Operational Performance Evaluation of Four Types of Exit Ramps on Florida's Freeways

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Outline

1. Introduction
2. Research Objective
3. Data Collection and Simulation
4. Freeway Section Analysis
5. Exit Ramp Section Analysis
6. Cross Road Section Analysis
7. Future Work
Introduction

In the State of Florida, several types of exit ramps are used for traffic to exit our freeways.

Drivers exiting freeways need to make decisions and execute maneuvers (i.e., lane change or lane merge) prior to the exit ramp in order to access cross roads at the interchanges.

Several issues and concerns need to be addressed in selecting the most optimum types of freeway exit ramps to use at a given interchange.
There are several types of exit ramps used for traffic to exit freeways in Florida. Typically, four types of freeway exit ramps are most widely used.

Type 1: Single-lane exit ramp with an taper

Upstream 1500ft
Introduction – Ramp Types

Type 2 : Single-lane exit ramp without an taper
Type 3: Two-lane exit ramp with an optional lane.
Introduction – Ramp Types

Type 4: Two-lane exit ramp without an optional lane
Introduction – Interchange Sections
Research Objective

To understand the impacts of different ramp types that affect the operational performances of freeway, ramp and even cross road.

To develop technical guidelines governing the selection of optimum exit ramp types to be used on Florida’s freeways, including some design issues.
## Data Collection

### List of Observing Sites

<table>
<thead>
<tr>
<th>No.</th>
<th>Observing Sites</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I-75 at Fowler Avenue</td>
<td>Tampa</td>
</tr>
<tr>
<td>2</td>
<td>I-4 at I-75</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I-4 at CR 579</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I-75 at SR 56</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I-275 at Hillsborough Ave</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I-275 at Ulmerton Road</td>
<td>St Pete</td>
</tr>
<tr>
<td>7</td>
<td>I-275 at 4th Street</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>I-4 at Universal Blvd</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>I-4 at Conroy Road</td>
<td>Orlando</td>
</tr>
<tr>
<td>10</td>
<td>I-4 at Lee Road</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>I-4 at Altamont Dr (SR 436)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>I-4 at SR 434</td>
<td></td>
</tr>
</tbody>
</table>
## Data Collection

### Methods of Data Collection

<table>
<thead>
<tr>
<th>Observing Time</th>
<th>Parameters</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 to 8:00 am or 5:00 to 6:00 pm</td>
<td>Hourly volume of each lane and total HV ratio in freeway</td>
<td>Counted by observer</td>
</tr>
<tr>
<td></td>
<td>Number of lane change in freeway in front of painted nose of exit ramp</td>
<td>Counted by observer</td>
</tr>
<tr>
<td></td>
<td>Hourly volume of each lane and total HV ratio in ramp terminal</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Queuing length of each lane in ramp terminal</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Signal timing and phasing in ramp terminal</td>
<td>Read by observer using timer</td>
</tr>
<tr>
<td></td>
<td>Speed in freeway and ramp</td>
<td>By radar gun</td>
</tr>
<tr>
<td>8:00 to 9:00 am or 6:00 to 7:00 pm</td>
<td>Hourly volume of each lane and total HV ratio of each approach (downstream intersection)</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Queuing length of each lane in each approach (downstream intersection)</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Signal timing and phasing in downstream intersection</td>
<td>Read by observer using timer</td>
</tr>
<tr>
<td></td>
<td>Hourly volume of each lane and total HV ratio of each approach (upstream intersection)</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Queuing length of each lane in each approach (upstream intersection)</td>
<td>By video camera</td>
</tr>
<tr>
<td></td>
<td>Signal timing and phasing in upstream intersection</td>
<td>Read by observer using timer</td>
</tr>
<tr>
<td></td>
<td>Speed in downstream and upstream intersection</td>
<td>By radar gun</td>
</tr>
</tbody>
</table>
### Data Collection - Example

#### Upstream Intersection

<table>
<thead>
<tr>
<th>Phase</th>
<th>Green time (s)</th>
<th>Yellow time (s)</th>
<th>Red time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>165</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Data Collection - Example

<table>
<thead>
<tr>
<th>Phase</th>
<th>Green time (s)</th>
<th>Yellow time (s)</th>
<th>Red time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>160</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
### Data Collection - Example

![Diagram of an intersection](image)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Green time (s)</th>
<th>Yellow time (s)</th>
<th>Red time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Data Collection - Example

Freeway

Ramp

2000ft: 56mph
1600ft: 56mph
1200ft: 56mph
800ft: 56mph
400ft: 56mph
Painted Nose: 56mph

12% incline

10ft

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Data Collection
Data Collection

TRAFED Window in CORSIM
Freeway Section Analysis

Number of Lane Change

Number of lane change is the total number of vehicles changing lanes in the upstream section (1500 ft ahead of painted nose point) on freeway.

An exponential model was presented to estimate number of lane change, independent variables included ramp types.
Freeway Section Analysis

Number of Lane Change

\[ Y = \exp(a_0 + a_1 X_1 + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9) \]

Where,
- \( Y \) – Expected number of lane change,
- \( X_1 \) – 1 if exit ramp type I, 0 others,
- \( X_2 \) – 1 if exit ramp type II, 0 others,
- \( X_3 \) – 1 if exit ramp type III, 0 others,
- \( X_4 \) – 1 if exit ramp type IV, 0 others,
- \( X_5 \) – Num of lanes on freeway,
- \( X_6 \) – Number of Lane Drop,
- \( X_7 \) – Volume on freeway,
- \( X_8 \) – Volume on ramp, and
- \( X_9 \) – Average speed.
Speed Distribution and Difference

Data of speed distribution and difference were calculated by CORSIM at the area of 1500 ft before painted nose and 1000 ft after it. All ramp types were changed respectively for each site. And detectors were set up to help get speed characteristics.

Based on data analysis of CORSIM, different ramp types effected freeway performances in speed.
Ramp Section Analysis

Speed Distribution and Super Elevation

Super elevation of ramp curvature based on fixed speed value can not match the situations in practical terms.

Data collection of speed distribution on ramp might help improve the design of super elevation.
Ramp Section Analysis

Speed Distribution on Ramp

Distance from painted nose on ramp (ft)

Speed (mph)
Ramp Section Analysis

Ramp Length

The design of ramp length shall satisfy this assumption, traffic in ramp shall never spill back to freeway section even in peak hour.

A more rigorous requirement needs enough space on ramp longer than deceleration distance to hold vehicles from freeway, besides queues on ramp.
Number of Lanes

Enough number of lanes can satisfy the needs of capacity and LOS, but not the more the better.

More lanes on ramp may result in the increase of speed difference, number of lane change, unbalanced lane utilization and etc, which will deteriorate ramp performance.

By changing number of lanes on ramp in CORSIM, performance of each scenario was compared to give quantified evaluations.
Ramp Section Analysis

Ramp Terminal

Some characteristics of ramp terminals were changed to see the affection to traffic on ramp.

These factors included control type (signal, yield, or stop control), adding left/right turn bays, channelized islands, and acceleration lanes.
Distance between up/downstream and terminal

The cross road connects exit ramp and transfers traffic from ramp. The design of cross road affects significantly safety and operational performance of ramp.

And the most important design parameters on cross road are the distance between ramp terminal and downstream/upstream intersections.
A method based on conflict analysis was used to determine the minimal distance between up/downstream intersection and ramp terminal before.

But traffic conflicts are difficult to observe, which require a great amount of work.

By using CORSIM, a method based on queuing length was used to present the minimal distance.
The distance between up/downstream intersection and ramp terminal shall be long enough to hold queuing length of each lane. Besides that, another distance for vehicles changing lanes to the right direction.

For each site, distance was changed to find out the critical value.

\[ D_{\text{min}} = f (\text{Volume, timing plan, number of lanes, speed}) \]
Future Work

Finish all simulations in CORSIM, and read results from it.

Analyze results of each site, find relationship among each variable, build up models to estimate some key characteristics.

Based on results and models, present some guidelines for choosing exit ramps and design issues.
THE END

Questions Welcome!