Interchanges in an Urban Environment

Transportation Education Series
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Presentation overview

• Interchanges categories, forms, and types
• Ramp spacing – NCHRP Report 687
• Interchange design considerations
• Access management within interchange influence area
• Multimodal considerations
• Case studies
  – OR213: I-205 to Redland Road Overcrossing
  – Glenn Highway and Muldoon Interchange
• Public involvement tools
## General Categories of Interchanges

<table>
<thead>
<tr>
<th>Crossroad Facility</th>
<th>Rural</th>
<th>Suburban</th>
<th>Urban</th>
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</thead>
<tbody>
<tr>
<td>Local Road or Minor Street</td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
</tr>
<tr>
<td>Primary Highway or Major Street</td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
</tr>
<tr>
<td>Freeway</td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
<td><img src="#" alt="Image" /></td>
</tr>
</tbody>
</table>

## Interchanges – General Types

- **Tand Y Interchanges**
  - Trumpet-Y
  - Diamond
  - Roundabout
  - Partial (Parclo) Cloverleaf

- **Cloverleaves**
  - Diamond
  - Cloverleaf
  - DIRECTIONAL WITH LOOPS
  - ALL-DIRECTIONAL

- **Directional Interchanges**
Partial Cloverleaf (PARCLO) Forms

- PARCLO - A
- PARCLO - A (2 QUAD)
- PARCLO - B
- PARCLO - B (2 QUAD)
- PARCLO - AB
- SINGLE LOOP

Interchanges - Diamond Forms

- Conventional Diamond
- Split Diamond
- Three-Level Diamond
- Tight Diamond
- Single-Point Diamond
- Three-Level Stacked Diamond
System Interchanges

• Freeway to Freeway (Florida)

Service Interchanges

• Freeway to Arterial (Walter J Hickel Pkwy/C St)
Cloverleaf Interchanges

- Interchanges with primary Highway in Rural Area
- Collector Distributor roads along each roadway
- Challenging pedestrian environment

Partial Cloverleaf (Parclo) Interchanges

- Highest capacity service interchange form
- Loops located to facilitate left turns
- Left turns store on ramps for “A” forms and on cross road for “B” forms
- Two or three phase signal depending on the configuration
High Capacity Diamond Interchanges

• **Single Point Diamond**
  – Single Intersection
  – Three Phase Signal
  – High Capacity
  – Narrow footprint

• **Tight Diamond**
  – Coordinated Overlap cycles
  – Four Phase Signal
  – Narrow footprint
  – Flexible to frontage roads

Skew negatively affects both of these diamond forms....

Single Point Interchange

Medford, Oregon
Roundabout Interchange Terminals

- Richardson Hwy/Badger Rd

High Capacity Diamond Interchanges

- Diverging Diamond (DDI)
  - Transposed travel streams
  - Two “cross overs”
  - Two phase Signals
  - Supported by FHWA as part of “Every Day Counts” Initiative.
Ramp Spacing – NCHRP Project 687

Project Report 687 focuses on “ramp spacing”

Ramp Spacing Guidance – Traffic Operations

- Considerations include
  - Mainline freeway
  - Ramp terminal intersections
  - Isolated merges and diverges
  - Closely spaced merges and diverges
Ramp Spacing Guidance - Geometry

• EN-EX Ramp Spacing Guidance

Between Diamond Interchanges

<table>
<thead>
<tr>
<th>Ramp Spacing Dimension</th>
<th>Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1800'</td>
<td>Likely Not Geometrically Feasible</td>
</tr>
<tr>
<td>1800' to 2600'</td>
<td>Potentially Geometrically Feasible</td>
</tr>
<tr>
<td>Greater than 2600'</td>
<td>Likely Geometrically Feasible</td>
</tr>
</tbody>
</table>

Design Elements Affecting Ramp Spacing Needs

• Single entrance (or exit) versus double entrance design
Design Elements Affecting Ramp Spacing Needs

• Turning Roadways
  – Convergence Angle

Interchange Design Considerations

• Vertical Clearance and its Impact on Approaching Roadway Lengths
• Freeway On- and Off-Ramp Lengths
• Loop Ramp Design Guidelines
• Driver Expectations
Vertical Clearance & Impact on Approaching Roadway Lengths

Example:

- 17.5 ft is a typical clearance height plus 7 ft for the structure = 25 ft.
- 3% is a typical maximum design grade for a highway crossroad.
- The approaching highway crossroad would need to be approximately 1,035 feet to elevate up to 25 feet.

Design Elements Affecting Ramp Design

- Ramp Design Components

NCHRP Report 687
Design Elements Affecting Ramp Design

- Queue storage needs
- Terrain and grades

Sight Distance Needs
Loop Design Guidelines

- A minimum radius is required when designing loop ramps to accommodate speed and grade requirements. For example, Oregon DOT:
  - Minimum Entrance Ramp radius – 160 feet
  - Minimum Exit Ramp radius – 190 feet

Driver Expectations

- Interchange should be consistent with other interchange forms along the highway
- Exit and entrance ramps should occur on the right side of the roadway (general purpose lanes)
- Single exit designs in advance of the cross street
- Ramps should be designed to typical acceleration and deceleration characteristics.
ODOT Interchange Access Spacing Requirements

- Minimum distance to first major intersection – 1,320’

- Minimum distance to first driveway beyond ramp terminal (limited to right-in/right-out) – 750’.
Multimodal Considerations

• Pedestrian Accessibility
  – National Guidance
  – Pedestrian ramps
  – Intersection layouts

• Bike Facilities
  – Shoulder bikeway / Conventional bike lanes
  – Colored pavement in conflict area / Bike signal
  – Bike box / Two-stage left-turn queue box

Americans With Disabilities Act (ADA)

• The ADAAG covers pedestrian access to sidewalks and streets, including the following:
  – Crosswalks,
  – Curb ramps,
  – Street furnishings,
  – Parking, and
  – Other components of public rights-of-way
New ADAAG Recommendations
(These Have NOT Been Adopted)

- Maximum 2% cross slope (perpendicular) for all crosswalks at intersections
- Maximum 5% running slope (longitudinal) for all crosswalks at intersections
- 3.5 ft/sec pedestrian crossing speed

New ADAAG Recommendations
(These Have NOT Been Adopted)

- Pedestrian-activated signals at all crosswalks at multilane roundabouts
- Pedestrian-activated signals at all right-turn slip lanes at intersections
- Minimum crosswalk width of 8 feet
- Audible and vibrating pedestrian signal indications
Right-turn slip lane: Design for pedestrians

Old Way

- Wide Angle
- 20° between vehicle flows.
- High speed, low visibility of pedestrians, head turner

Better Way

- Tighter angle
- 55 to 60° degree angle between vehicle flows.
- Slower vehicle speeds, good visibility of pedestrians

Perpendicular Pedestrian Ramp

- Oregon DOT

Flare slopes 10% for landings 4’ or wider and 8.33% for landings between 3’ and 4’ wide.

Landing (L) New Constr. 4’ min.
Alternatives 3’ min.

- 0.02
(See Gen. Note 5)
Parallel Pedestrian Ramp

- Oregon DOT

Pedestrian Ramp

- Orientation?
Pedestrian Ramp and Crosswalk Layout

• Crosswalk timing can have impact on intersection capacity

Pedestrian / Bike Treatments at Ramp Terminals

Complete Streets – Caltrans
Pedestrian / Bike Treatments at Ramp Terminals

Figure 9.6  Double-Lane Free-Flow On-Ramp Treatments
Classifie Two Movements

Figure 9.7  Treatments for Dual-Lane On-Ramps

Pedestrian / Bike Treatments at Ramp Terminals

Figure 9.8  Common Pedestrian and Bicycle Issues at Single Point Interchanges

1. It may take a pedestrian as many as four signal cycles to cross the interchange.
2. Large intersection exposes bicyclists to motor vehicles.
3. Pedestrians are prohibited from crossing the local street.
4. Through phases may not be long enough to allow a bicyclist to clear the intersection.
Pedestrian / Bike Treatments at Ramp Terminals

Figure 9-9  Treatments for Pedestrians and bicyclists at Single Point Interchanges

- Bicycle push button
- Bring the free right turn movement under STOP control
- Install bicycle push button to allow bicyclists to call for more time on next green cycle
- Install pedestrian push buttons
- Construct only a single free right turn lane

Shoulder Bikeway

Conventional Bike Lane
Colored Pavement in Conflict Zones

Bicycle Signal

Bike Box

Two-Stage Left-Turn Queue Boxes
Case Study: OR213: I-205 to Redland Road Overcrossing

Project History

- ODOT’s OR213 Corridor Study (June 2000)
- Oregon City is a 2040 Regional Center in the Metro Plan
- Anticipated Development
Project History

- Rivers at Oregon City Development
  - 10 corridor improvement concepts considered
  - Jughandle concept selected
  - Fall 2008 - Project put on hold

Project History

- Important to the regional transportation system
- City led the project
- Obtained JTA funding for Phase 1
Transportation Issues & Solutions

No Build Configuration
- Cross Weave
- At-grade Signalized Intersection
- Only 2 Northbound Lanes
- 3rd Lane Becomes Trap Lane

Proposed Improvements
- Grade Separation
- Reduced Cross Weave
- 3 Lanes in Each Direction

Traffic Operations: Weave & Segment

No-Build Condition
- $V_i = 145$ veh
- $V_i = 295$ veh

Proposed Improvements
- $V_i = 590$ veh
- Available Distance = 1,065'
Traffic Operations: Weave & Segment

- Procedure for Design Analysis of Frontage Road Weaving Sections (Joel Leisch, 1996)

- Input parameters
  - Through volume $V_1$
  - Total weaving volume $V_2$
  - Total Volume, $V_t = V_1 + V_2$
  - Estimated queue length downstream, $L_q$
  - Estimated stopping distance to the back of queue, $L_s$
  - Estimated weave length prior to stopping at back of queue, $L_w$
  - Total distance required to complete weave, $L_t = L_q + L_s + L_w$

Traffic Operations: Weave & Segment

- Proposed Improvements

- Required Weave Distance

<table>
<thead>
<tr>
<th>Direction</th>
<th>Weave Movement</th>
<th>$V_1$ (veh/hr)</th>
<th>$V_2$ (veh/hr)</th>
<th>$V_t$ (veh/hr)</th>
<th>$L_q$ (ft)</th>
<th>$L_s$ (ft)</th>
<th>$L_w$ (ft)</th>
<th>$L_t$ (ft)</th>
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</thead>
<tbody>
<tr>
<td>Southbound</td>
<td>L-R</td>
<td>3,745</td>
<td>590</td>
<td>4,335</td>
<td>165</td>
<td>775</td>
<td>80</td>
<td>1,020</td>
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</table>
Bridge Construction – Accelerated Construction

- Nighttime lane closures
- 18-24 month project construction duration
- Short-duration closure

- Construct foundations during nightly lane closures
- Construct the bridge girders, deck and rail adjacent to OR213
- 104 hour closure of OR 213 to move bridge
Extensive Public Outreach

- Traffic Flow
- Webpage Traffic
- Public Comments

"...I want to congratulate you on a job well done. ODOT did an outstanding job with getting the word out, carefully preparing for the event and providing a number of traffic controllers to direct traffic. Thank you!"
-Wendy Kaba, Beavercreek Resident

Video of Bridge Move During 4-Day Closure
Case Study: Glenn Hwy & Muldoon Rd Interchange

Ramp Design Basics

• Freeway Ramp Terminals
  – Single exit design
  – In advance of the cross street
  – Adequate spacing between ramp elements
  – Provide lane balance on the freeway
  – Provide Stopping and Decision Sight Distance

• Ramp Terminal Intersections
  – Appropriate intersection control
  – Appropriate attributes for the environment
  – Visibility for all users
Assessing the Existing Interchange

Freeway: Northbound

Assessing the Existing Interchange

Freeway: Southbound
Assessing Existing Interchange

Basic Lanes in each direction

Assessing the Existing Interchange

Capacity Limitations

Lane drop

Capacity constrained
Left turns
Assessing Existing Interchange

Pedestrian Quality of Service Challenges

- No pedestrian facilities on west side of bridge
- Circuitous route on east side

Challenging Crossing

Assessing the Existing Interchange

NB Ramp terminal intersection

“Urbanize” the ramp terminal intersection
Assessing the Existing Interchange

SB Ramp terminal intersection

2040 Design Hour Turning Movements
Tight Diamond – LOS & Delay

Partial Clover Type B – LOS & Delay
Workshop Tools – Public Involvement

• Tell Me:
  – Understanding of the components and implementation tools

• Show Me:
  – Integrating several “101” short courses into meetings/workshops for understand trade-offs

• Involve Me:
  – Engaging the stakeholders/general public to develop formal concepts

Freeway On- and Off-Ramp Lengths

• Minimum distances are required for a vehicle to decelerate off of the freeway to stop at ramp terminal.
  – Start with a minimum 1,200 foot

• Minimum distances are required for a vehicle to accelerate onto a freeway from the ramp terminal.
  – Start with a minimum 1,500 foot
Interchange design tool

• Scaled to match the aerial

• Shows common measurements such as minimum ramp lengths, loop ramp radii, access spacing standards, etc.

How to Use the Tool
Concept Developed by Public

Questions?

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