SINGLE LANE, MULTI LANE AND MINI ROUNDABOUTS: The Geometric Aspects

Presented by
Nazir Lalani
Nazirlalani1@gmail.com

ASCE | KNOWLEDGE & LEARNING

ASCE | KNOWLEDGE & LEARNING

Meet Your Instructor

- Course instructor for UC Berkeley on classes concerning on roundabouts
- Reviewer of many roundabout projects for five public agencies
- Responsible for implementing many mini-roundabouts in London
- Reviewed many roundabout locations both before and after construction of the roundabouts
- Provided peer review of roundabout designs by other transportation professionals
- Specialized expertise on designing roundabouts for all road users

2

Webinar Outcomes

- How to use to use the tools already in existence to design better roundabouts
- Learn about most critical components of roundabout design that affect crash rates
- Become familiar with the most current research about on roundabouts from various publications
- Learn from case studies of roundabouts that were not designed well and resulted in problems

ASCE | KNOWLEDGE & LEARNING

Participants - Be Ready to Answer Questions About Fixing Broken Roundabouts!

Which Roundabout is the Right Choice?
(Single lane, two-lane or more)

5

Planning Stages for a Roundabout (NCHRP 672)

- Planning Steps
- Considerations of Context
- Potential Applications
- Planning-Level Sizing and Space Requirements
- Comparing Performance of Alternative Intersection Types
- Economic Evaluation
- Public Involvement


Report No. K-TRAN: KSU-09-10 · FINAL REPORT · November 2012

A Study of the Impact of Roundabouts on Traffic Flows and Business

Eugene R. Russell, Ph.D., P.E.
E. Dean Landman, Ph.D.
Ranjit Godavarthy

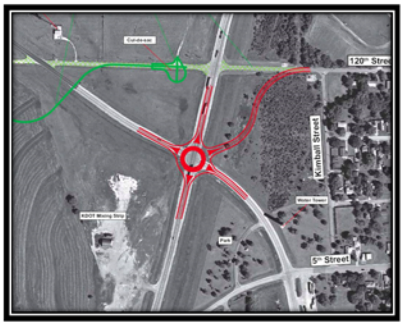
Kansas State University Transportation Center

A cooperative transportation research program between
Kansas Department of Transportation,
Kansas State University Transportation Center, and
The University of Kansas

Kansas
Department of Transportation

6

Provides New Alternatives



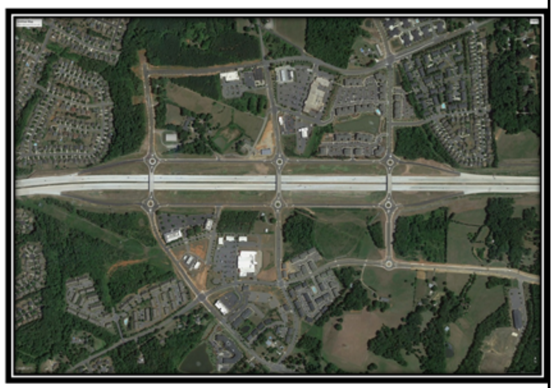


Table 6.1: Florida DOT Contraindicating Factors for Roundabouts

Factor	Analysis
Physical or geometric complications that make it impossible or uneconomical to construct a roundabout.	The conceptual layout (Figure 6.6) demonstrates suitability.
Proximity of generators of significant traffic that might have difficulty negotiating the roundabout.	No such generators are known to exist nearby.
Proximity of other traffic control devices that would require preemption, such as railroad tracks, drawbridges, etc.	No such traffic control devices exist nearby.
Proximity of bottlenecks that would routinely back up traffic into the roundabout, such as overcapacity signals, freeway entrance ramps.	The Perris Boulevard/Sunnymead Boulevard intersection's impact to this intersection is to be analyzed in the CAR (see "Recommendations").
Problems of grades or unfavorable topography that may limit visibility or complicate construction.	Topography and grades are favorable.
Intersections of a major arterial and a minor arterial or local road where an unacceptable delay to the major road is created.	Delay to Sunnymead Boulevard traffic is expected to be reasonable, to be confirmed in the CAR.
Heavy pedestrian movements that would have trouble crossing the road because of high traffic volumes.	Pedestrian traffic is light, and no pedestrian attractions are found on the north side of the street.
Isolated intersections located within a coordinated signal network.	The subject intersection is not found in a coordinated signal network.
Roadways with reversible lanes for morning and afternoon peak periods.	Reversible lanes are neither present nor planned.
Routes where large combination vehicles or over-dimensional vehicles will frequently use the intersection and insufficient space is available.	The roundabout will be designed to accommodate the occasional large truck.
Locations where vehicles exiting the roundabout would be interrupted by downstream traffic control that could create queues backing up into the roundabout.	The Perris Boulevard/Sunnymead Boulevard intersection's impact to this intersection is to be analyzed in the CAR.
Areas with a large number of cyclists.	The intersection is traversed only by the occasional cyclist.

Source: *Florida Roundabout Guide*, Section 2.2

ROUNDABOUT BY PRINCIPLE:
FOCUSING ON OPERATIONAL PRINCIPLES IN DESIGNING CHALLENGING RURAL ROUNDABOUT

Josh Thomson

Abstract: Roundabouts are at their core an operational negotiation between users; driver, bicyclists, and pedestrians. The author of this paper takes the positions that while well defined design standards, typical in other modes of intersection right-of-way control, are important it is of greater importance in roundabout design to focus on the operational principles. This argument is supported with this case study of the safe and efficient design of a five legged roundabout accommodating multiple challenging performance criterions. The subject roundabout is located on Old US 40 west of Reno, Nevada and has the primary function of providing a new access to a large residential development. A combination of context-dictated criteria excluded standard roundabout dimensions and features, leaving the designers without the standard tools and guidelines we are becoming accustomed to. By concentrating on the principles that result in a safe and efficient roundabout, the author contends that this non-conventional intersection overcame the obstacles and resulted in an innovative and functional improvement.

OVERVIEW

Transportation professionals who have been immersed in traffic operations for an extended period of time will likely come to fully appreciate the elegant simplicity of roundabouts. This author is beginning to embrace that roundabouts are here to stay, and for good reason. This paper is a case study of how the few guiding principles of roundabout operations were applied in challenging circumstances to generate an overall design meeting those challenges; providing safety and reducing congestion. In the *Context* section a brief explanation of the various contextual elements are brought together to provide the reader insight into this design effort. The *Criterion* section details the performance criterion set forth for the roundabout. The *Operational Principles* section details the guiding operational principles that guide both the conceptual thinking about the design and the specific details. In the *Product* section a schematic of the final design layout is provided for the reader to provide their own critique. There is an included discussion of how each challenging criterion was met. The final section, *Closing Thoughts*, once again allows the author to indulge his personal journey into full appreciation of the *elegant simplicity* of roundabouts.

CONTEXT

This project took place on historic Old US Highway 40 as it begins its journey from the Truckee Meadows of Northern Nevada to the Sierra-Nevada Mountains of California. This is a majestic expanse of land with inspiring vistas as witnessed by the many homes being built on the river banks and nearby ridges. Similarly, several large tracts of land have subdivided to provide additional housing, leading to a mix of long-standing residents and relatively new residents in the Verdi community west of the Reno, Nevada. One such development, Somersett, is situated north

Figure 2: *Old US 40 and Somersett Ridge Parkway Roundabout*

- ✓ Accommodate five legs
- ✓ Provide a 180 degree right turn
- ✓ Allow for U-turns of WB-50 tractor trailers
- ✓ Ensure stalled vehicles can be passed
- ✓ Incorporate marketing elements of new residential development
- ✓ Maintain ingress-egress for the trucking firm
- ✓ Perpetuate regional bike route transferring from roadway shoulders to bike path
- ✓ Meet the requirements of state and city standards

9

Operations Analysis for Proposed Roundabout (NCHRP 672)

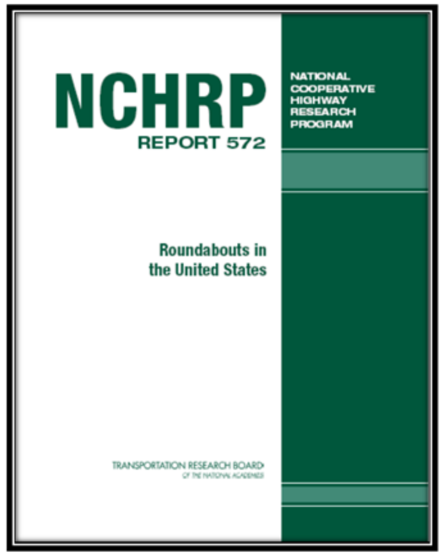
- Data Collection and Analysis
- Analysis Techniques
- Highway Capacity Manual Method
- Deterministic Software Methods
- Simulation Methods
- Lanes needed/approximate size of Inscribed Circle
- Preliminary Right of Way Requirements

10

Roundabout Capacity Software

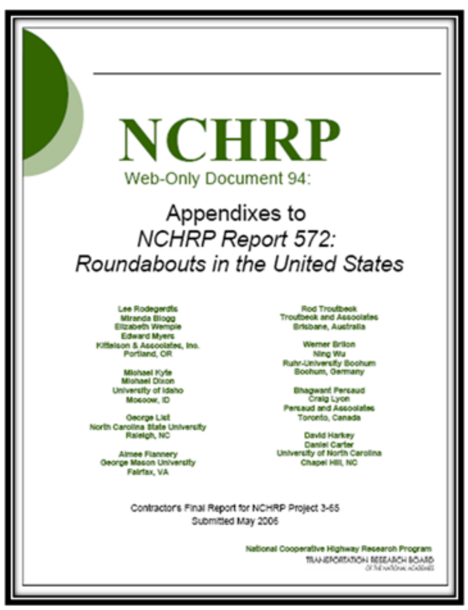
- **NCHRP 572:**

  Both methods overestimate capacity for U.S. conditions. Chapter 3 discussed models calibration for US conditions



http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_572.pdf

Appendix To Report 572



http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w94.pdf

Roundabout Characteristics Before Condition	# of Sites	Percent Reduction in Crashes		
		Total	PDO	Injury
Single Lane, Urban Stop Controlled	12	69%	67%	80%
Single Lane, Rural Stop Controlled	9	65%	63%	68%
Multi Lane, Urban Stop Controlled	7	8%	0%	73%
Urban Signalized	5	37%	31%	75%
All Sites	**33**	**47%**	**41%**	**72%**

Source: Ken E. Johnson, Mn/DOT Office of Traffic, Safety, and Technology, Member of Mn/DOT Roundabout Steering Committee

13

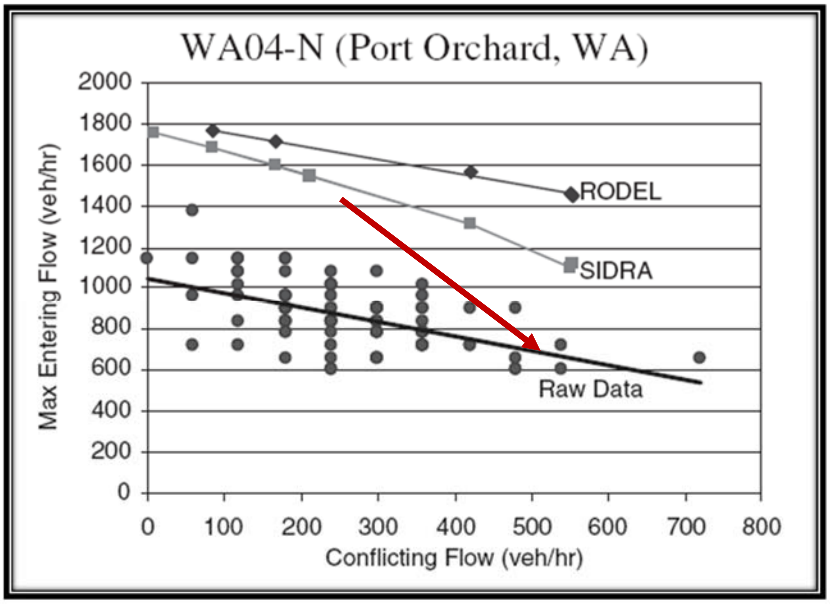
NCHRP Report 572-

Roundabouts in the US (2007)

Source: Ken E. Johnson, Mn/DOT Office of Traffic, Safety, and Technology, Member of Mn/DOT Roundabout Steering Committee

Intersection Type	Change in Total Crashes after Conversion	Change in Severe Injury after Conversion
All Four-Way Intersections	-35%	-76%
Signalized urban	SIMILAR	-60%
Signalized Suburban	-67%	TOO FEW
All-Way Stop Controlled	SIMILAR	SIMILAR
Two-Way Stop Controlled Urban	-72%	-87%
Two-Way Stop Controlled Suburban	-32%	-71%
Two-Way Stop Controlled Rural	-29%	-81%

14



Source: NCHRP 572

15

Selection of Design Vehicle is Critical to the Design Process

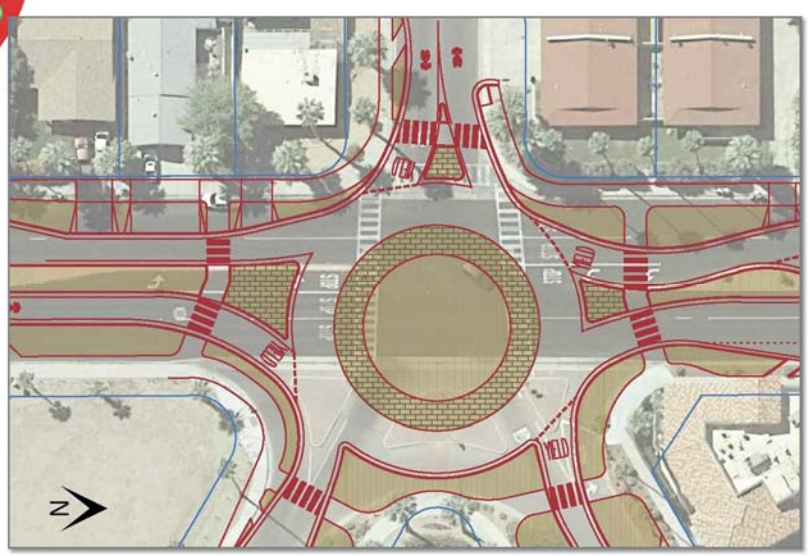
Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

Source: NCHRP 672

17

The Ideal Roundabout Location



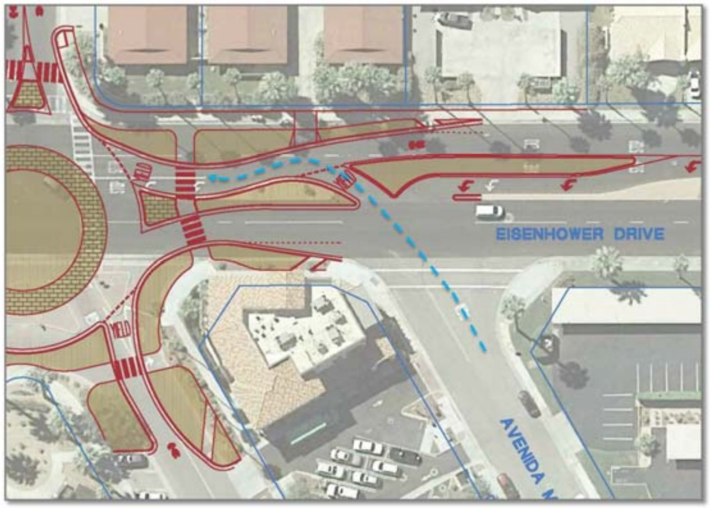
La Quinta Roundabout Interview – April 18. 2016, 4:00 PM

omni · means
ENGINEERING SOLUTIONS

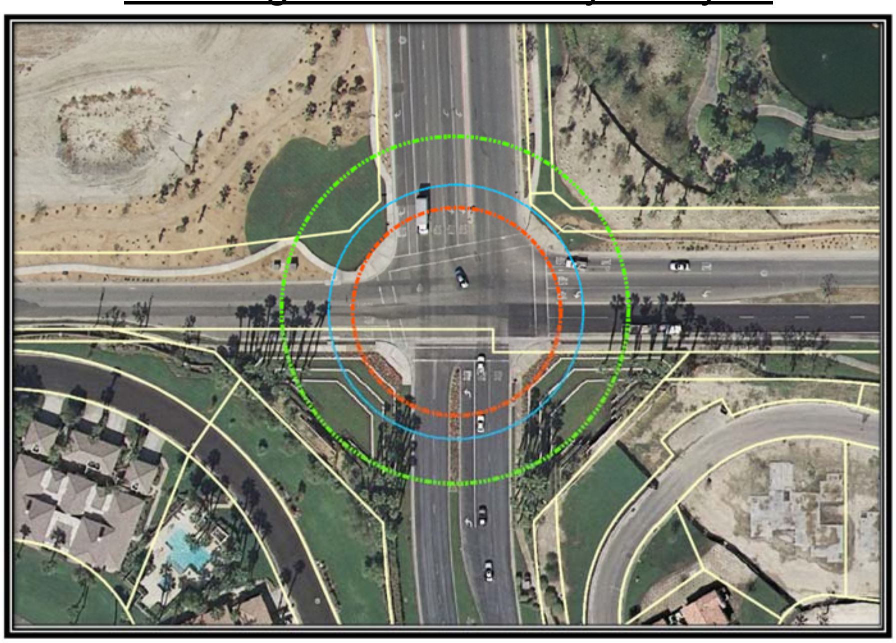
18

Addressing Key Issues

Solution To Maintaining Access:



Planning Level Feasibility Analysis



Preliminary Design Steps

- Collect information and data
- Run models
- Sketch, find circle location and sketch approaches
- CAD a concept. Recheck/test
- Public outreach
- Go to 30%, retest, Right of way and Utilities
- Public outreach
- Go to 60%

21

View at Route 9 and Route 67

22

What Key Geometric Design Parameters Are Common to ALL Roundabouts?

23

Key Deficiencies

Issues Mostly Due to Compromises – design team/agency.

Top Most Common Deficiencies:

1. Lack of Deflection
2. Size/Shape Not Optimized/Center Island Conspicuity
3. Path Overlap Problems

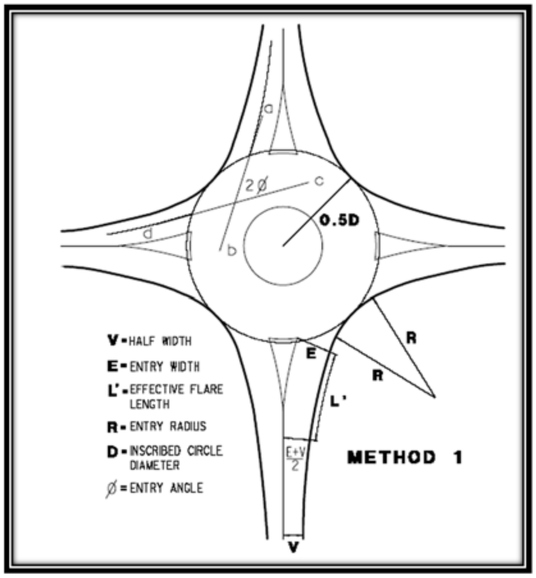
3. Truck Operations Dysfunctional

4. Approach signing and striping inadequate

5. Lack of Qualified Peer Reviews

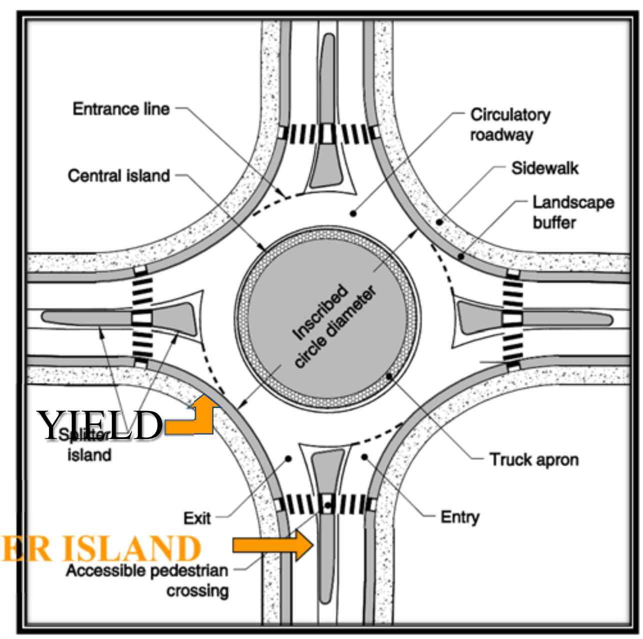
24

Geometric Design Parameters



Source: Facilities Development Manual (Wisconsin)

Source: NCHRP 672



There are Many Elements to Consider

- Entry Width
- Entry Flare
- Entry Angle
- Entry Radius
- Entry Deflection
- Entry Path Curvature
- Entry Speeds
- Fast Path Speeds
- Sight Distance
- Maneuverability of trucks
- Speed Consistency
- Entry & Circulating Visibility
- Splitter Island Design
- Exit Lanes and Geometry
- Appropriate Signing and Striping
- Pedestrians
- Vertical Design Parameters
- Bicyclists
- Aesthetics
- Trains

27

Key Elements

- Entering vehicles must yield
- Use median 'splitter' deflection to force lower speeds before entering roundabout
- Vehicles circulate in counter-clockwise direction at 15 - 25 mph
- Increasing the angle between arms sharply reduces crash frequency
- Increases in the entry width produce significant increases in capacity and crash frequency
- Crash frequency increases with larger circulating width – single lane~15-18' (with truck apron)

28


29


YIELD
TO ALL
VEHICLES IN
ROUNDABOUT
30

Design Process

- Begin by evaluating, checking and learning about the intersection
- Check for Stopping Sight Distance (SSD)
- Design process can find a solution to the SSD
- Most start by drawing - <u>not recommended</u>
- Collect and review adjacent land use data
- Obtain existing as built drawings
- Review traffic volume data
- Review recent crash data

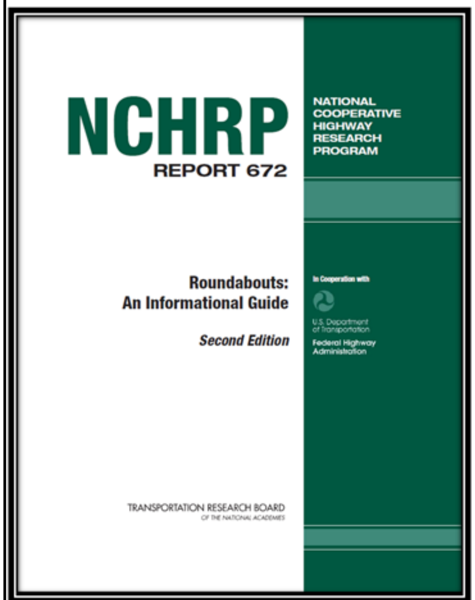
31

Roundabout Design Characteristics

	Design Element	Mini (1)	Urban (2) Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
General	Number of Lanes	1	1	1	2	1	2
	Typical max. (3) ADT	12,000	15,000	20,000	40,000	20,000	40,000
	Splitter Island Treatment	Painted, raised if possible	Raised	Raised	Raised	Raised extended	Raised extended
	Max. Design(4) Vehicle	SU	SU/BUS	WB-50	WB-50	WB-67	WB-67
Circulating	Inscribed Circle Diameter	45'-80'	80'-100'(5)	100'-130'(6)	150'-180'	115'-130'(6)	180'-200'
	Circulating Roadway Design Speed	15-18 mph	16-20 mph	20-25 mph	22-28 mph	22-27 mph	25-30 mph
	Circulating Roadway Width	14'-19'	14'-19'	14'-19'	29'-32'	14'-19'	29'-32'
Entry	Max. Entry Design Speed	15 mph	15 mph	20 mph	25 mph	25 mph	30 mph
	Entry Radius	25'-45'	25'(7)-100'	35'(7)-100'	100'-200'	40'(7)-120'	130'-260'
	Entry Lane Widths	14'-16'	14'-16'	14'-16'	25'-28'	14'-16'	25'-28'

Source: Chapter 9, Design Manual, WSDOT

32

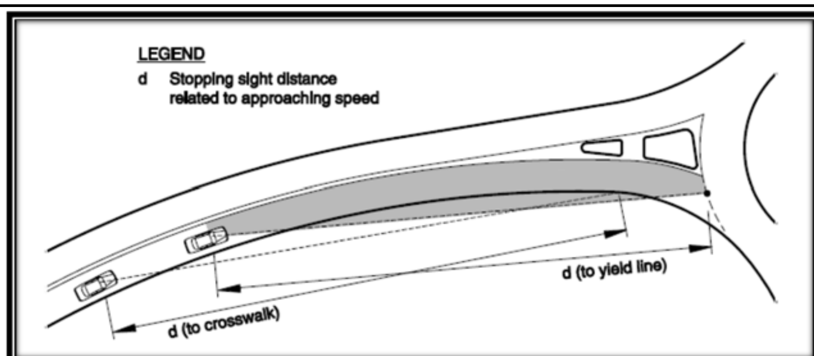


- Provide slow entry speeds and consistent speeds through the roundabout by using deflection
- Provide the appropriate number of lanes and lane assignment to achieve adequate capacity, lane volume balance, and lane continuity
- Provide smooth channelization that is intuitive to drivers and results in, vehicles naturally using the intended lanes
- Provide adequately for the path of design vehicles
- Design to meet the needs of pedestrians and cyclists
- Provide appropriate sight distance and visibility for driver recognition of the intersection and conflicting users

Why is Sight Distance Important?

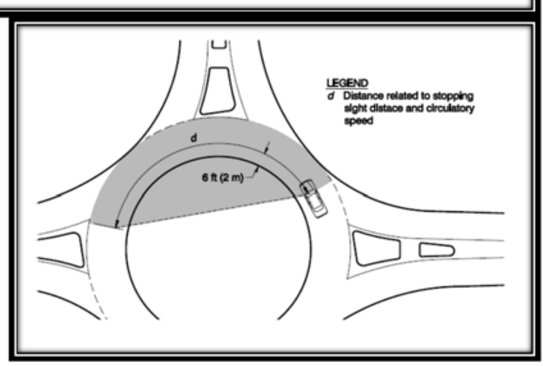
Important Sight Distance Checks

- Approach sight distance
- Sight distance on circulatory roadway
- Sight distance to crosswalk on exit
- Entering stream sight distance
- Circulating Stream



Stopping Sight Distance

Source: NCHRP 672



Stopping Sight Distance

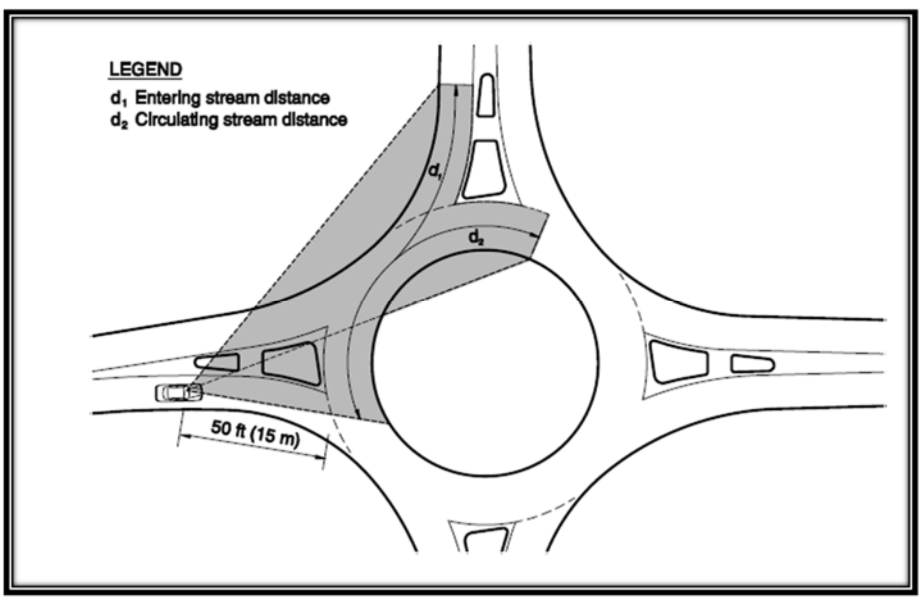
Speed (km/h)	Computed Distance* (m)	Speed (mph)	Computed Distance* (ft)
10	8.1	10	46.4
20	18.5	15	77.0
30	31.2	20	112.4
40	46.2	25	152.7
50	63.4	30	197.8
60	83.0	35	247.8
70	104.9	40	302.7
80	129.0	45	362.5
90	155.5	50	427.2
100	184.2	55	496.7

* Assumes 2.5 s perception–braking time, 3.4 m/s² (11.2 ft/s²) driver deceleration

Source: NCHRP 672

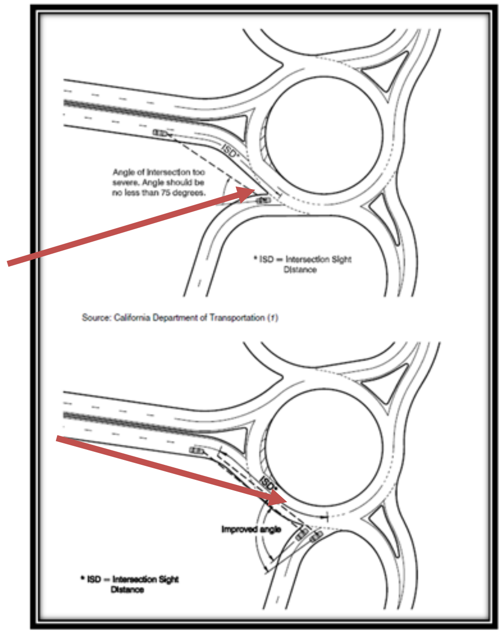
37

Entering Stream Distance and Circulation Stream Distance



Source: NCHRP 672

38



Source: NCHRP 672

$$d_1 = (1.468)(V_{major,\, entering})(t_c)$$

$$d_2 = (1.468)(V_{major,\, circulating})(t_c)$$

where

d_1 = length of entering leg of sight triangle, ft;
d_2 = length of circulating leg of sight triangle, ft;
V_{major} = design speed of conflicting movement, mph, discussed below; and
t_c = critical headway for entering the major road, s, equal to 5.0 s.

Conflicting Approach Speed (mph)	Computed Distance (ft)	Conflicting Approach Speed (km/h)	Computed Distance (m)
10	73.4	20	27.8
15	110.1	25	34.8
20	146.8	30	41.7
25	183.5	35	48.7
30	220.2	40	55.6

Note: Computed distances are based on a critical headway of 5.0 s.

41


Sight distance restricted by the landscaping

42

The Influence of Driver Sight Distance on Crash Rates and Driver Speed at Modern Roundabouts in the United States

THIS PAPER INVESTIGATES THE DRIVER SIGHT DISTANCE AS AN INDEPENDENT VARIABLE TO PREDICT PASSENGER VEHICLE SPEEDS AND VEHICLE CRASH RATES AT ROUNDABOUTS IN THE UNITED STATES BASED ON DATA COLLECTED AT 26 SINGLE-LANE ROUNDABOUTS.

INTRODUCTION

The objective of this paper is to establish that vehicle speeds and crash rates at modern roundabouts in the United States are related to driver sight distance. This paper investigated the relationship between driver sight distance and passenger vehicle speeds and vehicle crash rates at roundabouts in the United States based on data collected at 26 single-lane roundabouts.

The 85th percentile speed parameter was selected as an analysis technique because the current operating speed models for other roadway elements evaluate design consistency using this parameter. Models were developed that predict the 85th percentile approach speed, 85th percentile entrance speed, and the difference between the 85th percentile approach and 85th percentile entrance speeds. Models were developed to predict vehicle crash rates at roundabouts considering driver sight distance. The mod- throughout the United States under the research project funded by the National Cooperative Highway Research Program (NCHRP) project *Applying Roundabouts in the United States* (NCHRP 3-65). A primary objective of NCHRP 3-65 is to develop new models to estimate the safety and operational impacts of roundabouts and to enhance the criteria for the design of modern roundabouts in the United States. To support this effort, a key component of NCHRP 3-65 was the data collection and the development of a database on facility operation and safety for a variety of roundabout sites in the United States. NCHRP 3-65 was the first nationwide research project to develop a dataset concerning roundabouts in America and to investigate the implications of roundabout design with respect to operational and safety performance.

NHCRP contracted with a private

Published in the ITE Journal in July 2010

43

CONE-OF-VISION IMPACTS
IN ROUNDABOUTS
FINAL REPORT

Prepared for: Centre of Transportation Engineering & Planning

Prepared by:	Bunt & Associates Engineering (Alberta) Ltd.
Permit to Practice No.	P7694
File No.:	1122-03
Date:	May 27, 2010

bunt & associates
TRANSPORTATION PLANNERS AND ENGINEERS

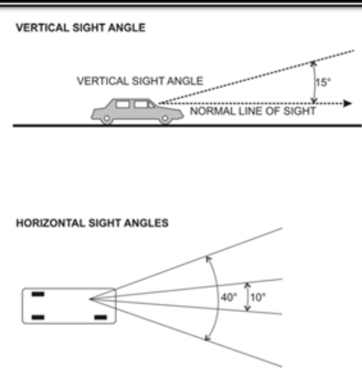


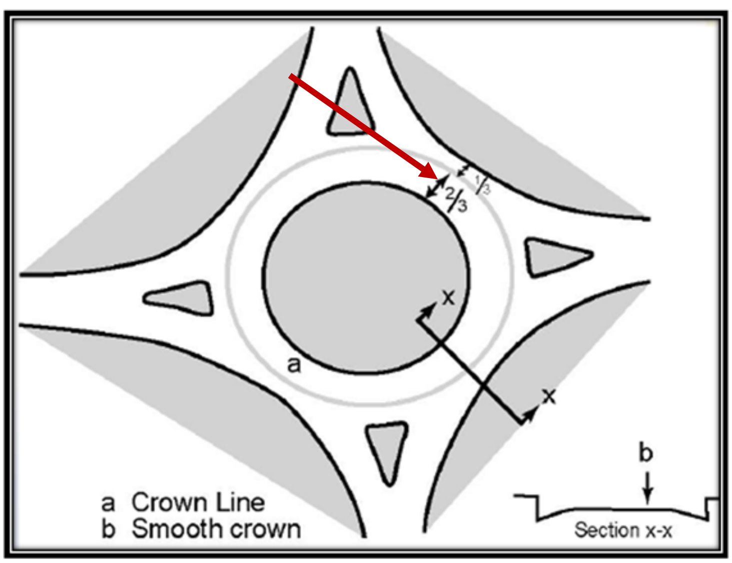
Figure 2.3: Driver Field of Vision

44

What About Drainage?

45

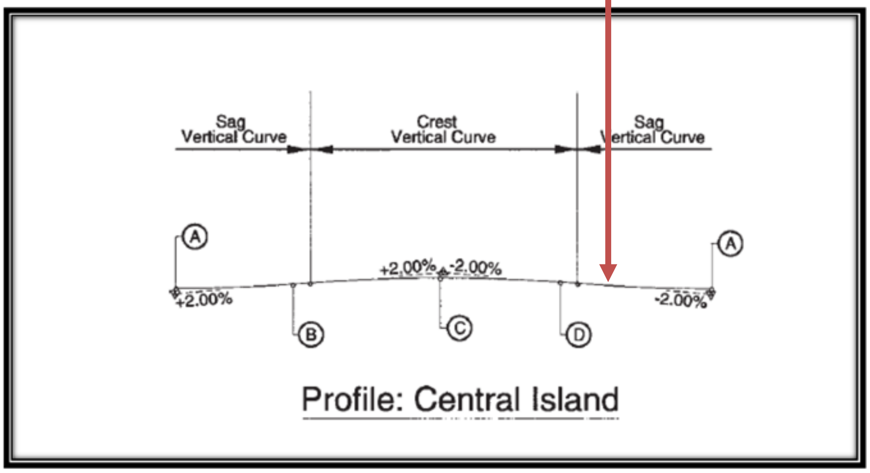
Grade Break Caused Truck Problems



Source: Janet Kennedy, Transport Research Laboratory, UK

46

Circulatory Roadway Profile



47

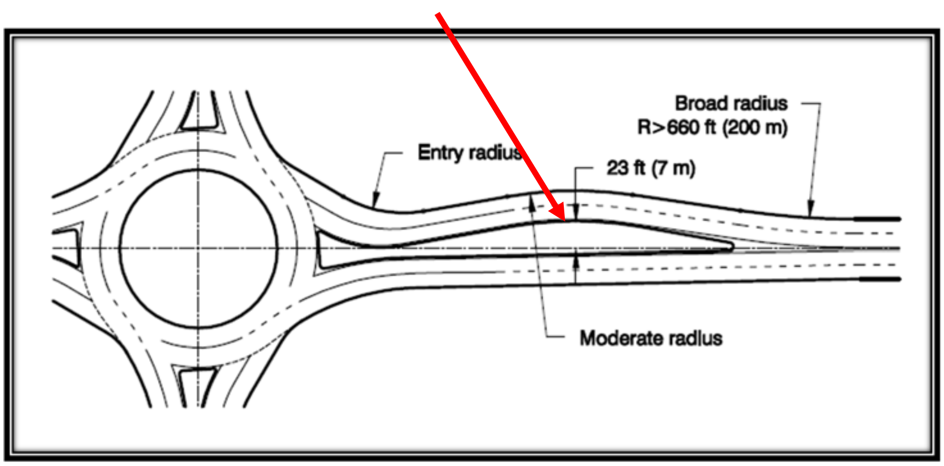
Negative Slope is Too Severe – Residents Report Skidding During Wet Weather

48

What About High Approach Speeds at Isolated Roundabouts?

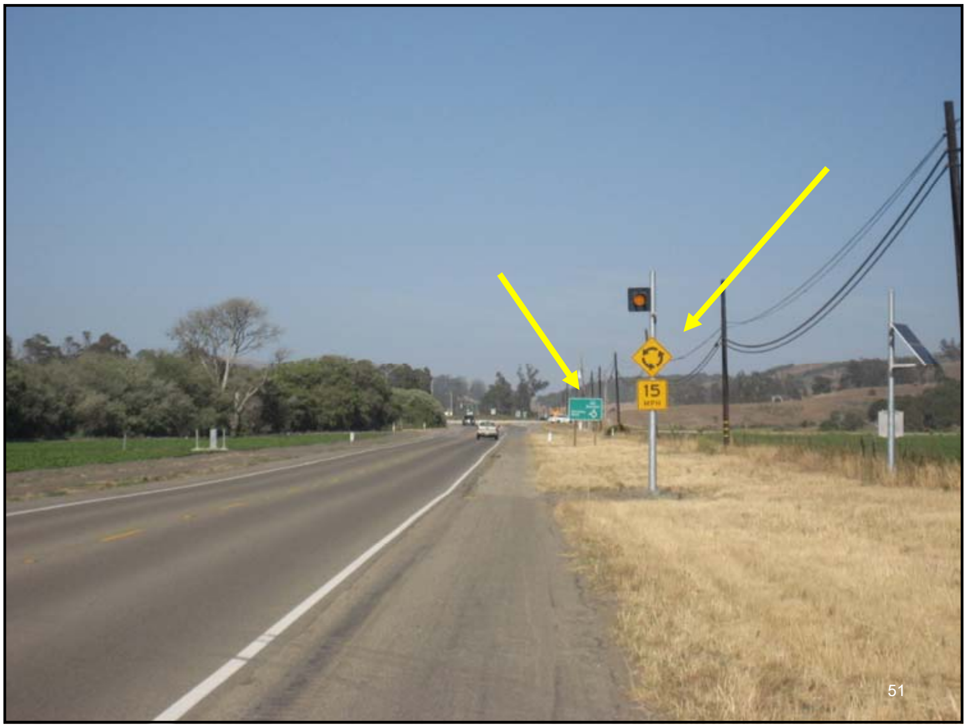
49

Successive Reverse May Be Necessary on High Speed Approaches to Roundabouts – Avoid Making Them Too Tight for Trucks



Source: NCHRP 672

50



51

Smittys Towing Company Staff Member Nick Armsheimer Reports:

- Collisions occur mostly at night
- Involve mostly just one vehicle
- Involve mostly vehicle damage
- Involve mostly eastbound/westbound traffic
- Smittys Towing has removed 20+ vehicles in the past 12 months
- Nick suggests:

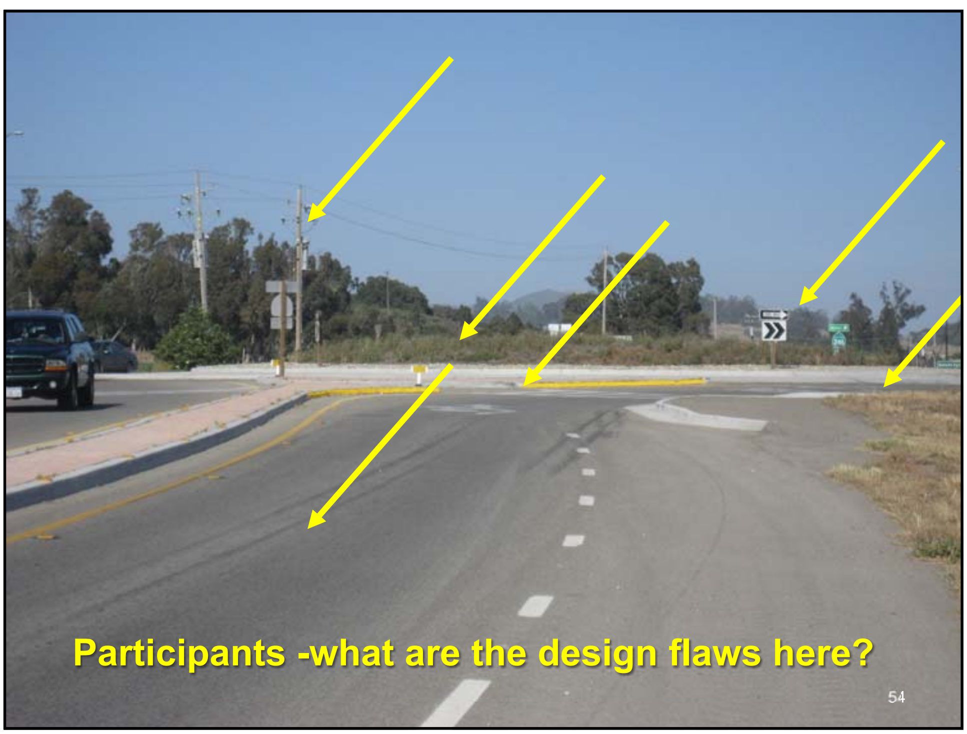
➢ Remove the roundabout and replace with a traffic signal

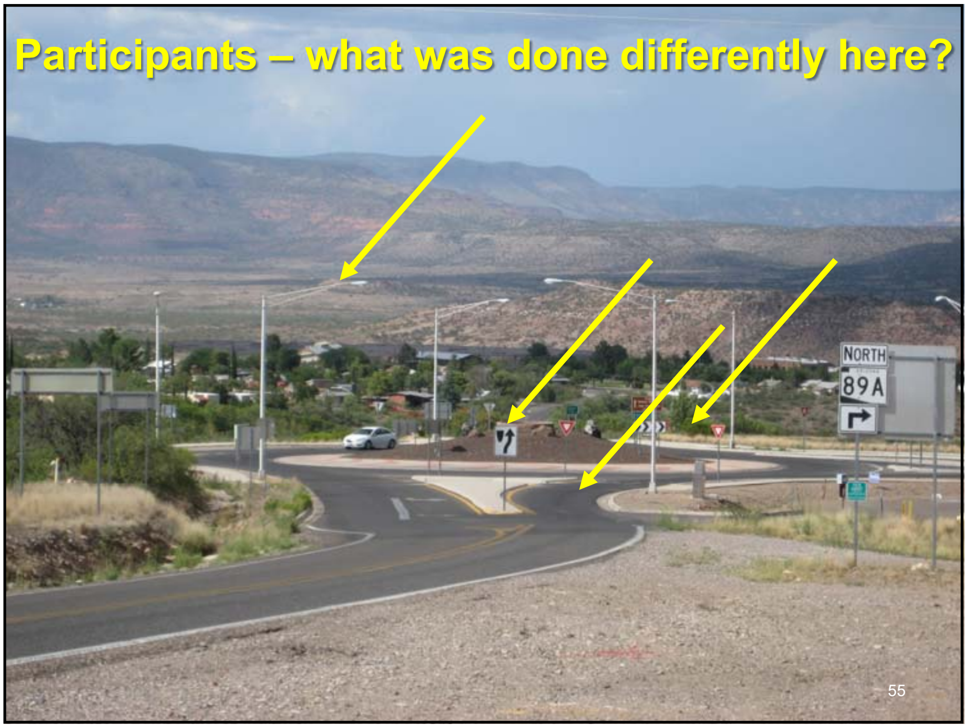
➢ Add more street lights, signs, reflectors

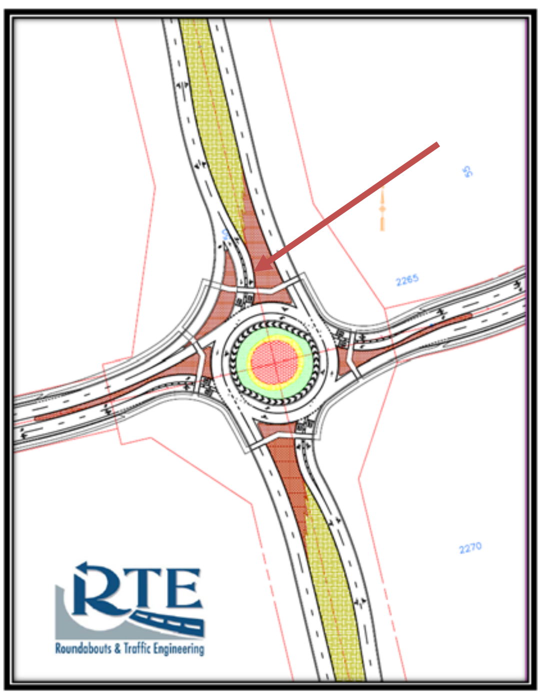
➢ Make it a two lane roundabout

52

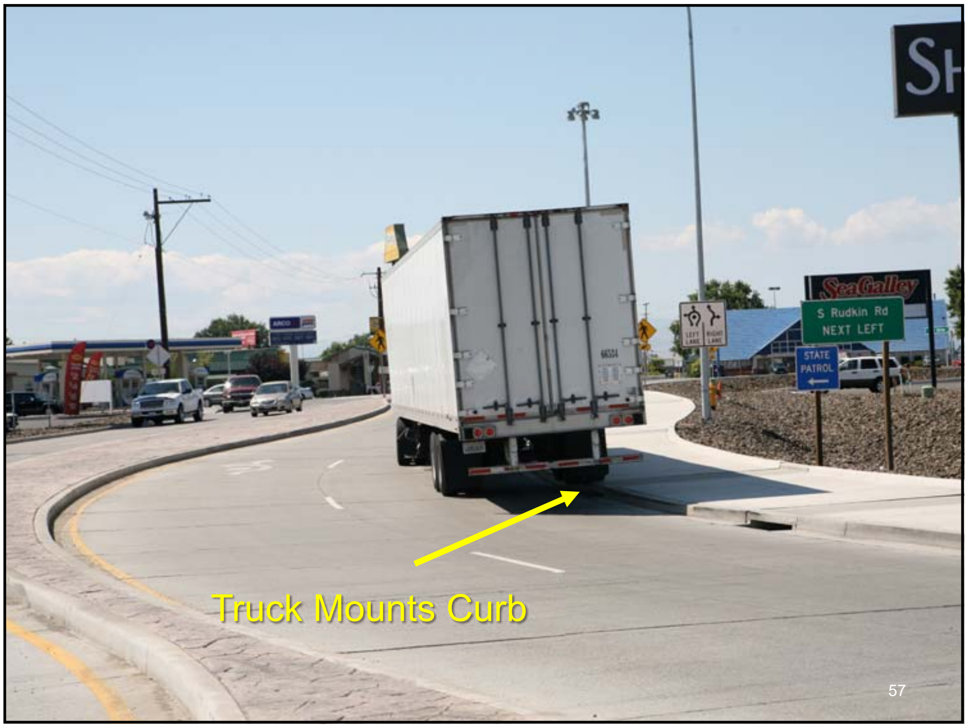

53


Participants -what are the design flaws here?
54


Participants – what was done differently here?
NORTH
89A
55


2265
2270
RTE
Roundabouts & Traffic Engineering

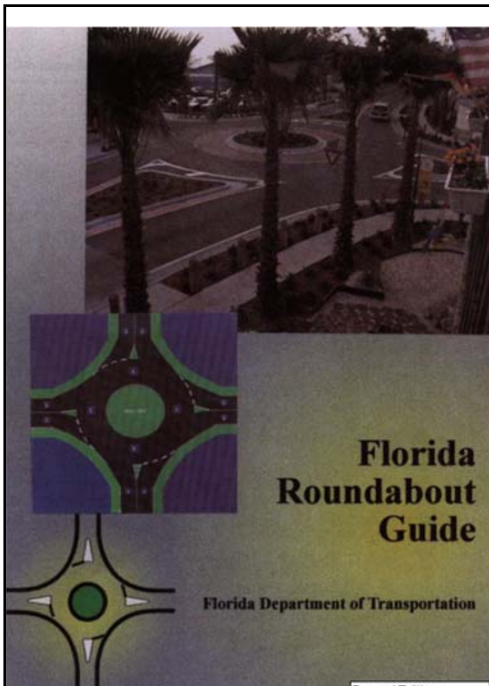
56


Truck Mounts Curb
SeaGalley
S Rudkin Rd
NEXT LEFT
STATE
PATROL
57


Mall Drive
58

What Are Key Geometric Design Parameters for Single Lane Roundabouts?

59



60

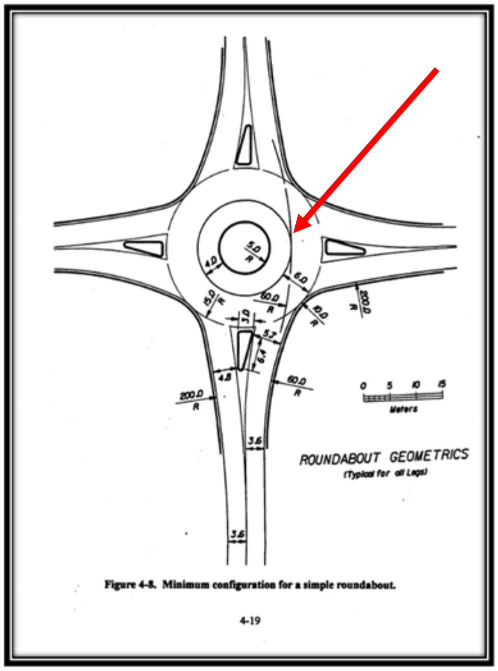


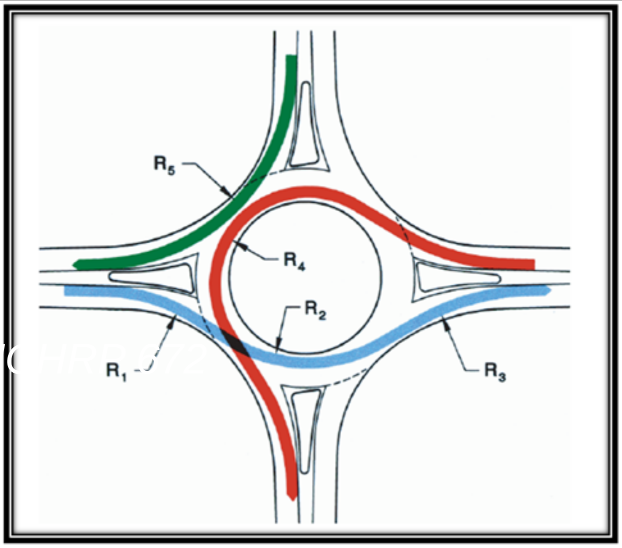
Figure 4-8. Minimum configuration for a simple roundabout.

4-19

61

Why is the Fastest Path so Important?

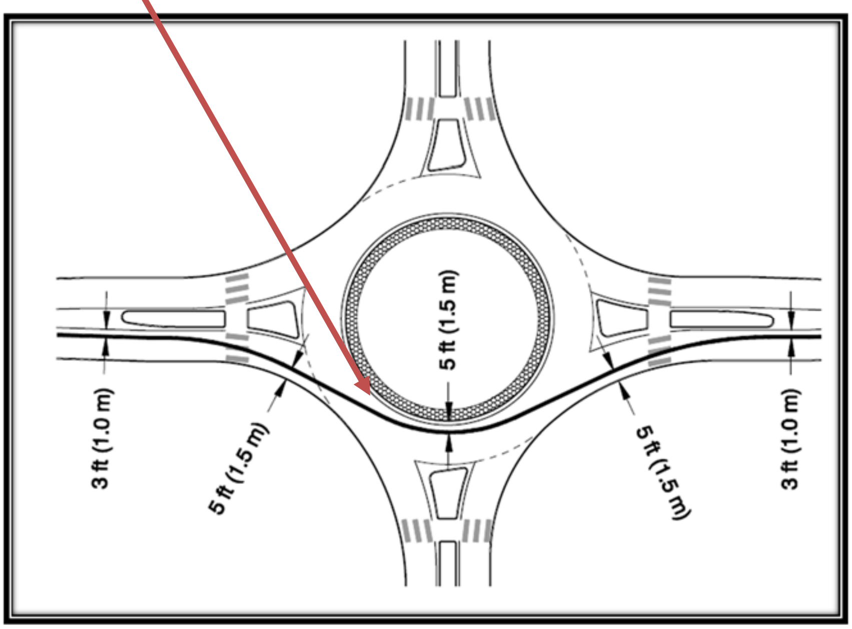
62



Site Category	Recommended Maximum Theoretical Entry Design Speed
Mini-Roundabout	20 mph (30 km/h)
Single Lane	25 mph (40 km/h)
Multilane	25 to 30 mph (40 to 50 km/h)

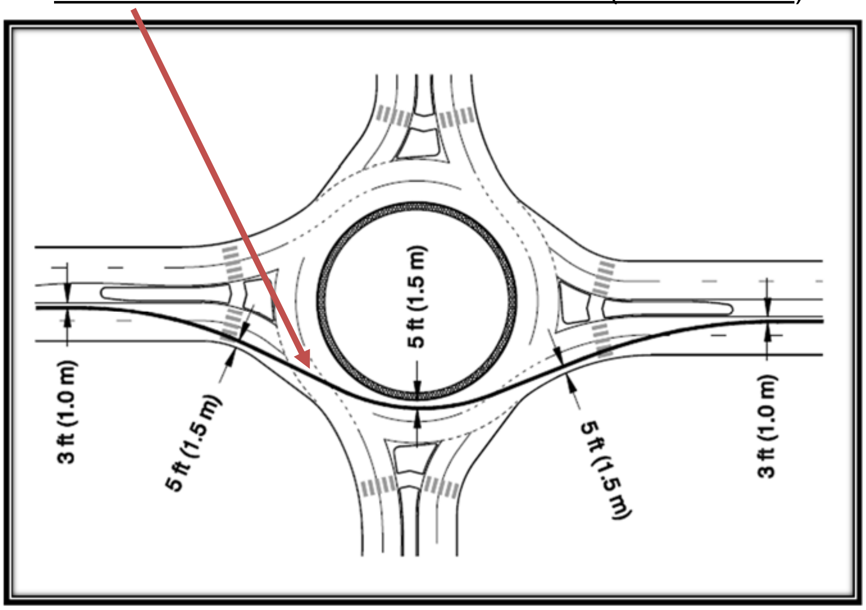
63

Fastest Path – Single Lane Roundabout (NCHRP 672)

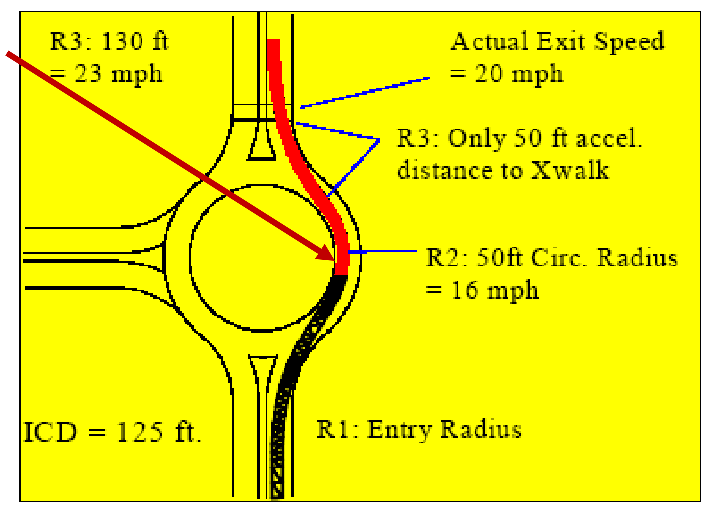


64

Fastest Path – Dual Lane Roundabout (NCHRP 672)



R 1 and R 2 Govern Exit Speed and NOT R 3 Due To Short Acceleration Distance Shown in Red



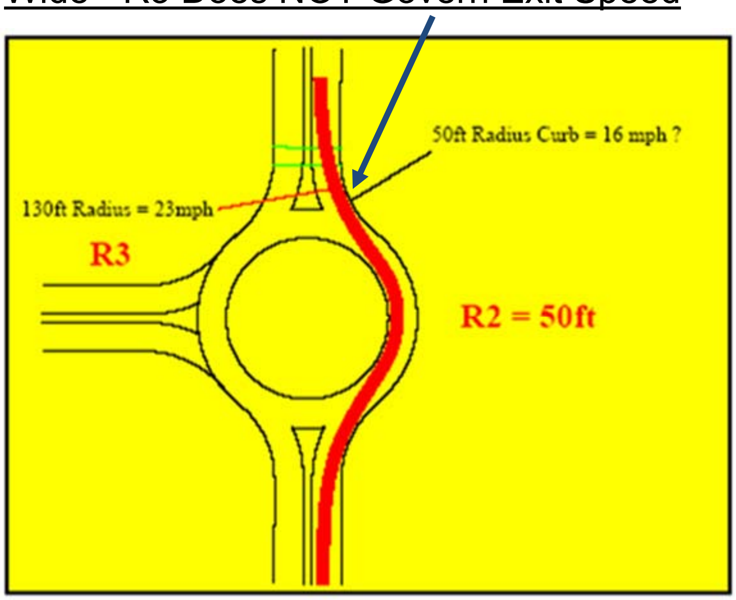
Source: Alternate Design Methods for Pedestrian Safety at Roundabout Entries and Exits (Baranowski)

South Glens Falls – Elliptical Single Lane

Courtesy Of Howard Mcculloch, NE Roundabouts

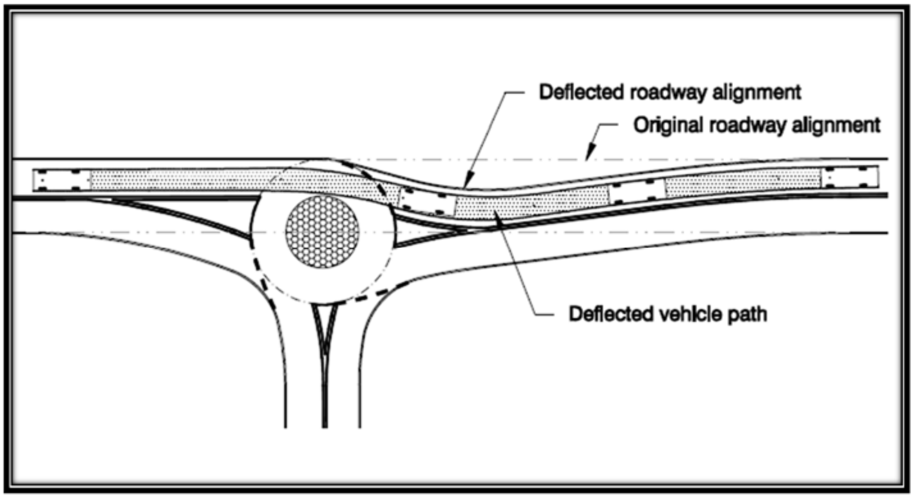
67

To Accommodate Trucks, Exit Needs to be 17' Wide - R3 Does NOT Govern Exit Speed



68

Alignment Modified to Create Deflection



69

70

Dual in Business area

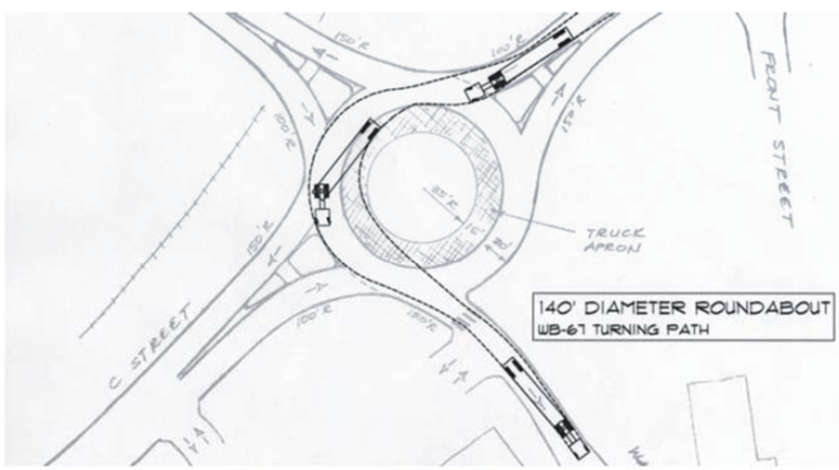
What about Trucks?

Note: Wisconsin Act 139 makes it so all vehicular traffic must yield to any semi or truck 40 ft. or larger when approaching, or in a roundabout, regardless of which lane the smaller vehicle occupies when in the roundabout with the semi.

The Circulatory Roadway Should NOT be Wider Than 18 Feet Excluding the Truck Apron

73

Inscribed Circle for WB 67

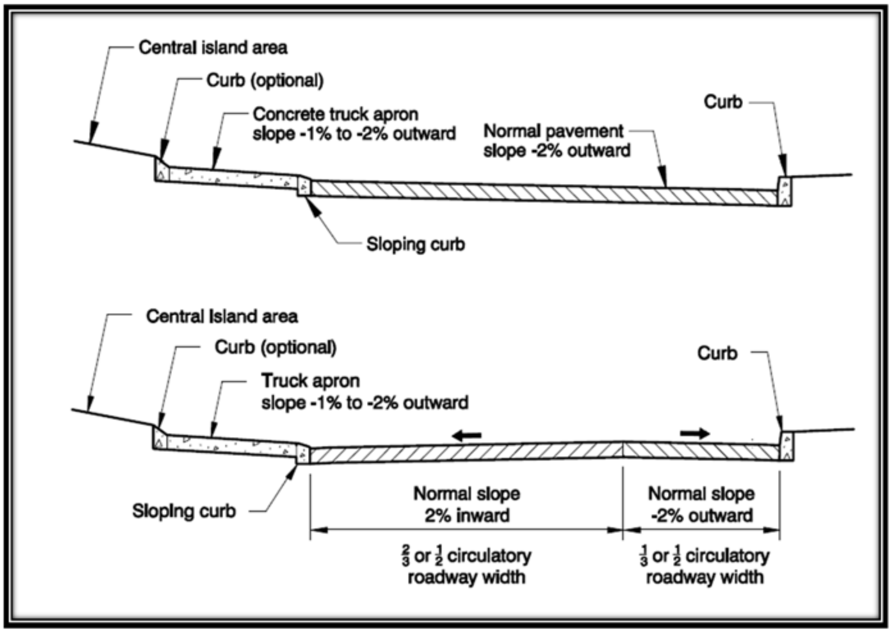


(b) Inscribed circle diameter of 140 ft (43 m)

Source: NCHRP 672

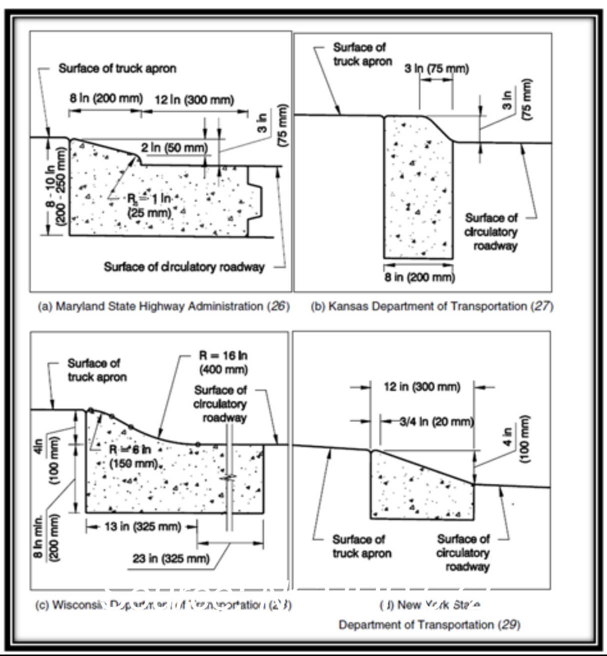
74

Truck Apron Design



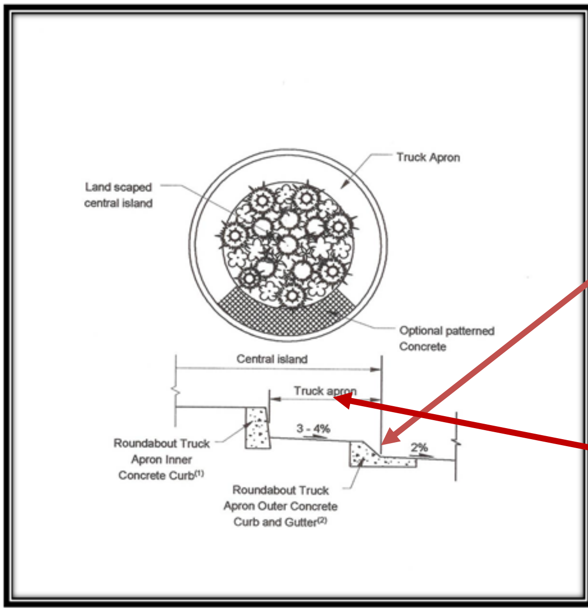
75

Truck Apron Transition Options from Circulatory Roadway



76

Height ~ 2”



Width will depend on design vehicle turning radius

Truck Apron Design

Source: WA DOT Design Manual – Chapter 915

77

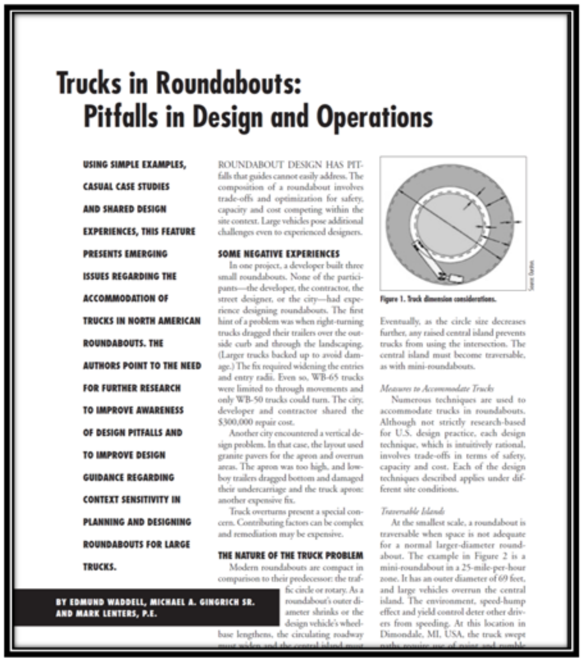
78

Rear Wheels Mount the Truck Apron

Video at www.traffexengineers.com

79

80



Trucks in Roundabouts: Pitfalls in Design and Operations

USING SIMPLE EXAMPLES, CASUAL CASE STUDIES AND SHARED DESIGN EXPERIENCES, THIS FEATURE PRESENTS EMERGING ISSUES REGARDING THE ACCOMMODATION OF TRUCKS IN NORTH AMERICAN ROUNDABOUTS. THE AUTHORS POINT TO THE NEED FOR FURTHER RESEARCH TO IMPROVE AWARENESS OF DESIGN PITFALLS AND TO IMPROVE DESIGN GUIDANCE REGARDING CONTEXT SENSITIVITY IN PLANNING AND DESIGNING ROUNDABOUTS FOR LARGE TRUCKS.

BY EDMUND WADDELL, MICHAEL A. GINGRICH SR. AND MARK LENTERS, P.E.

ROUNDABOUT DESIGN HAS PITfalls that guides cannot easily address. The composition of a roundabout involves trade-offs and optimization for safety, capacity and cost competing within the site context. Large vehicles pose additional challenges even to experienced designers.

SOME NEGATIVE EXPERIENCES

In one project, a developer built three small roundabouts. None of the participants—the developer, the contractor, the street designer, or the city—had experience designing roundabouts. The first hint of a problem was when right-turning trucks dragged their trailers over the outside curb and through the landscaping. (Larger trucks backed up to avoid damage.) The fix required widening the entries and entry radii. Even so, WB-65 trucks were limited to through movements and only WB-50 trucks could turn. The city, developer and contractor shared the $300,000 repair cost.

Another city encountered a vertical design problem. In that case, the layout used granite pavers for the apron and overrun areas. The apron was too high, and lowboy trailers dragged bottom and damaged their undercarriage and the truck apron: another expensive fix.

Truck overturns present a special concern. Contributing factors can be complex and remediation may be expensive.

THE NATURE OF THE TRUCK PROBLEM

Modern roundabouts are compact in comparison to their predecessor: the traffic circle or rotary. As a roundabout's outer diameter shrinks or the design vehicle's wheelbase lengthens, the circulating roadway

Figure 1. Truck dimension considerations.

Eventually, as the circle size decreases further, any raised central island prevents trucks from using the intersection. The central island must become traversable, as with mini-roundabouts.

Measures to Accommodate Trucks

Numerous techniques are used to accommodate trucks in roundabouts. Although not strictly research-based for U.S. design practice, each design technique, which is intuitively rational, involves trade-offs in terms of safety, capacity and cost. Each of the design techniques described applies under different site conditions.

Traversable Islands

At the smallest scale, a roundabout is traversable when space is not adequate for a normal larger-diameter roundabout. The example in Figure 2 is a mini-roundabout in a 25-mile-per-hour zone. It has an outer diameter of 69 feet, and large vehicles overrun the central island. The environment, speed-hump effect and yield control deter other drivers from speeding. At this location in Dimondale, MI, USA, the truck swept

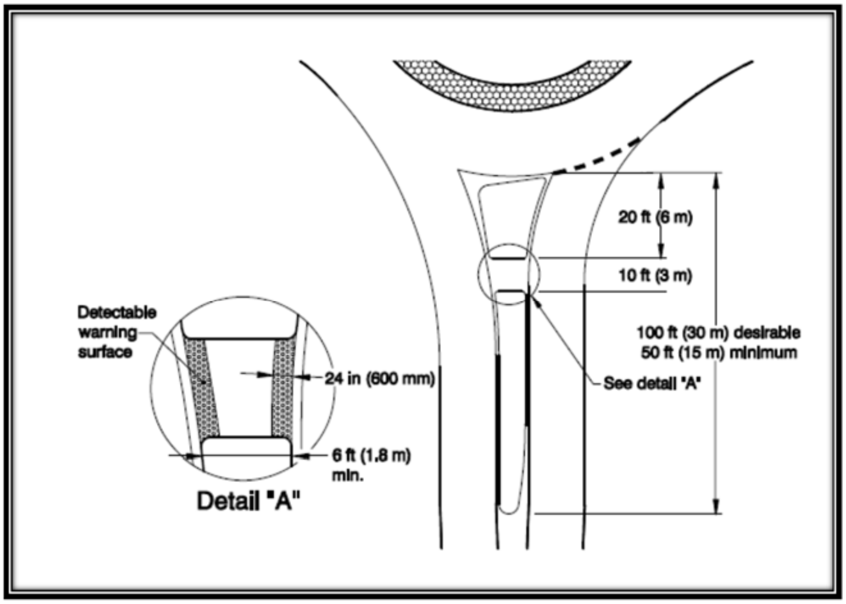
Published in the February 2009 ITE Journal

81

Splitter Island and Other Road Users

82

Splitter Island Layout and Dimensions



Source: NCHRP 672

83

Don't Forget Other Road Users

User	Dimension	Affected Roundabout Features
Bicyclist		
Length	5.9 ft (1.8 m)	Splitter island width at crosswalk
Minimum operating width	4 ft (1.2 m)	Bike lane width on approach roadways; shared use path width
Pedestrian (walking)		
Width	1.6 ft (0.5 m)	Sidewalk width, crosswalk width
Wheelchair user		
Minimum width	2.5 ft (0.75 m)	Sidewalk width, crosswalk width
Operating width	3.0 ft (0.90 m)	Sidewalk width, crosswalk width
Person pushing stroller		
Length	5.6 ft (1.70 m)	Splitter island width at crosswalk
Skaters		
Typical operating width	6 ft (1.8 m)	Sidewalk width

Source: (5)

84

What Are the Key Geometric Design Parameters for Two-Lane Roundabouts?


LRRB

Thinking of Building a Multi-Lane Roundabout?

READ THIS FIRST

Multi-lane roundabouts can be an effective intersection control and reduce injury crashes if the design and layout is carefully considered. Past experience has indicated that failure to yield and improper lane use violations can be over represented at multi-lane roundabouts, leading to a higher number of property damage crashes. Two LRRB funded studies have recently been conducted to attempt to address these violations. This document is a summary of findings from these studies and local agency experience to date.

What Can Be Expected With Multi-Lane Roundabouts?

Multi-lane roundabouts tend to see an increase in crashes due to failure to yield and improper lane use violations, however these crashes tend to be minor. Crash Modification Factors (CMF) Clearinghouse research indicates that conversion from a signal controlled intersection to a multi-lane roundabout has resulted in an overall increase in crashes but the crash reduction factor for severe crashes is still in the range of 60% to 70%.

Failure to Yield

Some drivers may incorrectly perceive roundabout entry as a "right turn" or "merge" situation. When they do, drivers in the right-hand lane may fail to yield to the left lane of cross traffic, leading to a collision. In this diagram, Vehicle 1 is at fault for failing to yield to both lanes of cross traffic.

Improper Lane Use

Some drivers may incorrectly perceive the roundabout as being a "circle road" and therefore may disregard lane use signs and instead attempt to turn left from the right-hand lane, thus cutting in front of the vehicle next to them. In this diagram, Vehicle 1 is at fault for failing to position themselves in the left-hand lane prior to turning left within the roundabout.

LOCAL ROAD RESEARCH BOARD | www.lrrb.org | Report #2016RIC12

www.LRRB.org

85

Guiding Principles for Designing MLR (NCHRP 672)

- Lane arrangements to allow drivers to select the appropriate lane on entry and navigate through the roundabout without changing lanes
- Alignment of vehicles at the entrance line into the correct lane within the circulatory roadway
- Accommodation of side-by-side vehicles through the roundabout (i.e., a truck or bus traveling adjacent to a passenger car)
- Alignment of the legs to prevent exiting–circulating conflicts
- Accommodation for all travel modes

86

Crash Frequency Increases With Increasing Inscribed Circle Diameter (D)

Table 70. Relationship between crashes and geometry, sorted on crash rates.

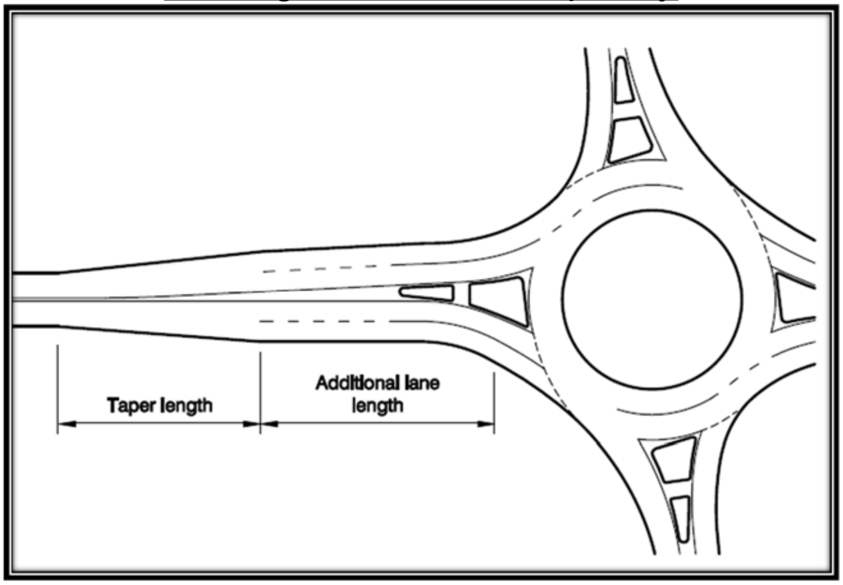
	Crash Frequency (crashes/yr)	Crash Rate (crashes/MEV)	Average Number of Lanes in Group	Average Inscribed Circle Diameter	Average Daily Traffic (veh/day)	Average Number of Legs in Group
Total Dataset	4.95	0.75	1.39	133 ft (41 m)	16,606	3.89
First Ten	0.02	0.00	1.20	95 ft (29 m)	9,295	3.70
First Thirty	0.59	0.10	1.23	123 ft (37 m)	14,961	3.73
Bottom Thirty	11.75	1.69	1.70	165 ft (50 m)	20,186	4.07
Bottom Ten	18.51	3.03	1.90	150 ft (46 m)	16,734	4.20

Legend: MEV = million entering vehicles; veh = vehicles

Source: NCHRP 572

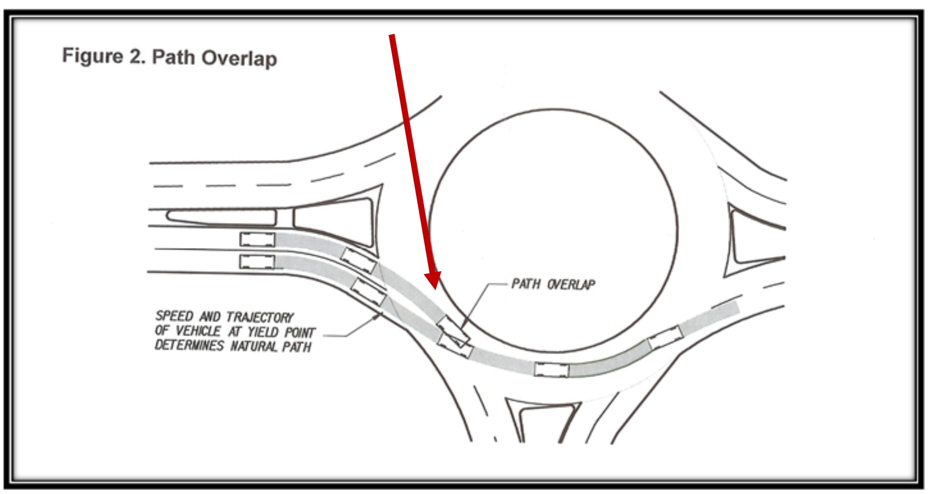
Path Overlap

Adding a Lane for Capacity

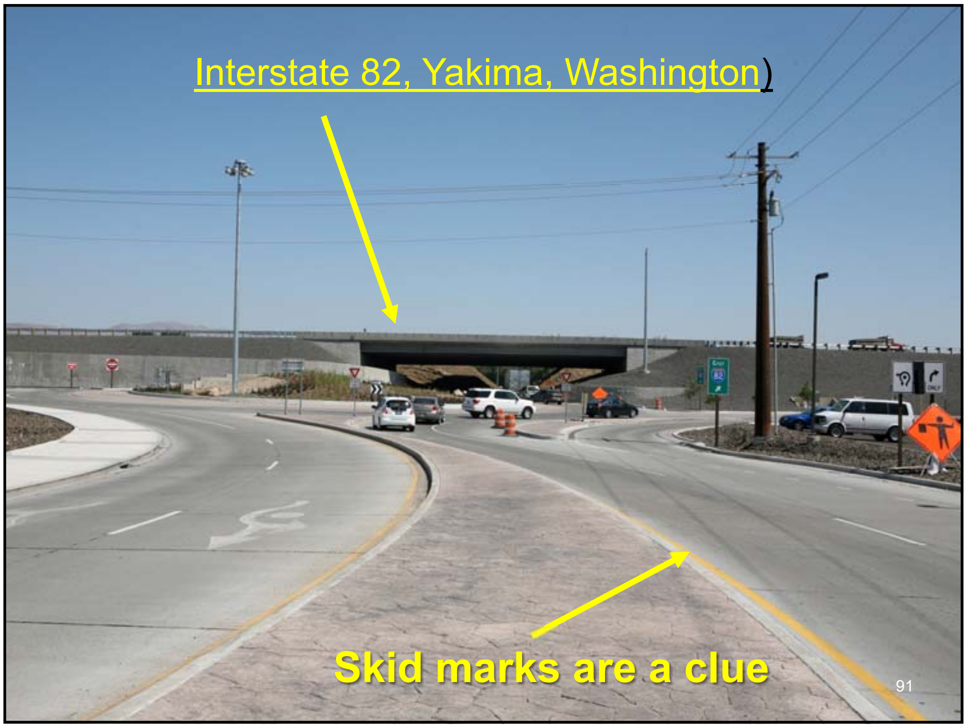


Source: NCHRP 672

Path Overlap is a Problem at MLRs

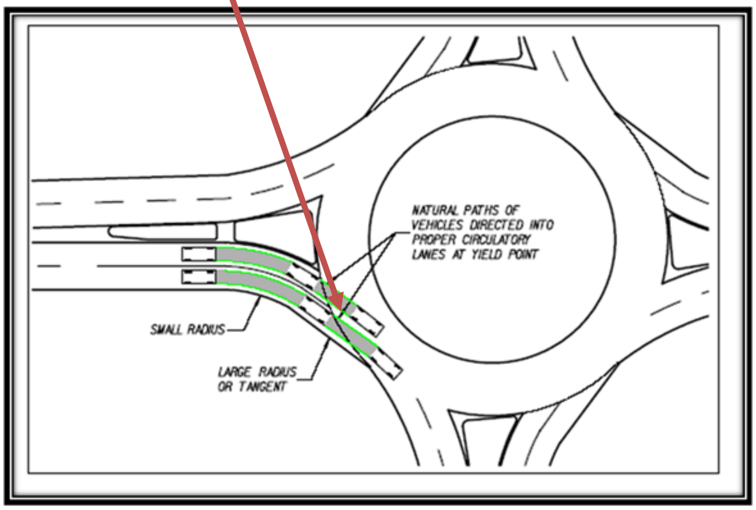


Source: Facilities Development Manual (WSDOT)


Interstate 82, Yakima, Washington)
Skid marks are a clue
91


Participants -what is broken here?
SHOPKO
92

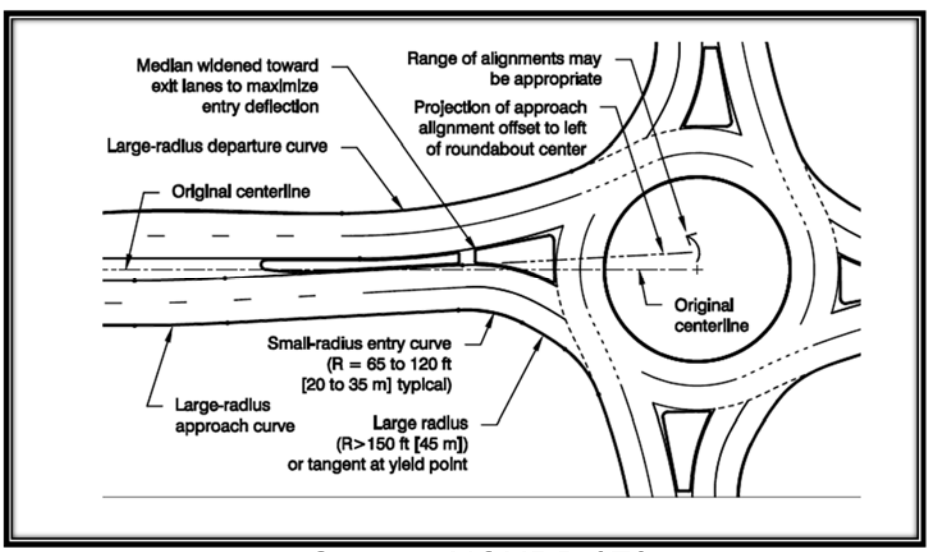
Greater Entry Deflection by Increasing ICD (Caution: Larger ICD will Increase Circulatory Speeds – not Pedestrian Friendly)



Source: Facilities Development Manual (WSDOT)

93

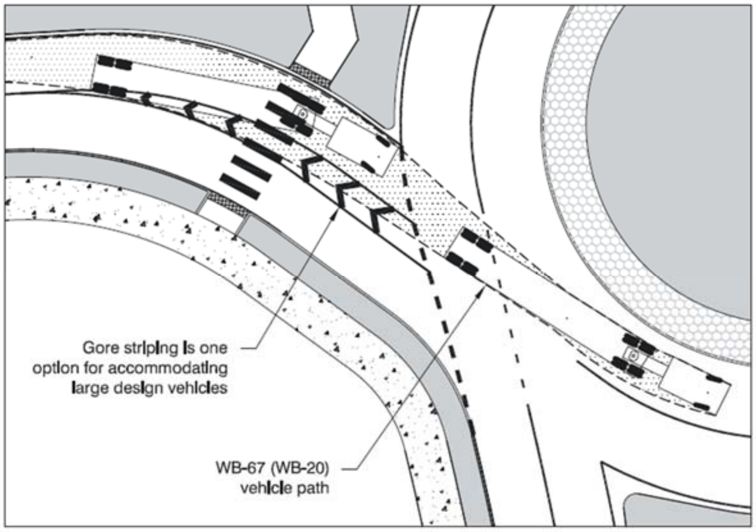
Modified Design to Correct Path Overlap



Source: NCHRP 672

94

Truck Path With Gore Striping (NCHRP 672)



Source: New York State Department of Transportation (*11*)

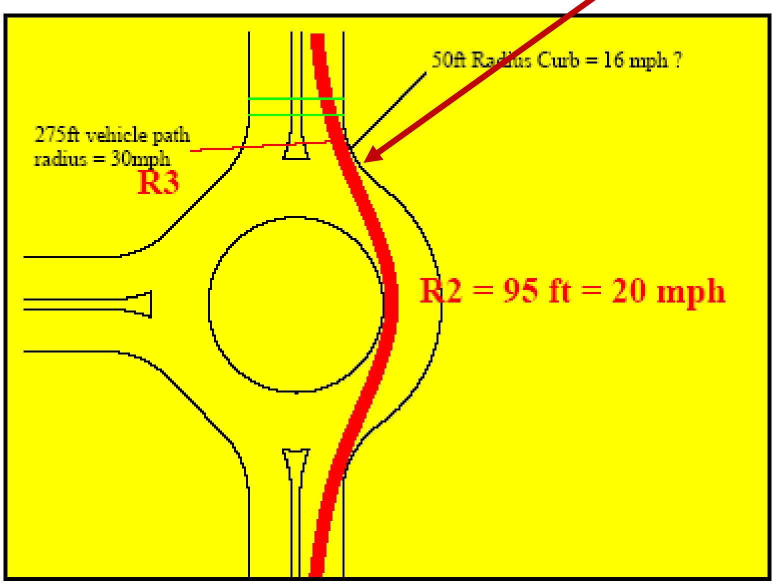
95

96

Path Overlap Conflicts at Exits

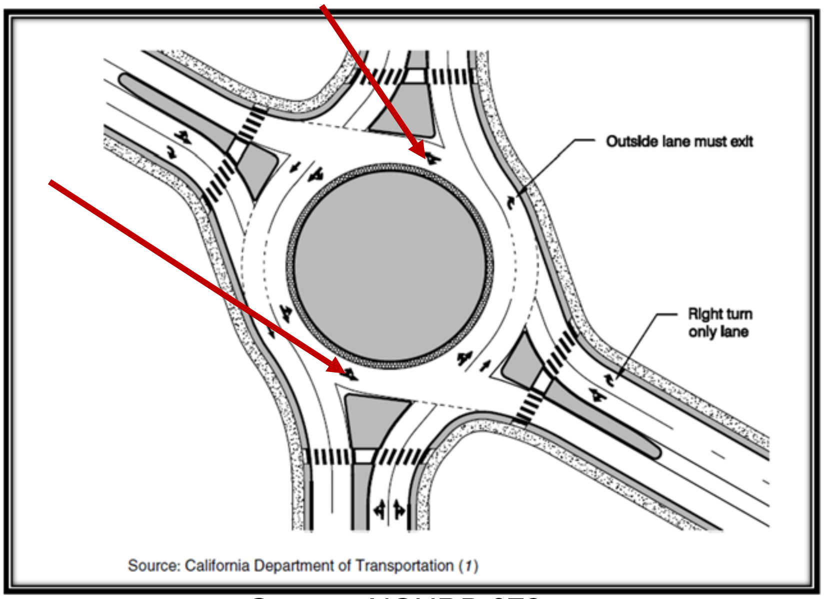
97

At Multilane Roundabouts (MLR), A Tight R3 Exit Radius Will Cause Exit Overlap and Crashes – R1 and R 2 Most Important



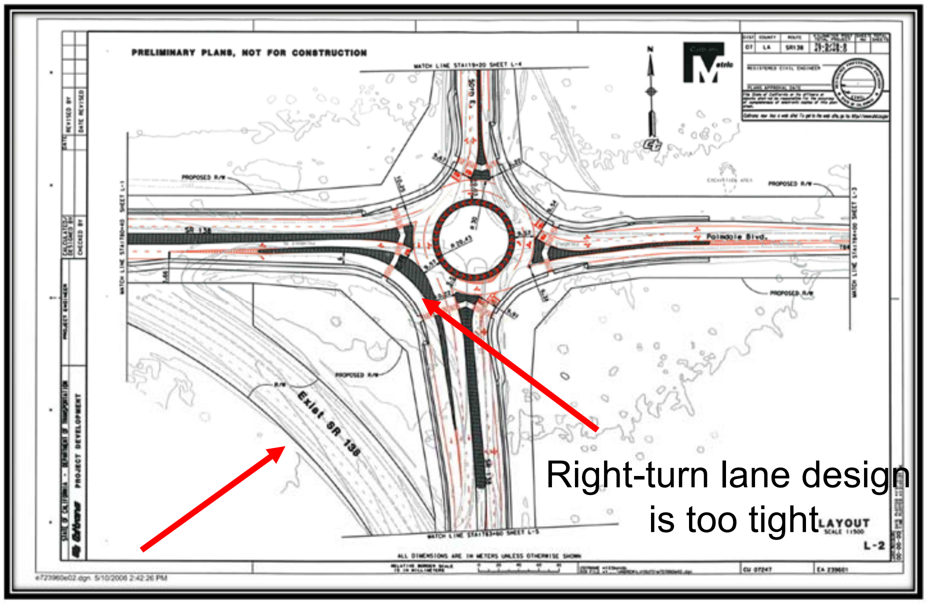
98

Lane Configuration to Resolve Exit Conflicts)



Source: NCHRP 672

Sharp Right-turn Lane


PRELIMINARY PLANS, NOT FOR CONSTRUCTION
Palmdale Blvd.
Exist SR 138
Right-turn lane design is too tight
LAYOUT
L-2
ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

101

102

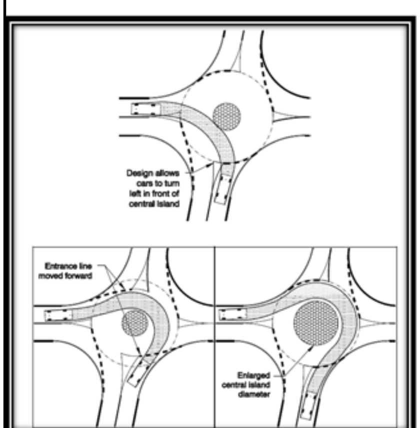

ONLY
ONLY
Marks are a clue
103

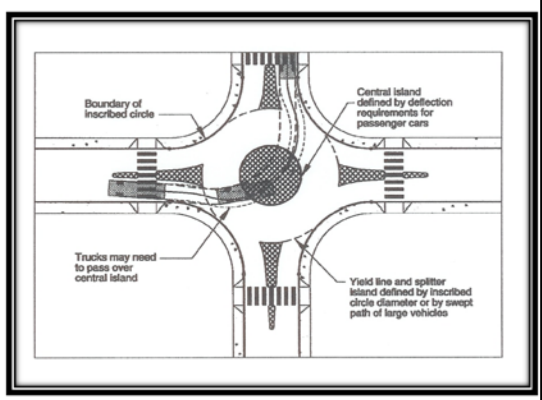

Participants -what is broken here?
104

What Are The Key Geometric Design Parameters for Mini Roundabouts?

105

Left-turning Truck Problem at Mini/Small Roundabouts



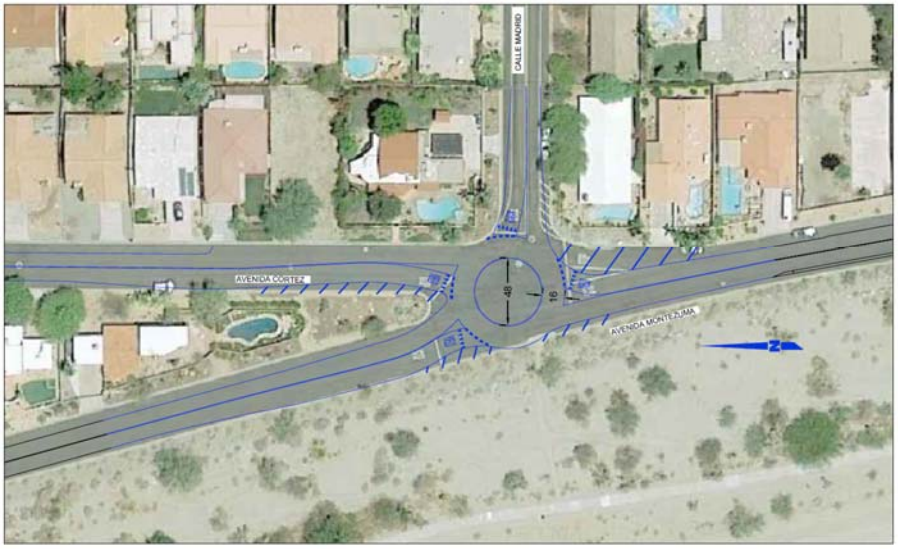


106

Mini in London - The White Dot

108

AVENIDA CORTEZ CONCEPT MINI-ROUNDABOUT



109

110

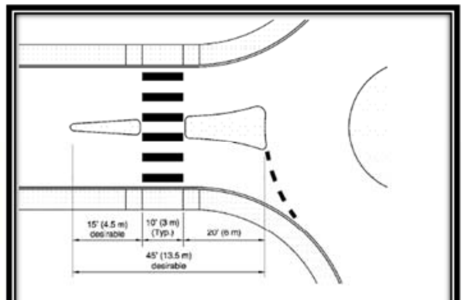
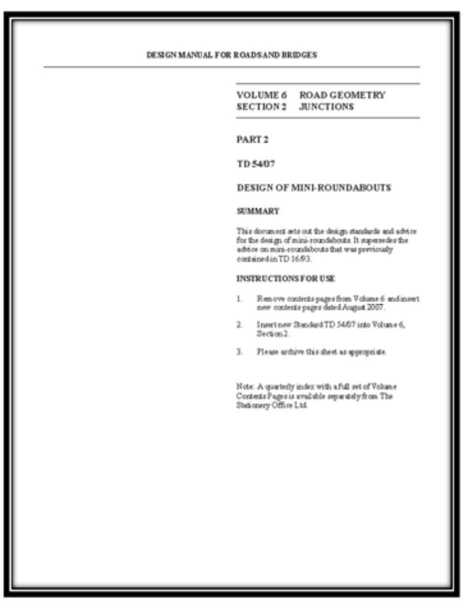


Figure 4: Recommended Longitudinal Dimensions for Splitter Islands at Mini-Roundabouts



DESIGN MANUAL FOR ROADS AND BRIDGES

VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 2

TD 54/07

DESIGN OF MINI-ROUNDABOUTS

SUMMARY

This document sets out the design standards and advice for the design of mini-roundabouts. It supersedes the advice on mini-roundabouts that was previously contained in TD 16/93.

INSTRUCTIONS FOR USE

1. Remove contents pages from Volume 6 and insert new contents pages dated August 2007.
2. Insert new Standard TD 54/07 into Volume 6, Section 2.
3. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

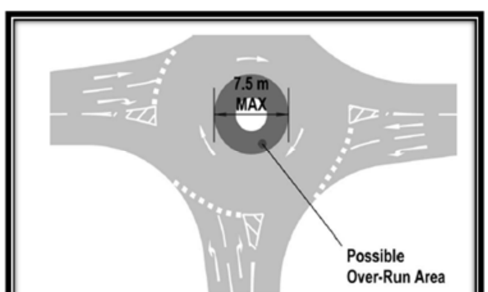
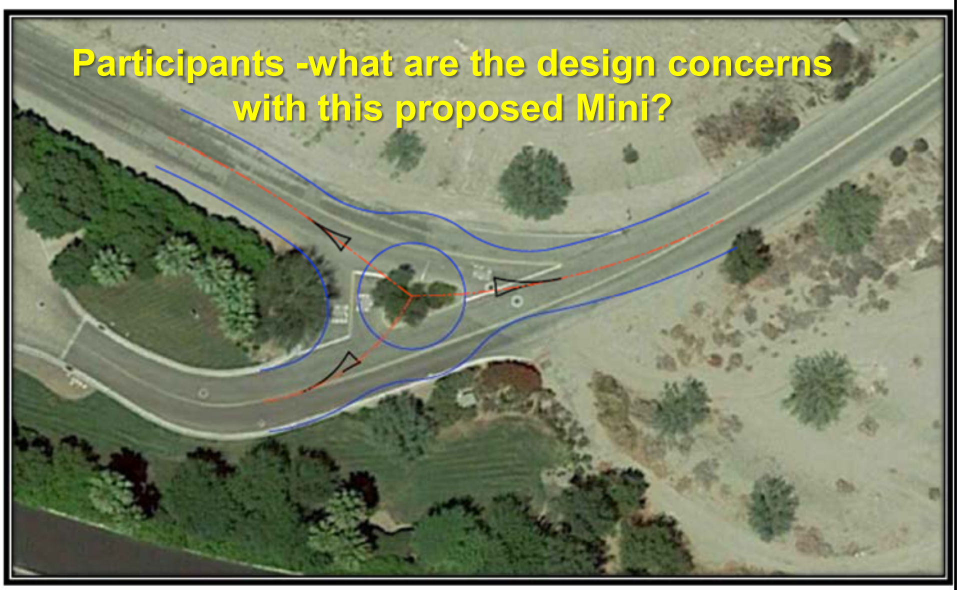


Figure 6/4 – Flared Approach with Central Overrun Area


Car goes over truck apron which is just red color

113


Participants -what are the design concerns
with this proposed Mini?

114

Why Should All Roundabouts Have Exits Clear at All Times?

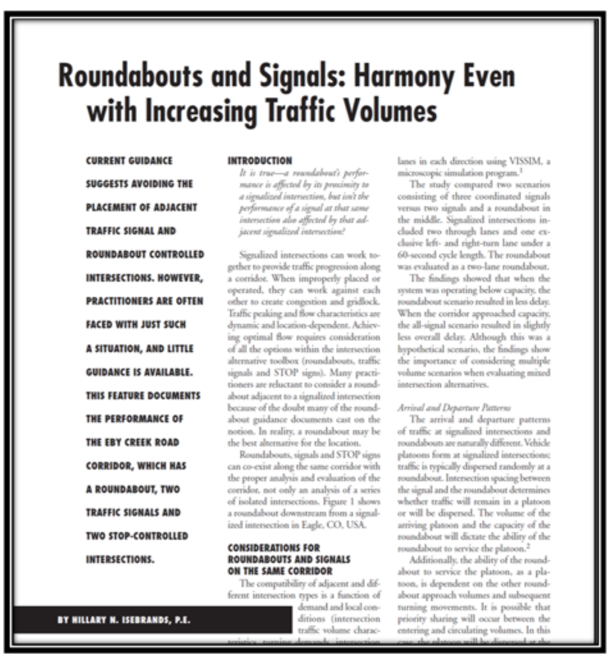
115

Minimum Distance to Nearest Access

Min. distance to nearest access (distance from splitter island)	600' on principal arterial 300' on minor arterial 100' on all collectors 30' on local access

Source: Roundabout Design Standards - City of Colorado Springs

116



Roundabouts and Signals: Harmony Even with Increasing Traffic Volumes

CURRENT GUIDANCE SUGGESTS AVOIDING THE PLACEMENT OF ADJACENT TRAFFIC SIGNAL AND ROUNDABOUT CONTROLLED INTERSECTIONS. HOWEVER, PRACTITIONERS ARE OFTEN FACED WITH JUST SUCH A SITUATION, AND LITTLE GUIDANCE IS AVAILABLE. THIS FEATURE DOCUMENTS THE PERFORMANCE OF THE EBY CREEK ROAD CORRIDOR, WHICH HAS A ROUNDABOUT, TWO TRAFFIC SIGNALS AND TWO STOP-CONTROLLED INTERSECTIONS.

BY HILLARY N. ISEBRANDS, P.E.

INTRODUCTION

It is true—a roundabout's performance is affected by its proximity to a signalized intersection, but isn't the performance of a signal at that same intersection also affected by that adjacent signalized intersection?

Signalized intersections can work together to provide traffic progression along a corridor. When improperly placed or operated, they can work against each other to create congestion and gridlock. Traffic peaking and flow characteristics are dynamic and location-dependent. Achieving optimal flow requires consideration of all the options within the intersection alternative toolbox (roundabouts, traffic signals and STOP signs). Many practitioners are reluctant to consider a roundabout adjacent to a signalized intersection because of the doubt many of the roundabout guidance documents cast on the notion. In reality, a roundabout may be the best alternative for the location.

Roundabouts, signals and STOP signs can co-exist along the same corridor with the proper analysis and evaluation of the corridor, not only an analysis of a series of isolated intersections. Figure 1 shows a roundabout downstream from a signalized intersection in Eagle, CO, USA.

CONSIDERATIONS FOR ROUNDABOUTS AND SIGNALS ON THE SAME CORRIDOR

The compatibility of adjacent and different intersection types is a function of demand and local conditions (intersection traffic volume charac-

lanes in each direction using VISSIM, a microscopic simulation program.[1]

The study compared two scenarios consisting of three coordinated signals versus two signals and a roundabout in the middle. Signalized intersections included two through lanes and one exclusive left- and right-turn lane under a 60-second cycle length. The roundabout was evaluated as a two-lane roundabout.

The findings showed that when the system was operating below capacity, the roundabout scenario resulted in less delay. When the corridor approached capacity, the all-signal scenario resulted in slightly less overall delay. Although this was a hypothetical scenario, the findings show the importance of considering multiple volume scenarios when evaluating mixed intersection alternatives.

Arrival and Departure Patterns

The arrival and departure patterns of traffic at signalized intersections and roundabouts are naturally different. Vehicle platoons form at signalized intersections; traffic is typically dispersed randomly at a roundabout. Intersection spacing between the signal and the roundabout determines whether traffic will remain in a platoon or will be dispersed. The volume of the arriving platoon and the capacity of the roundabout will dictate the ability of the roundabout to service the platoon.[2]

Additionally, the ability of the roundabout to service the platoon, as a platoon, is dependent on the other roundabout approach volumes and subsequent turning movements. It is possible that priority sharing will occur between the entering and circulating volumes. In this

Published in the February 2009 ITE Journal

118

Roundabout Close to a Traffic Signal

119

Roseville Galleria Shopping Center

Source: Fehr and Peers

120

Participants – what's broken here?

Final Design

122

Finally - Draw Accurately

- The design is done – problems largely solved
- Now refine and draw exactly (CAD)
- Check entry radii and adjust
- Check and adjust exit radii
- Accurately draw in context of the rough solution
- If details are drawn first (bottom up design)
  - Parts may be OK but the whole is wrong
- Bottom-up designs look stiff and formal
- Designs should have a flowing, organic look

123

Final Check

- Leave design for about 3-4 days
- Review it afresh – things become visible
- Horizontal is now totally FINSHED
- Only now do the vertical design
- Occasionally some horizontal / vertical interaction
- Some horizontal revision may be needed
- Signing and striping
- Refine for multimodal users
- Consider peer review

124

<u>Top Eight Most Common Design Deficiencies:</u>

1. Lack of deflection (#1 Key design principle)
2. Size/shape not optimized
3. Truck operations dysfunctional
4. Not site specific design/alternative solutions not considered
5. Lack of qualified peer reviews
6. Final plans not reviewed by roundabout designer
7. Roundabout exit blockage not take into consideration
8. Grades are too severe

125

126

Design Guidance

- Approach grades ~ 3%
- Entry grades < 2%
- Exit grades < 4%
- Circulatory roadway ~ 1.0 to 1.2 x entry width (for single lane, try 18' with truck apron)
- Two-lane entries into single lane circulatory roadway not recommended
- Splitter islands are essential

127

Roundabout Safety Review

✓ Is sight distance adequate at all points?

✓Signing easily understood?

✓Consistency among signs/markings to clarify approach?

✓Appropriate warning signs at correct distance from hazards?

✓Does landscaping or other signs obscure visibility?

✓Are the signs appropriate for the design speed?

✓Do markings clearly define routes for lane designations?

✓Are truck paths designed for the largest vehicles?

✓Are markings and sign letter heights adequate?

128

CASE STUDIES

129

Case Study I

Roundabout in Salem, Connecticut

130

Salem Four Corners

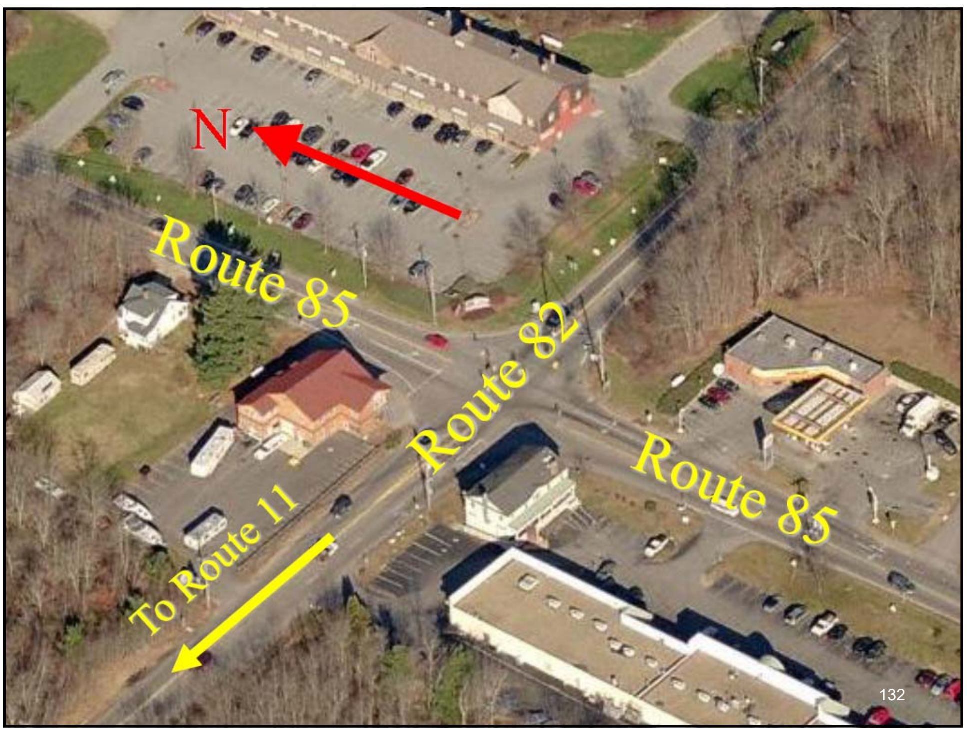
Proposed

MODERN ROUNDABOUT

Bob Ross
First Selectman
Town of Salem

May 2009

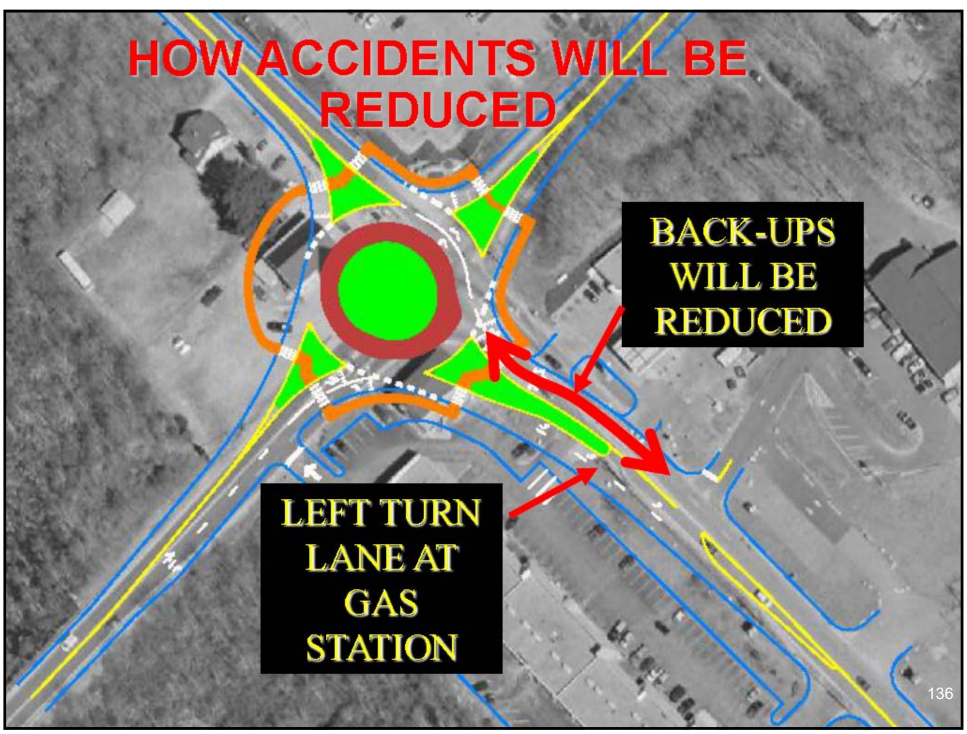
131

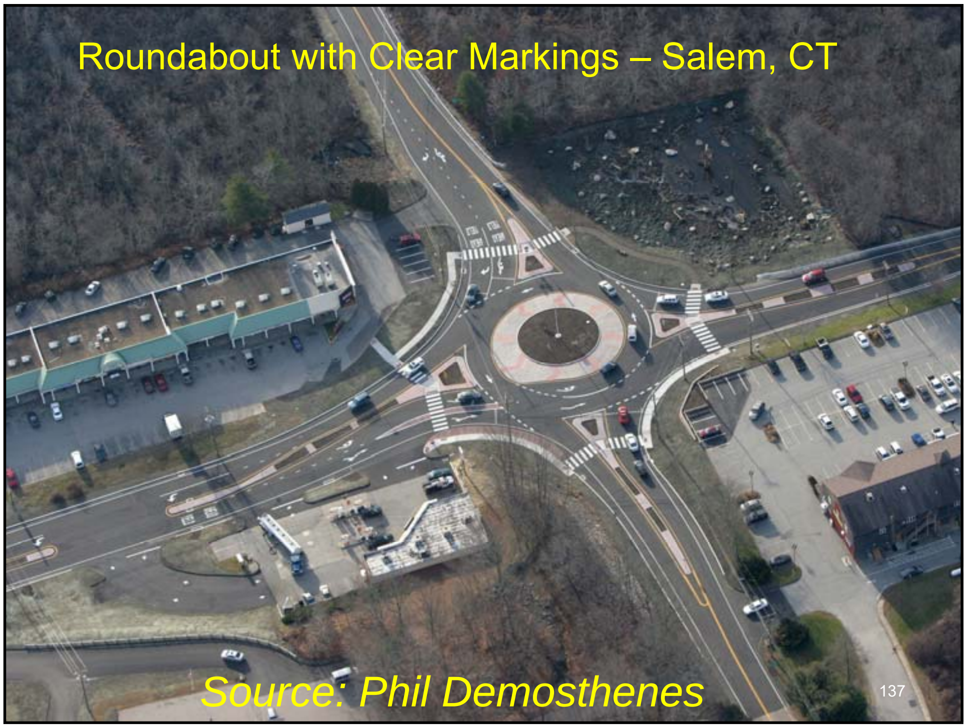



Head-On / Turn Collisions, 5 Years
24 Collisions
7 Injuries - 1 fatality
(#322)
38 Collisions
18 Injuries
(#121)
133


West Haven (Before)
CTDOT Project 156-173
Existing Conditions
134


West Haven (Built - 6/08)
135


HOW ACCIDENTS WILL BE REDUCED
BACK-UPS WILL BE REDUCED
LEFT TURN LANE AT GAS STATION
136



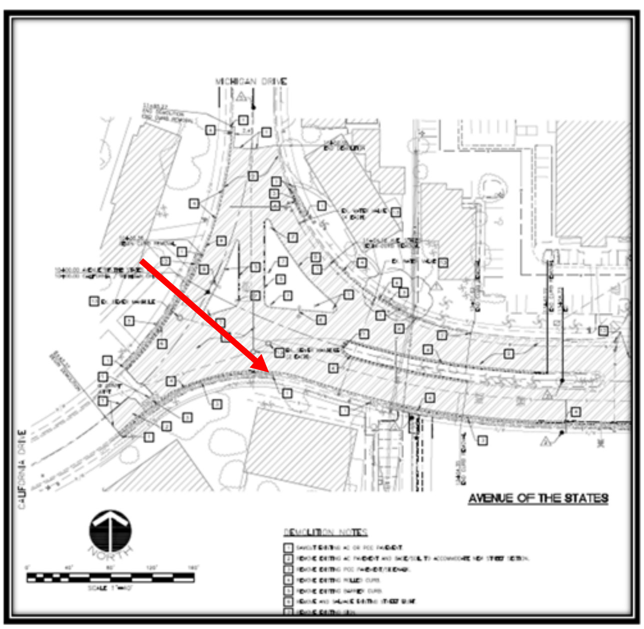
Case Study II

Challenges of a Y type intersection

(Aerial Photos Provided by Mark Diercks - City of Palm Desert)

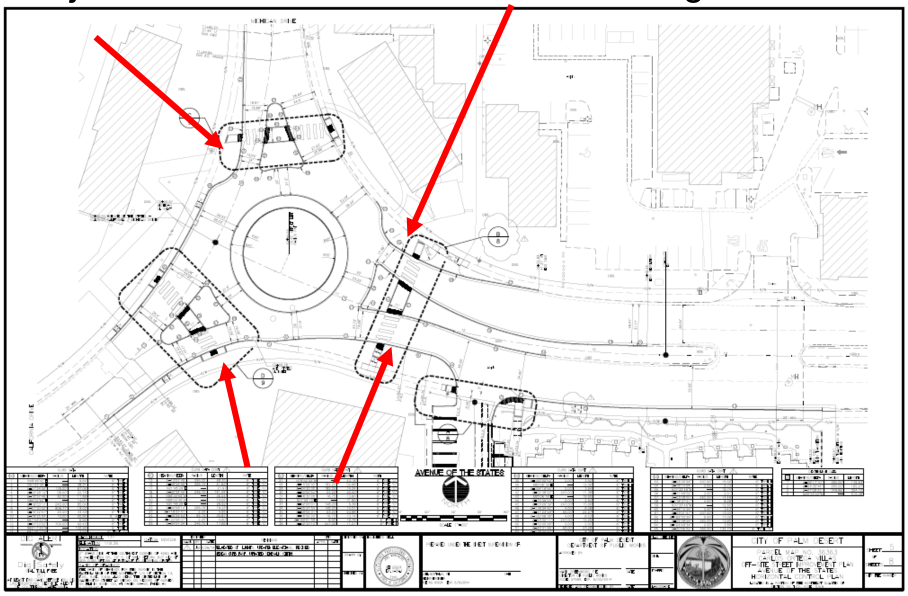
138


Before -Very Awkward Y
Type Intersection
139


MICHIGAN DRIVE
AVENUE OF THE STATES
CALIFORNIA DRIVE
NORTH
DEMOLITION NOTES

140

Retention of existing improvements within right of way of major concern as well as accommodating trucks



141

142

Case Study III

(Jefferson and Avenue 52 in

La Quinta, CA)

143

Problems with Roundabout

- Two lane entry into a single lane 28 foot wide circulatory road
- Many citizen complaints because of path overlap
- Second highest crash location in the City – entry speed 30 mph but circulatory speed 19 mph.
- Rear-end and sideswipe collisions due to path overlap
- 105 crashes in 10 years – more than 70% are drivers running into roundabout
- Signing changes recommended by designer have not worked

144


Single wide circular lane
Dual lane entry into
single lane roundabout
145


YIELD
Participants -what broken here?
Video at www.traffexengineers.com
146

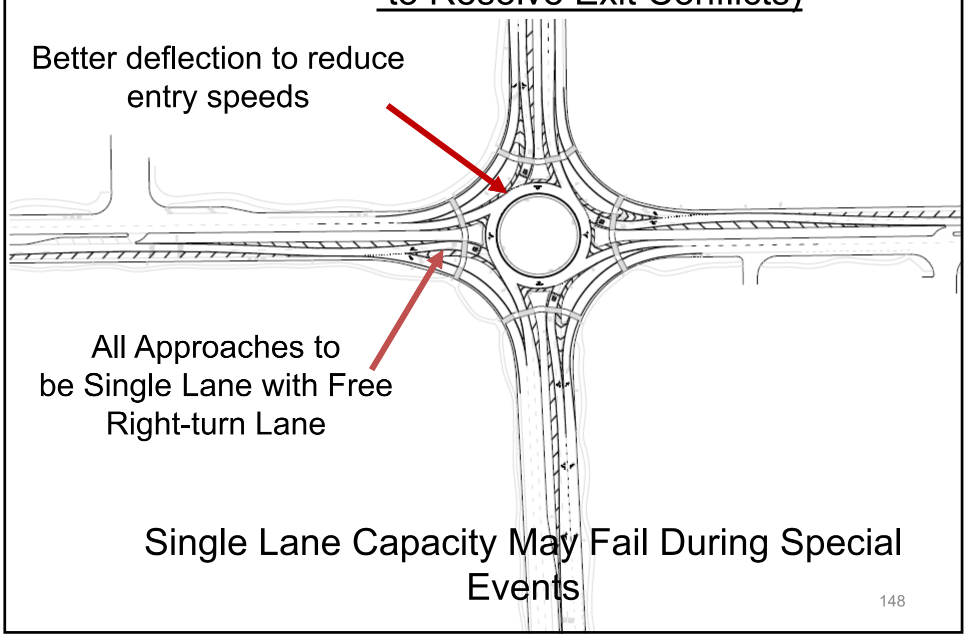
Proposed Changes Considered

- Dual lane striping on circulatory road with one lane sections

  (Per 2009 MUTCD)
- Signs to tell truck drivers to take both lanes (Unsure this will work)
- Restriping exits to make them only one lane wide
- Advance speed reduction markings to reduce entry speeds closer to the circulatory design speed of 19mph
- **Participants – what design changes should be implemented?**

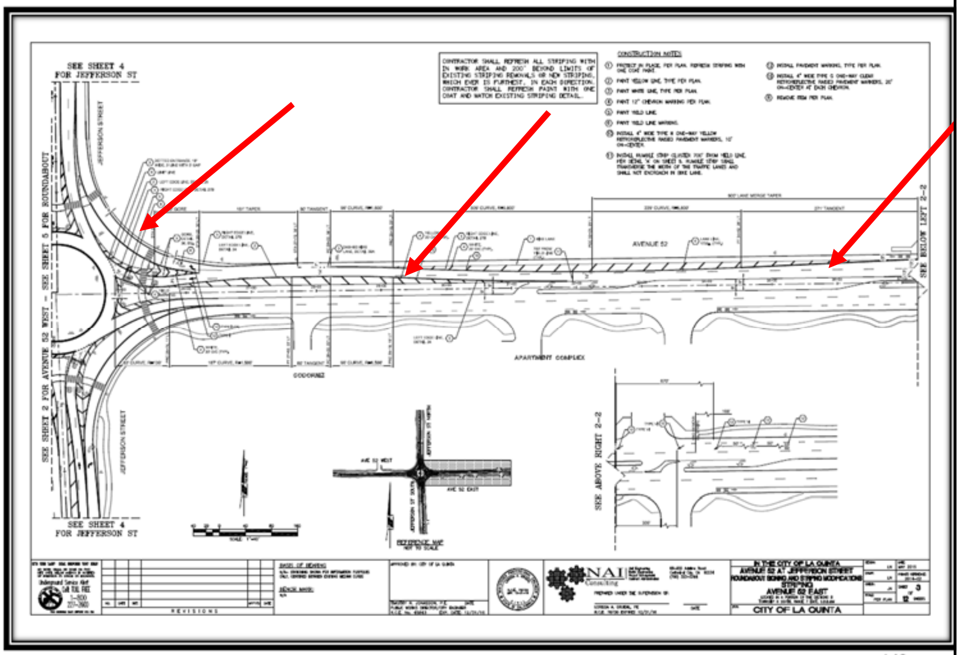
147

Restriping to a Single Lane Configuration to Resolve Exit Conflicts)



Single Lane Capacity May Fail During Special Events

148


SEE SHEET 4
FOR JEFFERSON ST
SEE SHEET 2 FOR AVENUE 52 WEST – SEE SHEET 5 FOR ROUNDABOUT
AVENUE 52
APARTMENT COMPLEX
SEE ABOVE RIGHT 2-2
SEE BELOW LEFT 2-2
SEE SHEET 4
FOR JEFFERSON ST
CONSTRUCTION NOTES
CITY OF LA QUINTA

149


Avenue 52
West
LEFT LANE ONLY

150


151


152

Roundabout fails during Special events

154

Facilities Development Manual — Wisconsin Department of Transportation
Chapter 11 Design
Section 26 Roundabouts

FDM 11-26-1 General — June 24, 2016

Revise 11-26 (Roundabouts) with global name change from OSOW Freight Network (OSOW-FN) to OSOW Truck Route (OSOW-TR).

1.1 General

This section and its sub-sections are comprised of roundabout design and operations guidelines developed through research and experience. Much of the prescribed guidance has been proven through application, evaluation and refinement - a truly continuous improvement process.

The Department has updated previous versions of this guide to account for changes in national roundabout guidelines made possible through research, namely NCHRP 572 - Roundabouts in the United States, 2006 and NCHRP 672, Roundabouts: An Informational Guide, Second Edition. The NCHRP guidelines and research are heavily relied upon in this chapter. Where appropriate and justified by local experience, exceptions for use by the Wisconsin Department of Transportation are noted. Where both references are cited but differences exist, the Facilities Development Manual guidance shall govern.

The modern roundabout is a subset of many types of circular intersections. The term modern roundabout and roundabout are used interchangeably throughout this document. The roundabout is a one-way circular intersection where circulating traffic is given priority over entering traffic and where entry speeds are low relative to older unconventional circular intersections. The term "modern roundabout" is used in the United States to differentiate roundabouts from the older and often large diameter nonconforming traffic circles, rotaries or very small traffic calming circles used on residential streets.

Traffic circles fell out of favor in this country by the mid 1950's because they encountered safety and operational problems as traffic volumes increased beyond their operational thresholds. However, substantial progress has been achieved in the subsequent design of circular intersections, and the modern roundabout should not be confused with the traffic circles of the past.

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals, and will process a wide range of side road volumes. Roundabouts can improve safety by reducing vehicle speeds and eliminating crossing conflicts that are present at conventional intersection. The required intersection sight distance is greatly reduced from what is required for a signalized intersection due to the reduced intersection speeds.

The modern roundabout is defined by three basic principles:

1. Yield-at-Entry - Vehicles approaching the roundabout must wait for a gap in the circulating flow, or yield, before entering the circle.
2. Deflection - Traffic entering the roundabout is directed or channeled to the right with a curved entry path into the circulating roadway.
3. Geometric Curvature - The radius of the circular road and the angles of entry are designed to slow the speed of vehicles.

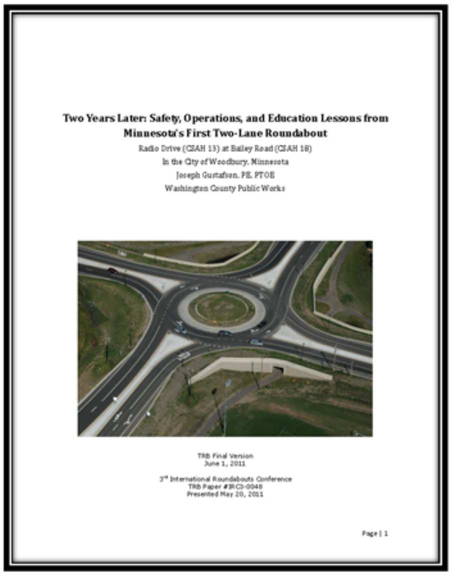
The following is a list of locations where a roundabout may be feasible:

1. Intersections with a high-crash rate or a higher severity of crashes
2. High-speed rural intersections
3. Freeway ramp terminals
4. Transitions in functional class or desired speed change (including rural to urban transitions)
5. Existing intersections that are failing
6. Aesthetics is an objective
7. Intersections of dissimilar functional class (arterial-arterial, arterial-collector, arterial-local, collector-collector, collector-access)
8. Four-leg intersections with entering volumes less than 5,000 vph or approximately 50,000 ADT
9. Three-leg intersections
10. Intersection of two signalized progressive corridors where turn proportions are heavy (random arrival is better than off-cycle arrival)

Page 1

Locations	Implem-entation Date	Before				After				Percent Reduction In Crashes/Year		
		Months	Total Crashes	Injury Crashes	Fatal Crashes	Months	Total Crashes	Injury Crashes	Fatal Crashes	Total Crashes	Injury Crashes	Fatal Crashes
Cearfoss (MD-58 and MD-63/ MD-494)	Dec-95	60	19	8	1	121	9	1	0	76.5%	93.8%	100.0%
Lisbon (MD-94 and MD-144)	Apr-93	60	42	19	0	161	18	4	0	84.0%	92.2%	0.0%
Lothian (MD-2 and MD-408/ MD-422)	Oct-95	60	39	26	1	122	40	11	0	49.6%	79.2%	100.0%
Taneytown (MD-140 and MD-832/ Antrim Boulevard)	Aug-96	60	30	15	0	112	10	3	0	82.1%	89.3%	0.0%
Leeds (MD-213 and Leeds Road/Elk Mills Road)	Aug-95	60	20	14	1	124	22	2	0	46.8%	93.1%	100.0%
TOTAL		300	150	82	3	640	99	21	0	69.1%	88.0%	100.0%

Table 1: Summary of crash reductions after conversion to roundabout intersections.



Two Years Later: Safety, Operations, and Education Lessons from Minnesota's First Two-Lane Roundabout

Radio Drive (CSAH 13) at Bailey Road (CSAH 18)
In the City of Woodbury, Minnesota
Joseph Gustafson, PE, PTOE
Washington County Public Works

TRB Final Version
June 1, 2011

3rd International Roundabouts Conference
TRB Paper #3RC3-0048
Presented May 20, 2011

Page | 1

"Other recommendations for future multi-lane roundabout projects would include the following:
1. Never characterize roundabout entries and exits as right turns, either verbally or in print, unless
a driver is actually making a right turn, such as entering northbound and departing eastbound.
a. Do not use right turn arrows on approaches to single-lane roundabouts.
b. Do not stripe across the exits of roundabouts.
c. Do not recommend that drivers use a right turn signal to exit a roundabout.
2. Ensure that proper striping is available upon the opening of a roundabout to traffic.
3. Be aware of other circular-shaped intersections, both locally and elsewhere, that may shape
driver perceptions of proper behavior at a roundabout.
4. Avoid providing more capacity than is needed. Doing so may increase drivers entry speeds and increase the potential for improper lane use maneuvers.
5. Work closely with other agencies, driver educators, and local media to ensure that a public consistent message is shared with the."

157

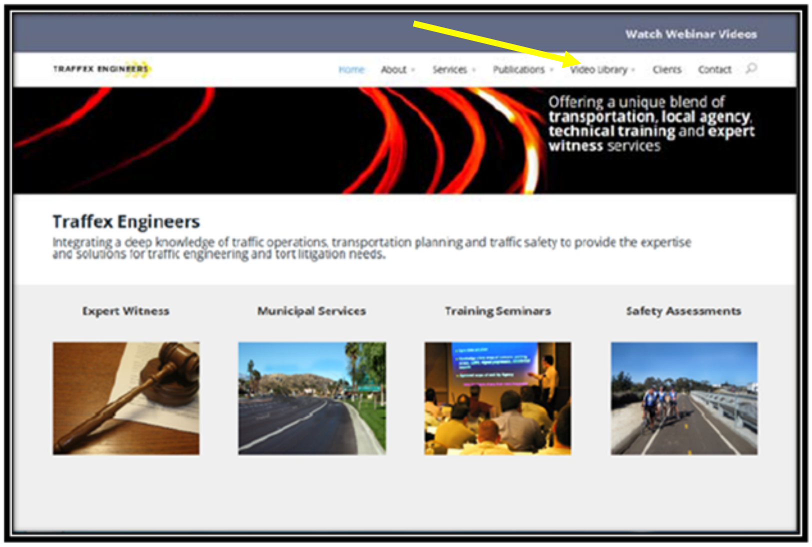
Roundabouts: Why is Mn/DOT Building Them?

Traffic Topics

August 5, 2010

Ken E. Johnson
Mn/DOT Office of Traffic, Safety, and Technology
Member of Mn/DOT Roundabout Steering Committee
ken.johnson@state.mn.us
651-234-7386

158



www. traffexengineers.com

159

160

Future Webinars

Single Lane, Multi Lane and Mini Roundabouts: The Operational Aspects	**Thursday, August 10, 2017 | 12:00 p.m. - 1:30 p.m. Eastern Time**
Pedestrian and Bicycle Safety Assessment Studies	Thursday, August 17, 2017 | 12:00 p.m. - 1:30 p.m. Eastern Time
Roadway Geometric Design for Improved Safety and Operations	Friday, September 8, 2017 | 11:30 a.m. - 1:00 p.m. Eastern Time
Work Zone Temporary Traffic Control	Friday, September 15, 2017 | 12:00 p.m. - 1:30 p.m. Eastern Time
Traffic Calming: The Lumps and the Bumps	Friday, September 22, 2017 | 12:00 p.m. - 1:30 p.m. Eastern Time

161