Development of Roundabout Application Guidelines for Ada County, Idaho

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Abstract
While no arterial or collector roundabouts currently exist in Ada County, Idaho (Boise metropolitan area), there has been a proliferation of circular, low-volume intersections resembling roundabouts within residential subdivisions. In addition, several roundabouts have been proposed on collectors and arterials in the county and an arterial roundabout has been constructed in neighboring Canyon County. The Ada County Highway District (ACHD) recognized the need to develop a common approach to roundabout development in the county to serve as an aid to ACHD staff, city planners, design engineers, developers, and others. This paper summarizes the results of a study commissioned by ACHD, with a focus on the process followed. The study included research of existing best practices from around the United States; use of a steering committee composed of representatives of the various ACHD departments, city and county planning staff, and representatives from several police and fire agencies in the county; the development of guidelines for siting and design; use of micro-simulation and empirical models to test the guidelines developed; a cost comparison between roundabouts and traffic signals; and a peer review.

INTRODUCTION

The purpose of this paper is to describe the process one agency choose to employ for the development of roundabout application guidelines and to outline the content of the end product of that effort. It is hoped that this will assist others who may contemplate doing something similar. The purpose is not to detail the research results or the final guidelines to be adopted by the agency.

Background

Roundabouts are gaining popularity across the United States as a safe, efficient means of controlling and accommodating intersection traffic. That popularity is driven by the safety, aesthetic, and efficiency benefits that roundabouts can provide. This trend has reached Idaho's Treasure Valley with the construction of a single-lane roundabout at the intersection of two arterial streets in Canyon County and a proliferation of low-volume traffic circles resembling roundabouts located within residential subdivisions.

The Ada County Highway District (ACHD) is the largest local roadway agency in Idaho with responsibilities for Boise streets and that of the five other cities in Ada County. In Ada County, roundabouts are being given increased consideration as an alternative to traffic signals or all-way stops on roadways ranging from local subdivision streets to arterials. ACHD currently has three roundabouts under design at locations on arterial and collector roadways, two of which were initiated by the public. Currently, ACHD is looking at several other possible roundabout

locations and is in the process preserving an arterial corridor for roundabouts. Additionally, at least 20 development-driven roundabouts are proposed in the county, with new locations coming through ACHD's review process almost monthly.

Need for Guidelines

The proliferation of circular intersections resembling poorly-designed roundabouts stems from a general lack of professional experience in designing roundabouts and no formal local guidance to direct the inexperienced. ACHD recognized the need to develop a common approach to roundabout development in the county to serve as an aid to ACHD staff, city planners, design engineers, developers and others as they consider and pursue roundabout solutions.

To that end, ACHD contracted with the Nampa, Idaho office of Project Engineering Consultants, Ltd. (PEC) to develop of set of guidelines for the development of roundabouts on roadways within its jurisdiction. Some of the guiding principles/objectives identified for the study were:

- Roundabout guidelines need to be formulated with care to allow the needed design flexibility.
- The guidelines are not intended to be a substitute for designer training and experience, nor are they intended to replace other available guides (such as the FHWA guide).

During the initial phase of the study, it was determined that using a multifaceted approach in developing the guidelines would result in the strongest product. This comprehensive approach led to the gathering of information from several types of sources, namely existing guidelines (e.g. FHWA guide) already in the possession of the study team, guides and technical papers acquired through internet searches, e-mail and phone conversations with roundabout experts from around the country, and additional guides and papers provided by those national experts. Lastly, a steering committee was assembled to make major decisions in the best interests of the guideline project and to ensure the quality of the project.

STEERING COMMITTEE

Purpose and Composition

Because a pure engineering approach sometimes misses important issues or even fatal flaws, a multidisciplinary committee approach was deemed necessary to provide a better product. The steering committee was formed with the intent of preventing any particular individual, group or organization from swaying the guidelines to fit his or her needs. The purpose of the steering committee was to assist with the development of the roundabout guidelines by representing their respective entity's needs and concerns, and to ensure the guidelines create consistency for roundabouts in the county.

The steering committee was a 17-person group composed of representatives from the local entities impacted by transportation decisions, including:

- Planners from the City of Boise, City of Meridian, and Ada County
- Representatives from Police and Fire Departments

- A utilities expert
- A bike/pedestrian liaison
- Traffic engineers from ACHD and PEC

Committee members were chosen due to their expertise and experience in the broad range of issues and perspectives that arise with any traffic-related project. Following an initial kickoff meeting, the steering committee members were asked to contribute by representing the interests of their stakeholder group, participating in scheduled meetings, and making recommendations.

How the Committee Was Utilized

Regular meetings helped to ensure that the issues, viewpoints, needs, and concerns of each committee member were addressed and accounted for in the study. The steering committee used the expertise of its members in all areas of the guidelines. The planners were instrumental in the issues of roundabout siting, the police in safety aspects, and the bike/pedestrian liaison with Americans with Disabilities Act (ADA) compliance.

With a group of this size, there were challenges to building consensus among the members. Challenges centered on learning curve issues and on preconceived notions regarding the operations, safety, and benefit of roundabouts. Most of the members were relatively unfamiliar with roundabouts; subsequently, there was a modest adjustment period for members to acquire an adequate level of understanding of roundabouts and their operations.

With the preliminary meetings acting as an introduction to roundabouts, soliciting input was difficult at best. However, as the knowledge level increased, the members brought valid concerns which improved the guidelines. As the familiarity increased, so did the varied opinions on what needed to be addressed, and consensus was not always easily formed. For example, the representative for the local law enforcement agency was insistent on having the circulatory roadway posted with a regulatory speed limit. However, after a thorough discussion on proper design and fastest path principles, the committee was able to agree that a regulatory sign is not needed at the roundabout entrances. The ability of the members to work through issues was one of the key assets in strengthening the final guidelines.

BEST PRACTICES RESEARCH

PEC contacted many roundabout experts across the country to solicit their input on the current state of the practice of roundabout design and on this guideline development effort. These experts provided valuable comments, documents, and links to additional information.

The list of experts contacted targeted public agency personnel. The request for information posed to them was as follows:

> My company has a contract with the Ada County Highway District (Boise, Idaho area) to help them develop a set of guidelines for the siting and design of roundabouts in the county. The end result of the study will be an addition to their development policy manual that will give guidance to agency staff, developers, and consultants regarding a number of issues, including (but not necessarily limited to): the selection of suitable locations for roundabouts, “typical” right-of-way requirements (in order to preserve right-of-way for future roundabout projects), ranges of

> appropriate design parameter values for different functional types and sizes of intersections, construction concerns, utility issues, and public outreach.
>
> If you are aware of any similar endeavors that others have already undertaken, please direct me to them so that we can learn from their previous work. Also, please let me know of other information sources relating to our study that you feel would be helpful.

Individuals responding to the request for information included representatives from four cities, two state transportation departments, two universities, the Federal Highway Administration (FHWA), and two consultants. Information was obtained from these individuals in the form of email messages, phone conversations, and references to other documents. Some forwarded other guides or technical papers for reference use on this project.

Much information on existing practices was acquired from various roundabout guides published by FHWA and state and local highway jurisdictions. PEC also performed an extensive internet search for information on this topic.

The results of the best practices research were summarized in a technical memorandum that constituted a starting point for the development of the Ada County guidelines.

ADA COUNTY GUIDELINES

After the best practices research was completed, the study team developed the draft Ada County guidelines as follows:

1. The results of the best practices research were reviewed in a steering committee meeting to educate the committee regarding what issues others have addressed in their guidelines and standards and the range of views (often conflicting) held by those entities. This meeting provided an opportunity for the committee members to state their views and concerns regarding what should or should not be allowed in Ada County and what form the guidelines should take.
2. The study team used the input from the steering committee, along with the results of the best practices research and the team's own professional experience, to develop a first draft of siting guidelines. These were distributed to the committee members for their review.
3. The steering committee discussed the proposed siting guidelines at length in a subsequent committee meeting, providing direction to the study team to refine the draft guidelines.
4. The procedure used for the siting guidelines was repeated for the design guidelines.
5. Extensive modeling was done to test and refine the guidelines and a peer review was performed, as discussed in later sections of this paper.

The process described above resulted in a complete set of siting and design guidelines for presentation to the ACHD Commission. As of this writing, the guidelines are awaiting formal adoption by the ACHD Commission. It is anticipated that the full report, including the guidelines, best practices research memorandum, peer review, and discussions of the modeling and steering committee activities, will be made available by ACHD to interested parties. The content of the guidelines is discussed in the following subsections.

Siting Guidelines

Roundabouts have been shown to function efficiently and safely under a wide range of local conditions. In short, a roundabout can be constructed at any location where a design that is efficient, safe, and appropriate to the site can be achieved. Making specific, exhaustive lists of locations or sets of conditions where roundabouts will and will not be allowed is, therefore, not practical. Rather, the decision was made to present in the guidelines information that should be considered in determining whether or not a given site is potentially a suitable location for a roundabout. The discussion in the guidelines is broken down into three general types/categories of locations:

- Locations where roundabouts are generally inappropriate (*example: location where pedestrians regularly comprise the predominant traffic movement*)
- Locations where roundabouts may be particularly advantageous (*example: location with high existing crash rates*)
- Locations where additional analysis will likely be needed to assess the suitability of a roundabout at the site (*example: location with a large imbalance of major vs. minor street traffic*)

The siting guidelines address a number of important issues, including:

- Right-of-way constraints
- Pedestrians
- Grades
- Traffic volumes
- Crash rates
- Intersection geometry
- Capacity needs
- Queue storage constraints
- Access management
- Approach widening feasibility
- Future traffic patterns
- Vehicle speeds
- "Gateway" intersections
- Presence of coordinated signal networks
- Intersection sight distance
- Downstream traffic constraints
- Traffic split between major and minor streets
- Major utility, irrigation, or drainage conflicts.

These siting guidelines provide a means of "screening" proposed roundabout locations to determine whether or not a roundabout solution can reasonably be advanced to the alternatives development and evaluation phase of the project development process. The alternatives analysis (potentially including other intersection control types, such as traffic signals and stop signs) should be the decision-making tool used to determine whether or not a roundabout will ultimately be constructed.

Design Guidelines

Traditional roadway design standards consist of minimum values for such design parameters as roadway width, shoulder width, centerline radius, curb return radius, vertical curve "K" values, and design vehicle. These minimum values provide the minimum acceptable design. Use of greater values, where possible, results in a more conservative, "better" design. The idea is that if a certain amount of something—such as the number of approach lanes to an intersection—is good, then more of it is even better. Although some design philosophies, such as "context sensitive design," have challenged that way of thinking, it is still the predominant approach used across the country.

Roundabout design requires a shift in thinking in the design of roundabouts and in the establishment of design policies. Providing greater than optimum values for design parameters can be as bad as or worse than providing less than optimum values. For example, providing pavement widths, entry curve radii, and inscribed circle diameters that are larger than optimum will result in excessive speed and reductions in safety and efficiency. Proper design also can not be achieved by following a "cookbook" process and selecting standard values for design parameters. The nuances of roundabout design and operation are such that the *combination* of parameter values for a given site is what will produce the desired result—not the individual values. This is sometimes referred to as taking a "holistic" approach to design. The different elements of the roundabout work in harmony to produce the desired operational efficiency and driver behavior. The "best" combination of parameter values will vary from site to site and even from one leg of the roundabout to another. This variation is due to such things as differing traffic characteristics, topographic constraints, and roadway function.

Based on the discussion above, the Ada County roundabout design guidelines are not prescriptive, hard standards. The intent was rather to provide guidance that a designer can use, in conjunction with his or her knowledge and expertise in roundabout design, to produce designs that avoid certain extremes deemed undesirable by ACHD. The intent was also to form the basis for the development of "sample" roundabout designs to assist ACHD in identifying right-of-way preservation needs for potential future roundabouts. The guidelines are not a substitute for designer experience, expertise, and engineering judgment. The Ada County guidelines encourage roundabout designers to be familiar with, and make liberal use of, nationally-accepted guidance documents. Examples of two such documents are the FHWA Roundabout Guide *(1)* and the Ourston Roundabout Design Guidelines *(2)*.

The Ada County roundabout design guidelines cover a wide range of design parameters. For each design parameter, a discussion of the issues associated with it is included, followed by specific design guidance. The design parameters addressed in the guidelines include:

- Design vehicle
- Design speed
- Inscribed circle diameter
- Entry and exit geometry
- Circulatory roadway width
- Truck apron
- Number of lanes
- Sight distance

- Central island features
- Splitter islands
- Bicycle and pedestrian facilities
- Signing and striping
- Drainage
- Illumination
- Access control

The design guidelines also include a discussion regarding design of roundabouts for single-lane to dual-lane expandability.

Figure 1 is an excerpt from the draft design guidelines illustrating the manner in which each design parameter is discussed and the types of design guidance that are provided. Figures 2 – 6 illustrate sample roundabout layouts incorporating these guidelines for various combinations of 2-lane, 3-lane, and 5-lane intersecting roadways. Figure 7 illustrates the application of the signing and pavement marking guidance.

Design Parameter	*Discussion*	*Design Guidance*
Design Vehicle	Roundabouts must be designed to accommodate any vehicle type and size that regularly uses the intersection. In general, this "maximum" vehicle will vary from location to location based on the adjacent land use and roadway function. It is incumbent on the designer to do background research to determine what vehicles must be accommodated at a particular location. Analysis of vehicle turning movements using a software package (AutoTURN, for example) should be done to check that the proposed geometry is adequate for the selected design vehicle.	WB-67 for principal arterial intersections, industrial areas, and access to industrial areas. WB-50 or larger for minor arterial intersections. BUS or larger for roadways in residential areas not intended to serve thru traffic.
Design Speed	Free-flow (non-congested) speeds in a roundabout are directly related to the curvature of the vehicular paths and the pavement cross-slope. The relationship between curve radius, cross-slope, and speed is detailed in *A Policy on Geometric Design of Highways and Streets* (AASHTO "Green Book", latest edition). Vehicles making left-turns or U-turns travel in a path that corresponds to the centerline radius of the circulatory roadway. Their speeds are therefore directly controlled, at least to some extent, by the roundabout diameter. The speeds of vehicles in the roundabout that are going straight through or turning right, however, are less impacted by the circle diameter. All of these movements have their paths (and speeds) controlled by a combination of roundabout diameter and the geometry of the entrances and exits. It is important to minimize the differences in speeds of the various vehicles using the roundabout. Guidance from the FHWA Guide, ORE Guide, and NCHRP 3-65 on fastest path analysis should be used to determine the expected speeds based on the proposed design.	Entering and circulating (left, thru, and right-turn movements) traffic speeds should be within a 6 mph spread from slowest to fastest. In order to minimize these differential speeds, design approaches to limit entry speeds to approximately the following: 100' ICD: 13-19 mph 130' ICD: 14-20 mph 150' ICD: 15-21 mph 180' ICD: 16-22 mph Other environmental factors (schools, etc.) may require further reduction in entry speeds.

FIGURE 1 Excerpt from the draft design guidelines.

DRAFT

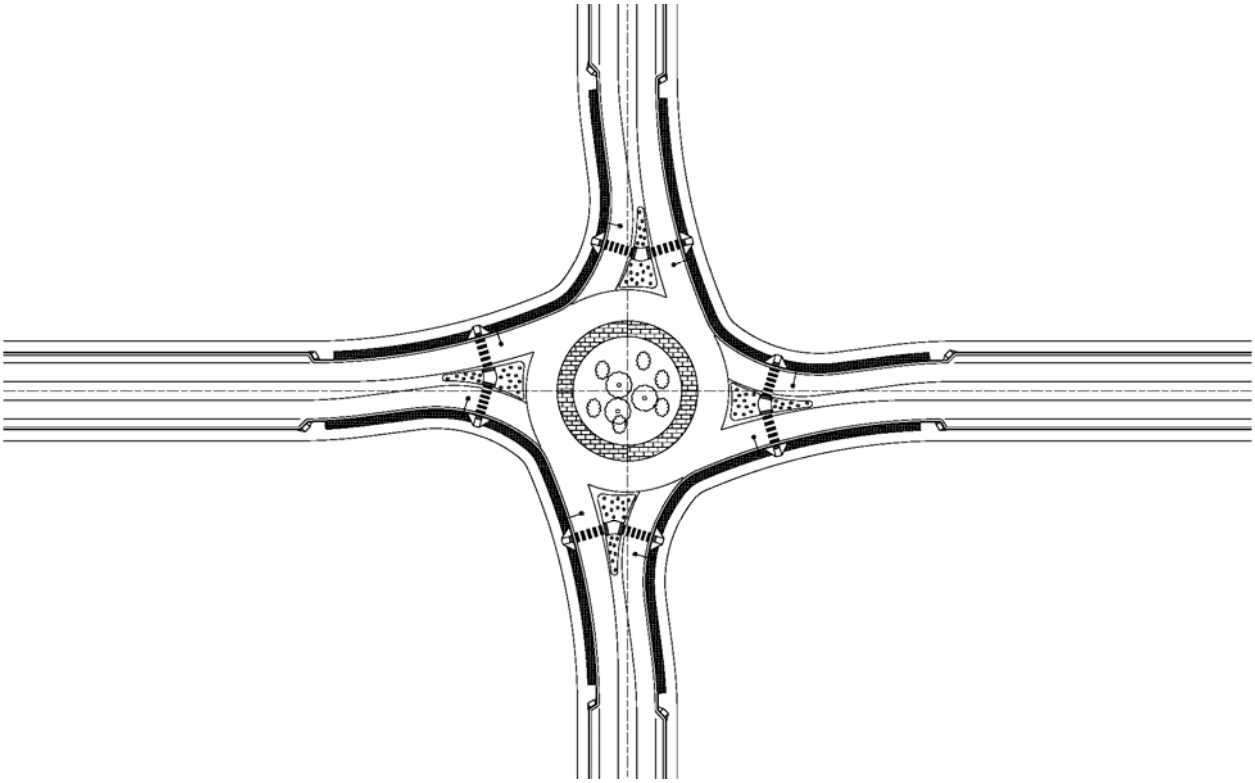

FIGURE 2 Sample single-lane roundabout layout at the intersection of two 3-lane roadways.

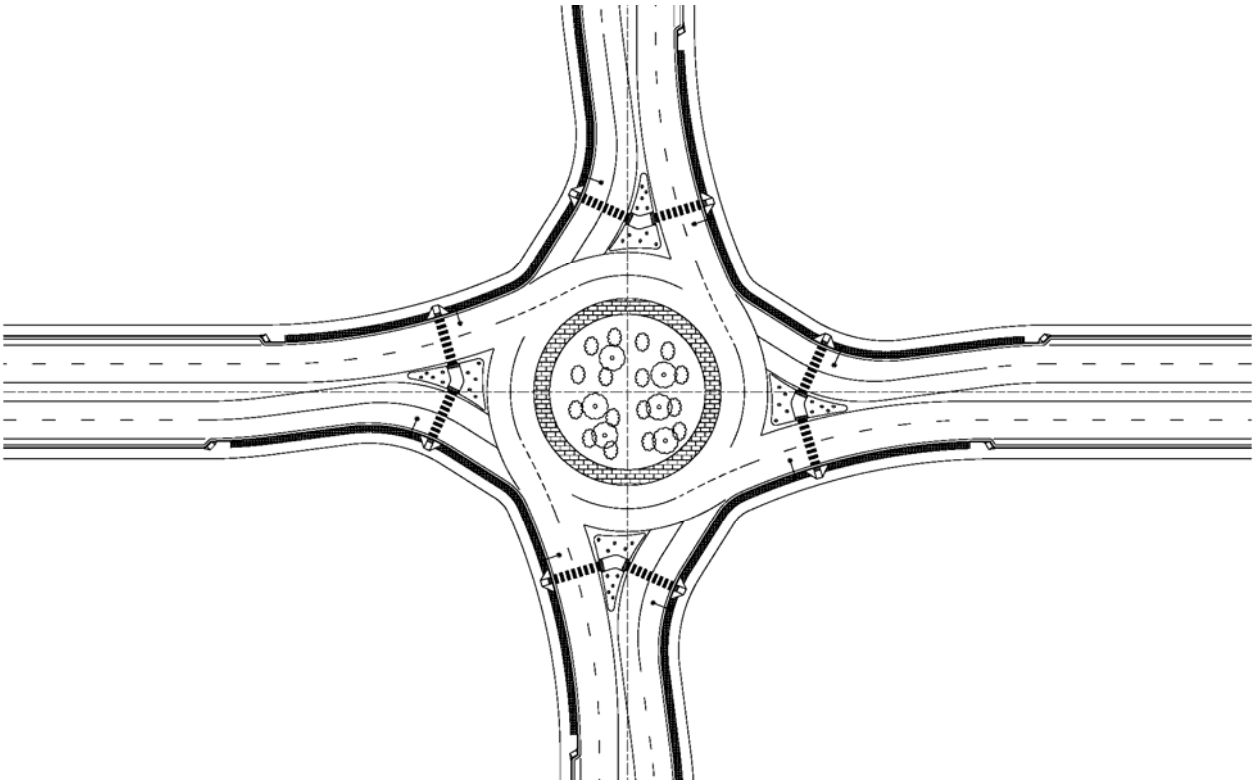

FIGURE 3 Sample dual-lane roundabout layout at the intersection of two 5-lane roadways.

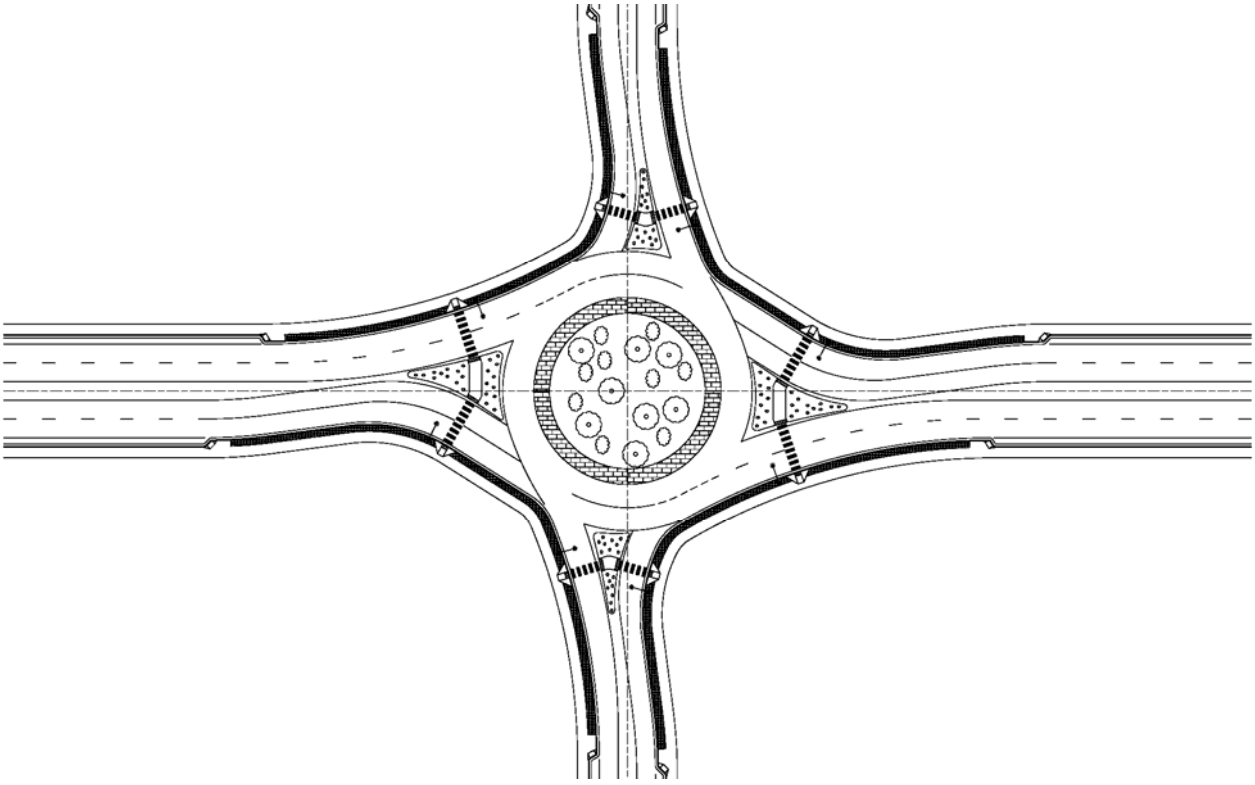

FIGURE 4 Sample dual-/single-lane roundabout layout at the intersection of 5-lane with 3-lane roadway.

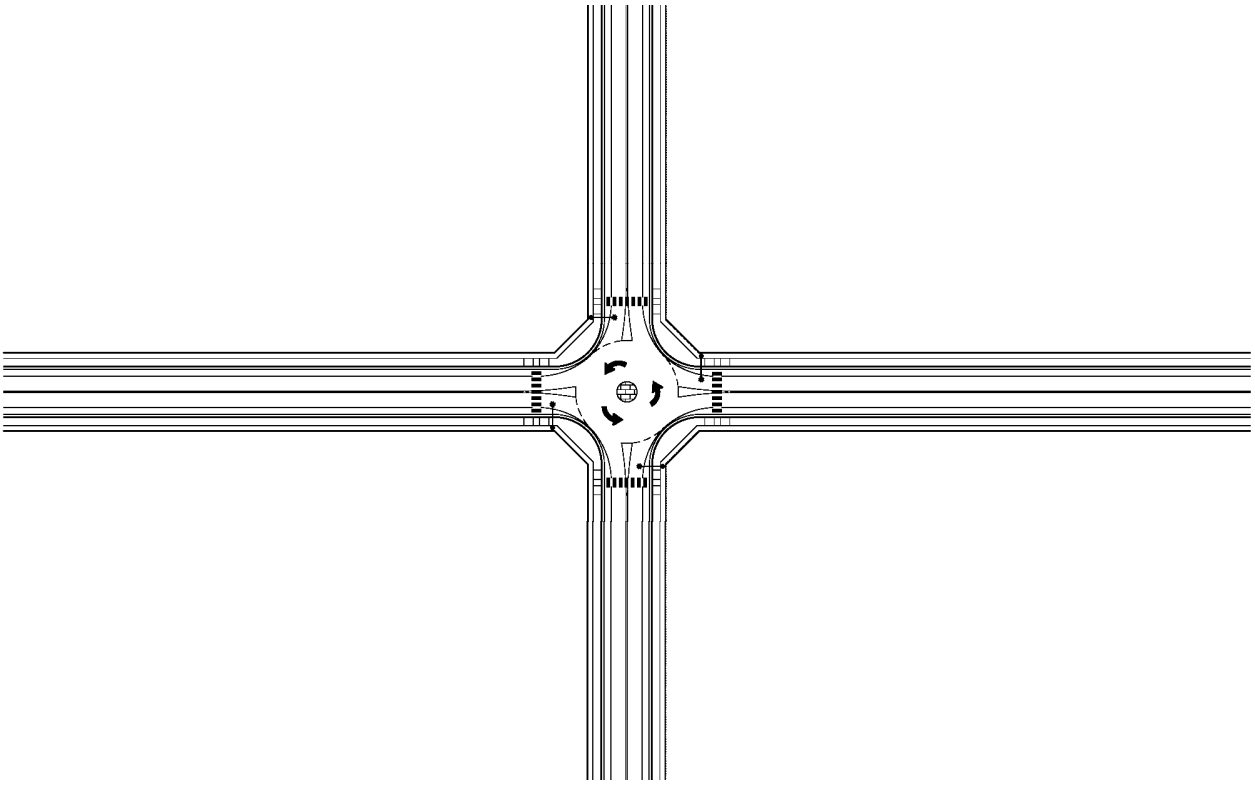

FIGURE 5 Sample mini-roundabout layout at the intersection of two 2-lane roadways.

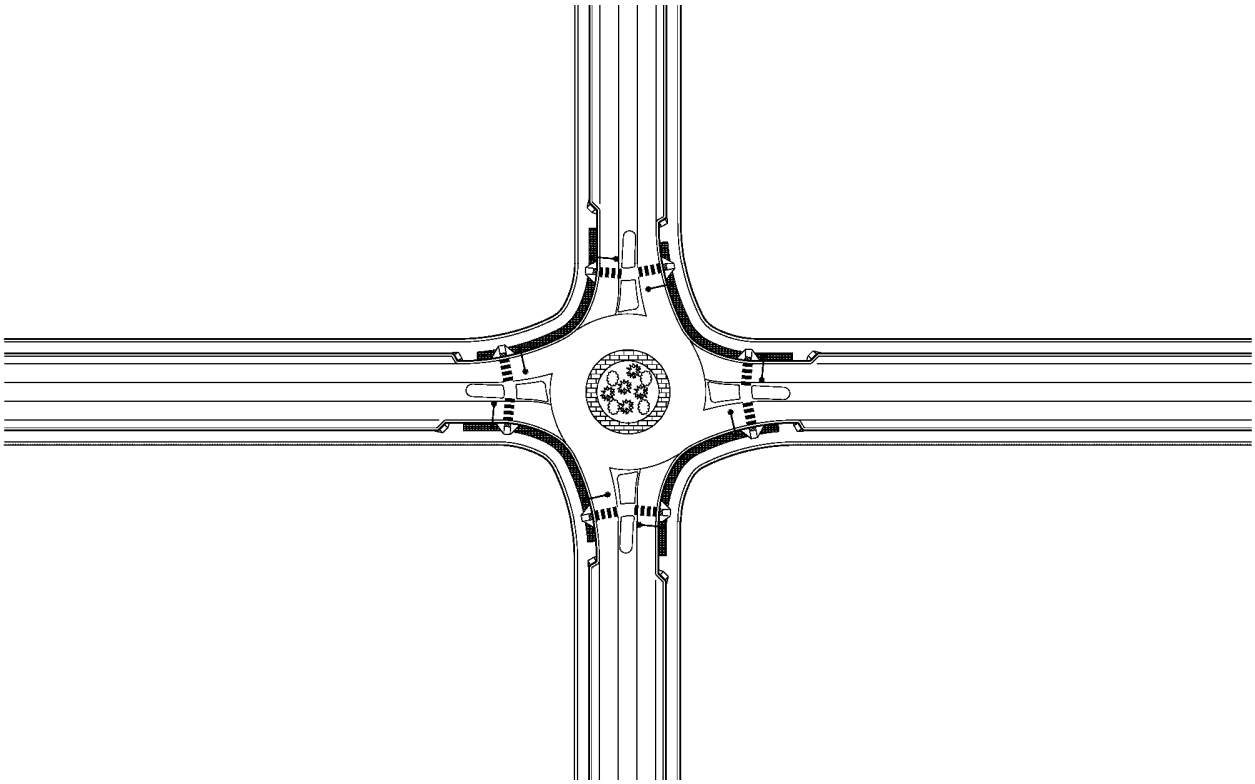

FIGURE 6 Sample urban compact roundabout layout at the intersection of two 3-lane roadways.

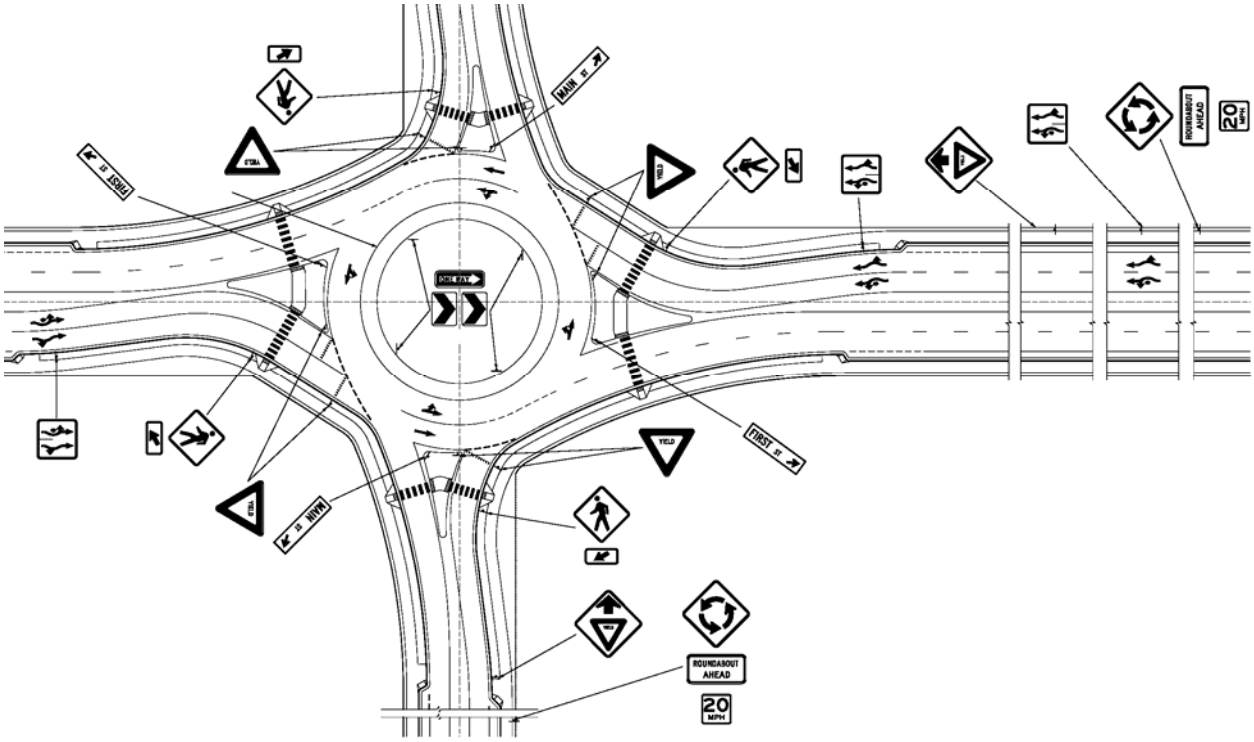

FIGURE 7 Portion of the sample signing and striping layout.

The purposes of the sample layouts shown in Figures 2 – 6 were to:

- Illustrate the application of the guidelines
- Provide a rough footprint for planning purposes
- Provide a basis for cost comparisons between roundabouts and traffic signals (sample layouts for corresponding signal options were also developed for that purpose)

Note that Figures 2 – 6 are all presented at approximately the same scale in order to convey a sense of the relative size of the various sample roundabouts depicted.

TESTING THROUGH MODELING

Modeling was performed to assist the study team in determining how capacity, delays, and other operational characteristics vary as a function of the design parameters. The guidelines include some "rules-of-thumb" for the number of entering lanes required vs. the entering and circulating peak-hour traffic volumes and the total entering daily traffic. The modeling allowed the team to test these "rules."

Two computer software packages were used in the testing: RODEL and VISSIM. RODEL was used due to its empirical nature and wide acceptance. VISSIM was used due to its flexibility in modeling complex traffic conditions. The study team was aware of the lack of consensus in the industry regarding the "best" modeling software to use. They believed that these two modeling packages represent the range of empirical and theoretical methods in use and provide an appropriate range of modeling results. Other software packages were also considered, but use of these two only was deemed by the team to be sufficient for the intended purposes.

The modeling was performed on a variety of traffic volumes, splits, and truck percentages and for a variety of geometric configurations. The results generally confirmed the previous conclusions of the study, but also resulted in some minor changes to the "rules-of-thumb" mentioned previously.

PEER REVIEW

PEC contracted with Ourston Roundabout Engineering (ORE) to perform a peer review of the draft guidelines and report. It should be noted that ORE disagreed with the approach taken to the development of the guidelines, opting instead for a document detailing exceptions to a nationally-recognized guide. However, they reviewed the substance of the guidelines and provided a number of valuable suggestions. ACHD disagreed with some of ORE's recommendations and chose not to follow them, but most of ORE's recommendations were employed, resulting in improved guidelines and increased confidence in the final product.

REFERENCES

1. FHWA. *Roundabouts: An Informational Guide*. Publication FHWA-RD-00-067. U.S. Department of Transportation, 2000.
2. *Roundabout Design Guidelines*. Ourston Roundabout Engineering, 2001.