Speed and Acceleration Characteristics at Metered On-ramps

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Presentation Overview

- Background
- Data Collection
- Data Extraction Procedure
- Data Analysis
- Major Findings
Problem Statement

- Metered On-ramp

Freeway Mainline

Downstream Acceleration Distance

Upstream Queue Storage Space
Problem Statement

- Tradeoff between acceleration length and queue storage space
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- Tradeoff between acceleration length and queue storage space

Proper ramp meter location
Field Cases

Hazel Blvd/WB 50, Sacramento, CA

12th Ave/NB 99, Sacramento, CA
Speed and Acceleration Measurement

- **Objectives**
  - Develop distance versus speed relationship for design
  - Explore distance versus acceleration profiles

- **Current Issues**
  - Out of dated data
  - Un-realistic assumptions

- **Challenge**
  - Measurement error
Previous Studies

Common Acceleration Models

(a) Constant model
(b) Dual-regime model
(c) Linear decreasing model
(d) Polynomial model
Previous Studies

Caltrans’s Probe Vehicle Testing (Oto, 1988)

- Average Acceleration Rate: 5.47 ft/s²
- $a_{100-400 \text{ ft.}} \approx \frac{1}{3} a_{0-100 \text{ ft.}}$
Previous Studies


(a) speed versus time, (b) acceleration versus time,
(b) (c) speed versus distance, (d) acceleration versus distance
Pilot Data Collection

Camera view on 40 feet mast
Pilot Data Collection

Parallel cameras with view overlapping
Pilot Data Collection

Probe vehicle equipped with GPS trajectory recorder
Pilot Data Collection

Camera view from un-manned drone at 150 ft.
Pilot Data Collection

Magnetic traffic counter
Pilot Data Collection

Parallel cameras with stopwatch synchronize the time
Field Data Collection
Field Data Collection

- Cone layout (Industrial Pkwy/NB ALA 880)
Data Extraction Procedure

\[ V_1 \rightarrow a(0 \sim S1) \rightarrow V_2 \rightarrow a(S1 \sim S2) \rightarrow V_3 \rightarrow a(S2 \sim S3) \]

\[ \frac{T_1}{2} \rightarrow a(t1 \sim t2) \rightarrow \frac{T_2}{2} \rightarrow a(t2 \sim t3) \rightarrow \frac{T_3}{2} \]

\[ v_0 \rightarrow v_{S1} \rightarrow v_{S1+S2} \rightarrow v_{S1+S2+S3} \]
Example of An Individual Sample
Example of An Individual Sample

![Graph showing acceleration vs. distance (ft.)](image-url)
Speed versus Distance Profile

Site: Fruitridge Rd/NB 99, Caltrans District 3

Distance - Speed Profile - Fruitridge/99

- 15th
- 50th
- 85th
Acceleration Length Design Recommendation
Average Acceleration vs. Distance Profile

Site: Fruitridge Rd/NB 99, Caltrans District 3
Taper vs. Parallel

Sites: Bradshow Rd/WB 50 & Fruitridge Rd/NB 99, Caltrans District 3
Passenger Car vs. Truck

Site: Industrial Pkwy/NB 880, Caltrans District 4
Three Stage Acceleration Behavior

Site: Douglas Blvd/WB I-80, Caltrans District 3
Three Stage Acceleration Behavior

Stage 1

Stage 2

Stage 3

530 ft.
Three Stage Acceleration Behavior

Site: Industrial Pkwy/NB ALA 880, Caltrans District 4
Three Stage Acceleration Behavior

Stage 1

Stage 2

Stage 3

400 ft.
Major Findings

- Passenger cars can usually accelerate from 0 mph to 40-45 mph in approximately 500 feet.
- Vehicles usually accelerate at a higher acceleration rate when the speed is lower and vice versa.
- A taper merging type ramp seems likely to generate higher acceleration rates compared with a parallel merging type ramp.
- A three stage acceleration behavior was observed at typical ramp metering sites in both Caltrans District 3 and District 4.
- The current used AASHTO acceleration lane length design standard seems to be too conservative for the modern vehicles.
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References


Questions and Discussions

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