

Lecture 2.9

2.4 Speed Studies

Fundamental Concepts of Speed in Traffic Engineering

Speed is one of the three primary traffic stream variables, along with traffic volume (flow rate) and traffic density.

In traffic engineering, speed measurements reflect road quality, driver satisfaction, vehicle performance, and level of service (LOS).

- Primary indicator of highway operational performance
- Inversely proportional to travel time and traffic density
- Directly influences stopping sight distance and accident severity
- Key parameter for setting speed limits and timing signals

Spot Speed: Definition and Practical Importance

Spot Speed is the instantaneous speed of a vehicle as it passes a specific specified spot or cross-section of a roadway.

Spot speed measurements are used to analyze speed distributions, establish speed limits, and design geometric elements at specific locations.

- Measured over a short distance (e.g., 15 to 50 meters)
- Reflects driver behavior under prevailing local highway conditions
- Used for redesigning dangerous curves, intersections, and school zones
- Forms the baseline for evaluating traffic enforcement effectiveness

Running Speed vs Journey Speed (Travel Speed)

Running Speed excludes stopped delays, while Journey Speed includes all delays encountered along the route.

Metric	Running Speed	Journey (Travel) Speed
Time Used	Running Time (moving only)	Total Journey Time (includes stops)
Formula	$\frac{\text{Distance}}{\text{Total Time} - \text{Stopped Delay}}$	$\frac{\text{Distance}}{\text{Total Journey Time}}$
Value	Always higher	Always lower (or equal if no stops)
Indicator	Vehicle performance	Overall corridor efficiency

- Large gap between running and journey speed indicates severe congestion delays.

Time Mean Speed vs Space Mean Speed

Time Mean Speed (V_t) is the arithmetic mean, while Space Mean Speed (V_s) is the harmonic mean of speeds.

Feature	Time Mean Speed (V_t)	Space Mean Speed (V_s)
Definition	Arithmetic mean of spot speeds at a point	Harmonic mean of speeds over a length
Formula	$V_t = \frac{\sum v_i}{n}$	$V_s = \frac{n}{\sum (1/v_i)}$
Magnitude	Always higher ($V_t \geq V_s$)	Always lower ($V_s \leq V_t$)
Relationship	$V_t = V_s + \frac{\sigma_s^2}{V_s}$ (Wardrop's Formula)	

Travel Time and Delay Definitions

Travel time is the duration required by a vehicle to traverse a designated highway segment.

Delay represents the extra time lost by a vehicle due to traffic interruptions, geometric bottlenecks, or control devices.

- Fixed Delay: Occurs regardless of traffic volume (e.g., red signal phase, stop signs)
- Operational Delay: Caused by vehicle interactions, congestion, and parking maneuvers
- Stopped Delay: Actual time a vehicle remains completely stationary
- Travel time surveys measure corridor efficiency and congestion costs

Factors Influencing Vehicle Speeds on Highways

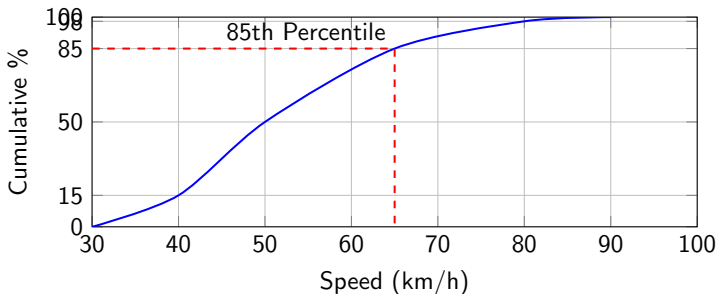
Vehicle operating speeds depend on physical driver capabilities, vehicle mechanical limits, road geometry, traffic density, and weather conditions.

Engineers analyze these factors to design safe speed limits and uniform traffic speeds.

- Driver Characteristics: Age, gender, perception-reaction time, aggressiveness
- Vehicle Capabilities: Engine power, braking efficiency, vehicle type
- Roadway Geometrics: Lane width, shoulder width, curvature, grade, surface quality
- Environmental Factors: Rain, fog, night visibility, roadside friction

85th Percentile Speed: Safe Speed Limit Standard

The 85th Percentile Speed is the speed at or below which 85% of drivers travel under free-flowing conditions.



- Reflects the collective judgment of reasonable drivers
- Used universally to set realistic, self-enforcing speed limits

98th Percentile Speed: Geometric Design Baseline

The 98th Percentile Speed represents the speed below which 98% of vehicles travel.

Because geometry must accommodate high-speed vehicles safely, IRC mandates using the 98th percentile speed as the Design Speed for geometric elements.

- Used for designing highway curve radius and superelevation
- Determines required Safe Stopping Sight Distance (SSD)
- Determines Overtaking Sight Distance (OSD) requirements
- Ensures fast vehicles navigate alignment features without instability

15th Percentile Speed & 50th Percentile (Median Speed)

The 15th Percentile Speed represents the lower speed boundary below which only 15% of vehicles travel.

The 50th Percentile Speed (Median Speed) represents the midpoint of the speed distribution.

- 15th Percentile Speed: Used to establish minimum speed limits on expressways
- Minimum speed limits prevent slow vehicles from causing rear-end crashes
- 50th Percentile Speed: Measures central tendency of traffic stream speed
- Used in signal timing synchronization along arterial corridors

Speed Variation and Pace (10 km/h Pace)

The Pace is defined as the 10 km/h speed increment that contains the highest proportion of observed vehicle speeds.

High concentration of speeds within a narrow pace indicates stable, uniform traffic flow with minimal speed variance.

- Pace Range: e.g., 50 km/h to 60 km/h on an urban arterial
- Percent Vehicles in Pace: Percentage of sample driving within pace limits
- Higher percentage in pace indicates lower crash potential
- Speed dispersion (standard deviation) measures safety hazard

Summary & Key Takeaways

Speed studies provide essential statistical parameters for highway geometric design, safety management, and regulatory control.

Understanding percentiles (98th for design, 85th for speed limits, 15th for minimum limits) is essential for diploma civil engineers.

- Spot speed measures instantaneous velocity; journey speed includes delays
- Space Mean Speed (V_s) harmonic mean ; Time Mean Speed (V_t) arithmetic mean
- 98th percentile speed used for highway geometric design (SSD, OSD)
- 85th percentile speed used for posting regulatory speed limits