Diverging Diamond Interchanges

KSPE June 2018
Diverging Diamond Interchange (DDI)

History

- Traffic crosses over to the opposite lanes at the ramp terminals.
- First DDI was constructed in France in the 1970s.
- First DDI to be constructed in Springfield, Missouri (June 2009).
DDI’s in the United States

- Over 90 DDI interchanges open in the US to date
- Over 200 DDI’s under study, design, construction or open in the US
- Currently in at least 29 States
  - MO (18)
  - NC (11)
  - UT (8)
  - KS (6)
  - MN (6)
- Kansas in the Top 5
Constructed DDI’s in Kansas

- K-18 & K-113 (Seth Child Road)
- I-435 & Roe Ave
- I-35 & 95th St
- K-10 & Ridgeview Rd.
- I-70 & US-77
- I-35 & Homestead Lane
- I-35 & Gardner Road (Selected Alternative)
When should you consider a DDI?

- If the existing diamond interchange is approaching, at, or exceeding capacity
- Traffic is headed to and from the highway instead of straight through the interchange
- Where conventional improvements are prohibitive on account of expensive ROW or surrounding economic activity
- When you have a high volume of left turn movements
DDI Cost and Impact Advantages

- May reduce costs by retrofitting existing structures
- Potentially reduces the number of lanes on the crossroad, minimizing space consumption
- Retrofit has minimal impact to R/W footprint
DDI Operational Advantages

- Two-phase signals with short cycle lengths
- Increases the capacity of an existing overpass or underpass by accommodating higher left turn movements
- Simplified left and right turns
- Bicycle and Pedestrian Accommodations
- U-Turn Movements from Highway
DDI Disadvantages

- Drivers may not be familiar with configuration
- Free-flowing traffic in both directions on the non-freeway road is not possible. Could be an issue with high volumes of traffic
- Oversize load restrictions
- Off-ramp traffic might not be able to re-enter the highway
- Pedestrian accommodations may negatively effect the interchange operations with extra signals
- DDI’s might not work well when adjacent crossroads are too close
I-435 & Roe Ave. DDI (Oct 2014)
I-435 & Roe Ave. Construction
DDI Safety Advantages

- Less total conflict points vs. standard diamond interchange
- Conflict points spread out throughout interchange
- Improved sight distance
- Traffic calming effect with lower speeds - eliminate wrong way movements on ramp
- Wrong way entry to ramps are difficult
Collision Reduction

- A recent study by the Transportation Research Board, Safety Evaluation of the Seven Earliest Diverging Diamond Interchange Installed in the US, shows that converting a traditional diamond interchange to a DDI

  - Reduced Collisions by 33%
  - Reduced Injury Collisions by 41%
Pre-Project Crashes (2011-2013)

91 Total Crashes

High-Concentration of Left Turn Crashes

High-Concentration of Rear-End Crashes

Legend

Accident Types
- Rear end - 43
- Angle - 8
- Sideswipe - 2
- Loss of control - 1
- Fixed object - 7
- Left turn opposing - 28
- Other - 2

Before
91 Total Crashes

52 Total Crashes

Legend
Accident Types
- Rear end - 23
- Angle - 4
- Sideswipe opposing - 1
- Sideswipe - 12
- Loss of control - 1
- Fixed object - 10
- Left turn opposing - 1
Pedestrian Accommodation

Case by case basis but carrying pedestrians in the center island is becoming a first option to investigate.
I-35 and 95th Street, Lenexa (Aug. 2016)

Gateway Interchange Constructors, LLC
- Clarkson Construction Co.
- Kiewit Infrastructure Co.
- HDR Engineering, Inc.
- GBA
K-10 and Ridgeview Road, Kansas City (July 2015)

Gateway Interchange Constructors, LLC
- Clarkson Construction Co.
- Kiewit Infrastructure Co.
- HDR Engineering, Inc.
- GBA
Retrofit Existing Diamond Interchange to a DDI

Project Began with a Value Planning Study for the City of Manhattan, KS

Providing opportunity for U-turn construction traffic for the K-18 Wildcat Creek Bridge Replacement project
K-18 / K-113 MANHATTAN, KANSAS

South Half Construction
North Half Construction
Turn on Red ??

Left - The MUTCD says if you encounter a red arrow, a left turn is not allowed. Some believe a DDI could be viewed as a one way street or that any movement can be made unless it is restricted by signing.

Right - Be able to see where traffic is coming from.
I-35 and Homestead Lane, Edgerton (Oct 2013)
I-35 & Homestead Lane – DDI Selection

- **Project Need**
  - Demand for improved access to I-35 in SW Johnson County
  - BNSF Intermodal Facility and Logistics Park Traffic Increase

- **Project Purpose**
  - Provide adequate capacity to address increase in local traffic
  - Provide access to planned development

- **Social, Economic and Sustainable Design Considerations**
I-70 & US-77, Junction City Retrofit (December 2016)
I-70 & US-77 Key Features

▪ Selection based on:
  – I-70 bridges to remain
  – Met left-turn needs (No space for left turn bay)
  – Provided the best operational Level of Service
  – Improved safety with fewer conflict points
  – Traffic calming transition from rural to urban roadway

▪ Challenges
  – Keeping interchange fully open during construction
  – Sight distance in constrained space
  – Avoidance of adjacent development
  – Construction around existing bridge footings
I-35 & Gardner Road
(Selected Alternative May 2018) Retrofit
I-35 & Gardner Road Key Features

- Serving Logistics Park KC Traffic
- High Left Turning Volumes
- Limited Left Turn Storage between Ramp Terminal and Local Road

Existing Conditions
- Result in queuing traffic on I-35
- Result in risky turning movements with limited gaps on Gardner Road
- 191st Street Intersections too close to Ramp Terminals

Proposed Design
- DDI Retrofit
- Relocation of 191st Street North and South
## Retrofit vs New Construction

<table>
<thead>
<tr>
<th>Retrofit</th>
<th>New Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimizes New R/W</td>
<td>More R/W Needed</td>
</tr>
<tr>
<td>Compact Ramp Terminal Intersections</td>
<td>May allow for Larger footprint Ramp Terminals</td>
</tr>
<tr>
<td>Complicated Construction Sequencing and MOT</td>
<td>Simpler MOT</td>
</tr>
<tr>
<td>Limited space for signing</td>
<td>Expanded areas for signing</td>
</tr>
<tr>
<td>May preserve existing bridges</td>
<td>New Bridges</td>
</tr>
<tr>
<td>Lower Cost</td>
<td>Higher Cost</td>
</tr>
<tr>
<td>I-70 &amp; US-77 - $7.0M</td>
<td>Homestead Lane - $21.3M</td>
</tr>
<tr>
<td>I-435 &amp; Roe Ave - $9.5M</td>
<td></td>
</tr>
<tr>
<td>K-18 &amp; K-113 (Seth Child) - $2.6M</td>
<td></td>
</tr>
</tbody>
</table>
Design Elements

- Through traffic passenger vehicles should be able to proceed at 20-30 mph. WB-67’s should be able to proceed at 20 mph.

- Considerations should be made for intersection sight distance and the location of concrete safety barrier

- Utilize 12’ lane widths and then adjust based on off-tracking, receiving lanes should be a 14’ to 16’ lane width
Design Elements

- The horizontal crossover geometrics is the major controlling element of DDI design speed.
  - the crossing angle of the crossover
  - The tangent length approaching and following the crossover
  - Curve radii approaching and following the crossover

Curves can range from 150-300’
Lessons Learned

Check overhead bridge clearance taking into account road crowning, changes to drainage and new pavement thickness

Check for sufficient distance between intersections adjacent to DDI to allow vehicles to naturally end their target lane

Properly line up ramp lanes with DDI receiving lanes- check the intersection sight distance with a crest/sag curve

Don't assume existing drainage will be adequate when converting an existing interchange to DDI
Any Questions??