The evaluation of modern roundabouts as an alternative to signalized and two-way stop controlled intersections in a urban and rural environment
by Travis John Eickman

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering
Montana State University

Abstract:
The comparison of roundabouts with other intersection forms of traffic control is becoming an increasingly common occurrence. With little overall experience within the United States, the data for roundabout comparison is somewhat varied. This report includes the results of five models created using VISSIM traffic modeling software in the comparison of a two-way stop, signal and roundabout in an urban environment, and a two-way stop and roundabout in a rural environment.

A large amount of field data in the form of traffic volumes, vehicle types, gap timing and headway distances were used in the calibration and validation of the various models. Multiple runs of the models were conducted to attain an expansive data pool from which to evaluate the different modes of traffic control. Measures of effectiveness included crash reduction, delay, and queue length.

Due that crash data could only be obtained for the before period of the base case studies, a detailed crash reduction analysis could not be conducted. A limited analysis was conducted to review the possible reduction in the possibility of accidents and their severity. Delay values indicated the roundabout provided the best performance, followed by the signal, and lastly the two-way stop. Average queue length data indicated that the roundabouts functioned with no notable queuing experienced. The results of the signal indicated improved performance on that of the two-way stop.

The results indicate that roundabouts are a viable alternative to a two-way stop and signal. For a more accurate, long-term evaluation, growth projections should be applied to existing conditions to determine the operational effectiveness of the intersection traffic control type at some point in the future. Depending on the purpose and need of any intersection being evaluated, additional focus can also be concentrated on obtaining additional field information for driver behavior, gap timing, headway distances, delay times and average queue lengths.

THE EVALUATION OF MODERN ROUNDABOUTS AS AN ALTERNATIVE TO SIGNALIZED AND TWO-WAY STOP CONTROLLED INTERSECTIONS IN A URBAN AND RURAL ENVIRONMENT

by

Travis John Eickman

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Civil Engineering

MONTANA STATE UNIVERSITY – BOZEMAN
Bozeman, Montana

July 2004

APPROVAL

of a thesis submitted by

Travis John Eickman

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Dr. Jodi L. Carson — Jodi L. Carson (Signature) — 6/10/04 (Date)

Approved for the Department of Civil Engineering

Dr. Brett Gunnink — (Signature) — 7/8/04 (Date)

Approved for the College of Graduate Studies

Dr. Bruce McLeod — Bruce R. McLeod (Signature) — 7-14-04 (Date)

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University – Bozeman, I agree that the Library shall make it available to borrowers under rules of the Library.

If I have indicated my intention to copyright this thesis by including a copyright notice page, copying is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright Law. Requests for permission for extended quotation from or reproduction of this thesis in whole or in parts may be granted only by the copyright holder.

Signature Travis J. Eickman

Date June 10, 2004

ACKNOWLEDGMENTS

This has been a long process covering the span of four years that could not have come to a conclusion had it not been for the support and encouragement of so many. This includes family, Morrison-Maierle co-workers, Montana State University and Montana Department of Transportation staff.

To the staff of the Civil Engineering Department at Montana State University and Montana Department of Transportation, I thank you for the educational and financial opportunity provided to me to complete this endeavor. Special thanks and recognition goes to Dr. Jodi Carson for her patience, tutelage, and 'tell-it-like-it-is' edits while acting as my committee Chair. Though the process may have been painful at times, the end result is an expanded knowledge base – for the better.

I would like to thank my committee members; Jodi Carson, Scott Bell, and Scott Keller for their hard work and understanding in getting this thesis completed in the final stretch of the semester. With timelines short, and schedules always full, I thank you for taking the time out to help me complete this milestone.

To my wife, Colleen, and our two boys, Trevor and Tucker, I extend my deepest gratitude for your sacrifices and encouragement. Through sleepless nights, countless edits, and years worth of higher education you have been there to instill the drive and never quit attitude. This is as much an accomplishment for you as it is for me.

I also extend my sincere appreciation to my extended family at Morrison-Maierle, Inc. for providing their support, knowledge base, and placing the company assets at my

disposal. This thesis could not have come to fruition had it not been for their patience in educating me on the finer arts of computer skills, editing, and being there to "kick" me along whenever I started to stray. Those deserving special recognition include; Keith Belden, Phillip Forbes, Scott Bell and Creg Dieziger.

TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

LIST OF TABLES

Table Page

LIST OF TABLES - CONTINUED

LIST OF FIGURES

Figure Page

ABSTRACT

The comparison of roundabouts with other intersection forms of traffic control is becoming an increasingly common occurrence. With little overall experience within the United States, the data for roundabout comparison is somewhat varied. This report includes the results of five models created using VISSIM traffic modeling software in the comparison of a two-way stop, signal and roundabout in an urban environment, and a two-way stop and roundabout in a rural environment.

A large amount of field data in the form of traffic volumes, vehicle types, gap timing and headway distances were used in the calibration and validation of the various models. Multiple runs of the models were conducted to attain an expansive data pool from which to evaluate the different modes of traffic control. Measures of effectiveness included crash reduction, delay, and queue length.

Due that crash data could only be obtained for the before period of the base case studies, a detailed crash reduction analysis could not be conducted. A limited analysis was conducted to review the possible reduction in the possibility of accidents and their severity. Delay values indicated the roundabout provided the best performance, followed by the signal, and lastly the two-way stop. Average queue length data indicated that the roundabouts functioned with no notable queuing experienced. The results of the signal indicated improved performance on that of the two-way stop.

The results indicate that roundabouts are a viable alternative to a two-way stop and signal. For a more accurate, long-term evaluation, growth projections should be applied to existing conditions to determine the operational effectiveness of the intersection traffic control type at some point in the future. Depending on the purpose and need of any intersection being evaluated, additional focus can also be concentrated on obtaining additional field information for driver behavior, gap timing, headway distances, delay times and average queue lengths.

CHAPTER 1

INTRODUCTION

The overall purpose and goal of public and private entities involved in transportation is, in one way or another, tied to providing safe and efficient movement from an origin to a destination. Automobile transportation comprises multiple components that work together as a system to provide this safe and efficient movement. Intersections (i.e., nodes), roads (i.e., links), signals, regulatory and warning signs, striping, guardrail and other elements are part of this "system".

As the volume of traffic approaches the capacity of the roadway system, delays grow rapidly, particularly at intersections. One strategy used to alleviate these intersection-related delays and minimize associated safety risks is to remove all left-turn movements. In doing so, the associated left-turn start-up and clearance lost times in the intersection are eliminated. This, in turn, adds to the amount of time that can be dedicated to through traffic movements. While this strategy may improve overall delay at an intersection, direct accessibility for those making the left-turn movement is compromised.

In the last several decades, the desire for a safer, more efficient intersection that does not compromise accessibility has resulted in new designs and methods that include circular intersections. Three distinct types of circular intersections exist: rotaries, neighborhood traffic circles, and roundabouts (1). Rotaries, used in the United States prior to the 1960's, are characterized by a large diameter that promotes excessive speeds. This geometric feature, when combined with no yield to entering traffic practices and

little to no horizontal deflection, discourages its use today. An alternate form of circular intersection that is more prevalent today, the traffic circle, is typically built at the intersection of local streets for reasons of traffic calming and aesthetics. Roundabouts, the topic of this thesis, are similar to traffic circles aside from a few design points related to yield-at-entry practices, traffic deflection and upstream roadway flares (i.e., additional lanes) (see Figure 1).

Roundabouts are being effectively used throughout Europe and the rest of the world with favorable results related to both safety and efficiency. However, several impediments include unfamiliarity, a lack of design guidelines, differences in interchanges/intersections and traffic control preferences and regulation inhibit widespread implementation in the United States. With further research and public education, however, the roundabout may be a powerful addition to the transportation engineer's toolbox.

Background

A roundabout is a circular type of intersection that has been widely used throughout Europe and is quickly gaining popularity throughout the rest of the world as a replacement for two-way stop-controlled (TWSC), all-way stop-controlled (AWSC), and signalized intersections. It's predicted that roundabouts in the United States will be built by the hundreds in the upcoming years and by the thousands annually in the next few decades, duplicating trends observed first in Britain and Australia during the 1970's and 1980's and now being reported throughout western Europe (2).

Modern Roundabout or Nonconforming Traffic Circle?

Unlike nonconforming traffic circles, modern roundabouts conform to modern roundabout guidelines. Among other important new features, modern roundabouts have yield-at-entry, deflection, and (often) flare, as illustrated below.

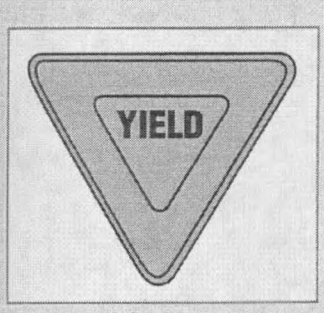
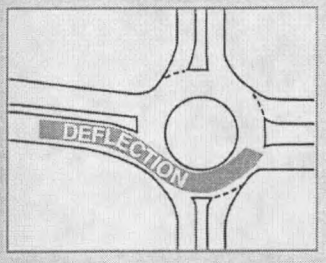
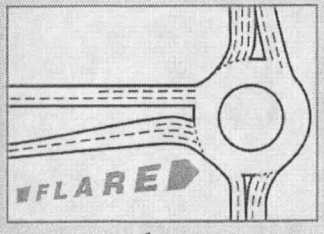
	Modern Roundabout	Nonconforming Traffic Circle
 Yield-at-Entry	**Entering traffic yields to circulating traffic.** • Circulating traffic always keeps moving. • Works well with very heavy traffic. • No weaving distance necessary. Roundabouts are compact.	**Entering traffic cuts off circulating traffic.** • Circulating traffic comes to a dead stop when the circle fills with entering traffic. • Breaks down with heavy traffic. • Long weaving distances for merging entries cause circles to be large.
 Deflection	**Entering traffic aims at the center of the central island and is deflected slowly around it.** • Slows traffic on fast roads, reducing accidents. • Deflection promotes the yielding process.	**Entering traffic aims to the right of the central island and proceeds straight ahead at speed.** • Causes serious accidents if used on fast roads. • Fast entries defeat the yielding process.
 Flare	**Upstream roadway often flares at entry, adding lanes.** • Provides high capacity in a compact space. • Permits two-lane roads between roundabouts, saving pavement, land, and bridge area.	**Lanes are not added at entry.** • Provides low capacity even if circle is large. • For high capacity, requires multilane roads between circles, wasting pavement, land, and bridge area.

Figure 1. Circle Components Comparison – Roundabout vs. Traffic Circle (2)

Because roundabouts are still relatively new to the United States (approximately 250 are in service (2), a number of issues have yet to be addressed. Public acceptance, safety concerns, ability to function acceptably with existing infrastructure and their integration with established signal networks are just a few of the factors that come into question.

The modern roundabout was developed in the United Kingdom in 1966 with the adoption of the mandatory "give-way" rule for entering traffic at circular intersections (1). Since its inception, the design has spread to most British-influenced countries like Australia, New Zealand, Ireland, Barbados, and Bermuda, as well as France, Switzerland, Norway, Denmark, Sweden, Germany, Spain, Portugal and the Netherlands.

In the U.S., the preferred type of intersection is the crossroads, or four-leg cross intersection with the traffic signal or stop signs as a predominant form of traffic control. Contrary to this practice, Britain chooses not to use this type of intersection in new construction due to its inefficient traffic performance and poor accident record; existing crossroads are often converted to offset intersections that promote safety. Further, traffic signals are used only when no other alternatives exist (see Figure 2) (3).

All-way STOP sign control is not used in Britain or in any other country outside of North America. YIELD signs instead of STOP signs are used in Britain except at intersections having poor sight distance. Such STOP sign policies promote respect for the law, while at the same time reducing delay, emissions, and fuel waste.

Contrary to this practice, the United States favors use of the STOP sign; the YIELD sign is used on a limited basis. Citations are issued for sensible driver actions: making a