Fundamental parameters of traffic flow

Transportation Systems Engineering

Introduction

- Traffic flow
  - Complex movements
  - Stochastic in nature
- Traffic Engineering
  - Control and management of facilities
  - By modeling driver, vehicle, road, and environmental conditions

Traffic stream parameters

- Measures
  - Quantitative (for modeling)
  - Qualitative (for evaluation)
- Characteristics
  - Macroscopic
  - Microscopic

Traffic stream parameters

- Fundamental parameters
  - Speed
  - Flow
  - Density
- Derived parameters
  - Time headway
  - Space headway
  - Travel time

Speed

- A quality measurement of travel
  - Drivers and passengers perception of journey
  - Rate of motion in distance per unit of time
  - Speed or velocity is given by
    \[ v = \frac{d}{t} \]
  - Where
    - \( v \) is the speed of the vehicle in m/s
    - \( d \) is the distance traveled in meters
    - \( t \) time in seconds
- Various types
  - Spot speed
  - Running speed
  - Journey speed
  - Time mean speed
  - Space mean speed
Speed

• Spot Speed
  – instantaneous speed at a point
  – Application:
    • Geometrical design
    • Location and size of signs
    • Design of signals
    • Safe speed
    • Speed zoning
    • Accident analysis
    • Congestion analysis

Spot Speed measurement
  – Enoscope
  – Pressure contact tubes
  – Radar speedometer
  – Time-lapse photography
  – Video image processing

Running speed
  – Average speed over a stretch of road
  – Does not consider stop time
  – Takes care of variability in traffic and geometric conditions

Journey speed
  – Effective speed between two points
  – Journey speed < Running speed
  • journey follows a stop-go traffic
  – Journey speed ≈ Running speed
  • comfortable travel conditions.

Time and space mean speeds

• Time mean speed \( v_t \)
  – Average speed of all the vehicles passing a point on a highway over time period
  – Mean speed of vehicles over a period of time at a point in space
  – Point measurement

• Space mean speed \( v_s \)
Time and space mean speeds

- **Space mean speed** $v_s$
  - Average speed of all the vehicles in a given section of a highway at a given time instant
  - Mean speed over a space at a given instant of time
  - It is an instantaneous measurement

- **Relationship**
  - $v_s \neq v_s$ normal traffic
  - $v_s = v_s$ if all vehicles have same speed

Flow

- **Definition**
  - Number of vehicles that pass a point on a road during a specific time interval
  \[ q = \frac{n}{t} \]
  - $n$, number of vehicles passing a particular point in a road
  - $t$, time duration in hours
  - $q$, the flow vehicles/hour

- **Units**
  - Vehicle/day
  - Vehicle/hour
  - Vehicle/second

- **Variations of Volume with time**
  - Monthly
  - Weekly
  - Daily
  - Hourly

- **Type of averaging**
  - Average Annual Daily Traffic (AADT)
  - Average Annual Weekday Traffic (AAWT)
  - Average Daily Traffic (ADT)
  - Average Weekday Traffic (AWT)

- **Average Annual Daily Traffic (AADT)**
  - The average 24-hour traffic volume at a given location over a full 365-day year
  - Total number of vehicles passing the site in a year divided by 365

- **Average Annual Weekday Traffic (AAWT)**
  - The average 24-hour traffic volume occurring on weekdays over a full year
  - It is computed by dividing the total weekday traffic volume for the year by 260
Flow

• **Average Daily Traffic (ADT)**
  - An average 24-hour traffic volume at a given location for a period of time less than a year
    - Six months or a season
    - A month or week
  - ADT is valid only for the period over which it was measured

• **Average Weekday Traffic (AWT)**
  - Average 24-hour traffic volume occurring on weekdays for some period of time less than one year
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Flow

• **Measurements**
  - Manual counting
  - Detector/sensor counting
  - Moving-car observer method

Density

• **Definition**
  - Number of vehicles occupying a given stretch of road expressed as vehicles per km.
    \[
    n = \frac{n_x}{x}
    \]
  - \(n_x\) number of vehicles in the stretch
  - \(x\) distance in km
  - \(k\) flow vehicles/km

Derived parameters

• **Derived parameters**
  - Time headway or headway
    - Related to flow
  - Distance headway or spacing
    - Related to density
  - Travel time
    - Related to speed
**Derived parameters**

- **Time headway**
  - Time difference between any two successive vehicles when they cross a given point
  - Adding all headways
    \[ \sum_{i=1}^{n} h_i = t \]
  - But flow is defined as
    \[ q = \frac{n}{t} = \frac{n}{\sum_{i=1}^{n} h_i} = \frac{1}{h_{\text{ave}}} \]
  - Av. Headway = Inverse of flow

- **Distance headway**
  - Distance between corresponding points of two successive vehicles at any given time
  - Adding all the spacing
    \[ \sum_{i=1}^{n} s_i = x \]
  - But density is defined as
    \[ k = \frac{n}{x} = \frac{n}{\sum_{i=1}^{n} s_i} = \frac{1}{s_{\text{ave}}} \]
  - Av. Spacing = Inverse of density

**Derived parameters**

- **Travel time**
  - Travel time is inversely proportional to the speed
  - In practice, the speed of a vehicle fluctuates over time and the travel time represents an average measure

**Time-space diagram**

- **Trajectory**
  - A graph which gives position of vehicle with respect to time
  - The trajectory provide an intuitive, clear, and complete summary of vehicular motion in one dimension.

**Time-space diagram**

- **Single vehicle**

- **Multiple vehicle**
# Conclusion

- **Fundamental Parameters**
  - Flow or volume $q$
  - Density or concentration $k$
  - Speed: Time and space mean $v_s$ and $v_t$

- **Derived Parameters**
  - Headway $h$
  - Spacing $s$
  - Travel time $t$

- **Time-Space diagram**

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Thank You

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