate expressions include Fatalities per 100,000 Population (demographic risk), Fatalities per 10,000 Registered Vehicles (vehicle fleet risk), and Crash Severity Index (ratio of fatal crashes to total crashes).

- Population Rate: $\frac{\text{Total Fatalities}}{\text{Population}} \times 100,000$ (Measures public health burden)
- Registered Vehicle Rate: $\frac{\text{Total Fatalities}}{\text{Registered Vehicles}} \times 10,000$ (Measures fleet safety performance)
- Severity Index: $\frac{\text{Total Fatalities}}{\text{Total Crashes}} \times 100$ (Measures crash outcome intensity)
- Use of rates for national planning and international safety benchmarking

Spot Map Method for Accident Mapping

The Spot Map method is a visual graphic technique used by traffic engineers to pin-point crash locations on scaled physical base maps of a city or highway corridor.

Color-coded pins or symbols are placed on map locations corresponding to recorded crashes over a specific period (e.g., 1 to 3 years). Dense clusters of pins immediately reveal high-risk locations requiring detailed engineering investigation.

- Visual Clustering: Immediate graphical identification of crash-prone locations
- Symbol Conventions: Red pins for fatalities, yellow for injuries, black for PDO
- Base Map Requirements: Scale maps showing alignment, intersections, and milestones
- Limitations: Physical map clutter, static maintenance difficulty, lack of attribute search

GIS-Based Accident Spatial Analysis

Geographic Information Systems (GIS) have revolutionized crash recording by replacing manual spot maps with dynamic, spatially referenced digital database systems.

GIS enables spatial density analysis (Kernel Density Estimation), automated heatmap generation, buffer zone queries around schools/intersections, and seamless overlay of crash data with road geometry, traffic volume, and pavement condition layers.

- GPS Coordinates: Direct geo-referencing of crash locations using smartphone sensors
- Kernel Density Estimation (KDE): Mathematical generation of continuous crash risk heatmaps
- Multi-Layer Overlay: Combining crash clusters with speed limits, lighting, and curve radii
- Spatial Querying: Extracting crash trends within specific corridor buffers or zones

Modern Digital Data Collection Systems: iRAD

In India, the Integrated Road Accident Database (iRAD) project, developed by IIT Madras and NIC under MoRTH, represents a state-of-the-art digital framework for crash reporting.

Using a mobile application, responding police officers capture crash details on-site with auto-filled GPS location, photographs, and time stamps. The data instantly syncs across Police, PWD, Health, and RTO departments.

- iRAD Mobile Application: Real-time on-site crash data entry by field police
- Automated Capture: Precise GPS location, photo evidence, and timestamp integration
- Unified Stakeholder Dashboard: Instant access for highway engineers, doctors, and RTOs
- AI & Analytics Integration: Automated black spot detection and predictive safety modeling

Challenges in Accident Data Collection and Quality Control

Despite technological advancements, maintaining high data quality and completeness in crash registries remains a persistent challenge in developing highway networks.

Major issues include significant under-reporting of minor and PDO crashes, inaccurate location description by non-technical staff, delay in data entry, inconsistent terminology between states, and lack of medical follow-up for late-stage hospital fatalities.

- Under-Reporting: Minor crashes and rural incidents often unrecorded by police
- Location Errors: Approximated kilometer stones leading to spatial misallocation
- Skill Gaps: Need for training police personnel in technical crash data recording
- Data Incompleteness: Missing vehicle fitness or driver license details in final reports

Summary of Accident Recording and Analysis

This lecture covered the systems, forms, rate calculations, and mapping techniques essential for systematic accident recording and traffic safety engineering.

Accurate data collection through standardized forms (IRC:53) and digital platforms (iRAD), combined with exposure-adjusted rate calculations and GIS mapping, provides the diagnostic foundation for highway safety interventions.

- Accident data collection bridges law enforcement, civil engineering, and medical care
- Standardized IRC forms and digital apps (iRAD) streamline field data capture
- Volume-adjusted rates (MVkm, MEV) enable objective comparison across road corridors
- Spot maps and GIS heatmaps visualize spatial crash clusters for targeted engineering
- High-quality crash data is indispensable for identifying black spots and evaluating countermeasures