

Access Management Considerations for High Capacity Multi-Lane Roundabout Design and Implementation

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**8th National Access Management Conference -
“Sustainable Solutions for Transportation”**

Baltimore, MD
July 13 - 16, 2008

Abstract

Roundabouts are compatible with many access management principles. The operational characteristics differ from signalized intersections in many substantial ways. This allows for more flexibility that can be of significant benefit when balancing the competing objectives of roadway safety, capacity, and access needs of existing and or proposed land uses. This paper explores examples of the different opportunities that roundabouts can provide and the effects on how the transportation infrastructure is planned and designed. It specifically addresses business access into and near roundabouts, roundabouts in series, and other access management issues compatible with roundabouts in redevelopment, new development and urban constrained environments.

Introduction

Roundabouts enhance access management strategies. According to the TRB Access Management web site, access management is defined as the:

“Systematic control of the location, spacing, design and operation of driveways, median openings, interchanges, and street connections” (AHB70, 2008).”

Roundabouts are not only compatible with these access management principles, but provide the versatility and flexibility often needed when balancing the competing objectives of safety, congestion, user, and access needs of existing or proposed land uses.



Figure 1: Highway 54 in Wisconsin Rapids, WI (Source: MTJ Engineering, LLC)

A narrower roadway cross section is possible with roundabout design (i.e. less approach lanes and flared entries at the roundabout) as compared to the roadway cross section width required for the same traffic volumes at a signalized intersection. Intersection capacity is typically the limiting factor of the overall roadway capacity. A single-lane approach roadway at a roundabout can be flared to a two or three-lane entry to achieve the capacity needed. Placing the capacity where it is needed, at the intersection, can in many cases preclude the need for widening the entire roadway.

By eliminating the excess roadway width needed for exclusive through and turn lanes, roundabouts allow room for raised medians on the approaches, which become a natural extension of the roundabout splitter islands. The raised medians facilitate access control along the roadway link and/or near the intersections. Roundabouts make U-turns possible and effortless along corridors and include $\frac{3}{4}$ accesses at certain locations, all while minimizing right-of-way impacts.

The operational characteristics of roundabouts allow for business accesses to be located much closer to intersections, as shown in Figure 1, whereas the operational characteristics of signalized intersections renders this undesirable due to the queuing created during the red phase and ‘at-speed’ conditions and delay. Conversely, if there is an existing access problem mid-block, the problems will be similar with the roundabout or signalized alternative. Access issues related to private entrances and near interchanges ramp terminals, as shown in Figure 2, can also be explored further with roundabout designs. Furthermore, roundabouts can provide solutions for existing roadway networks as well as redevelopment areas and new developments. As traffic demands increase, existing intersections are in need of creative solutions to accommodate all the land uses, businesses and users.

Regardless of the intersection or access management issue, each intersection must be planned and designed considering all aspects of the roadway system to provide safety and operational benefits for all modes of travel.



Figure 2: I-35 and CSAH 2 in Forest Lake, MN (Image Source: Google Maps; Conceptual Design: MTJ Engineering, LLC)

Business Access

Commercial Access - Roundabout that Serve Commercial Land Uses and Access Needs

Commercial businesses can range from big box retail to lifestyle centers to health care facilities. Driveways leading to commercial businesses often operate as an intersection with a large number of turning movements and trips into and out of the parking areas. Roundabouts can be designed with a commercial entrance as one of the legs of the roundabout and maintain its' efficiency.

Wal-Mart –Monona, WI

This Multi-Lane Urban Constrained Roundabout Opened in 2007, and serves as primary access to the new Wall-Mart Super Center.

The roundabout was the key component for approval and redevelopment of this (high volume/traffic) challenging commercial site. The roundabout provided access where signalized alternatives could not and improved maneuverability and safety for all the existing industrial park and retail traffic along this corridor.



Figure 3: South Town Drive/Industrial Drive in Monona, WI (Source: MTJ Engineering, LLC)



Figure 4: Wal-Mart Super Center on South Town Drive/Industrial Drive - Monona, WI (Image Source: Google Maps)

Figures 4 and 5 show an aerial view of the proposed Wal-Mart Super Center and roadway network and the horizontal design of the multi-lane roundabout, respectively.

The roundabouts operational characteristics, low delay and improved safety provides excellent mobility, ingress and egress thru equal priority for lefts, thru movements and u-turns.

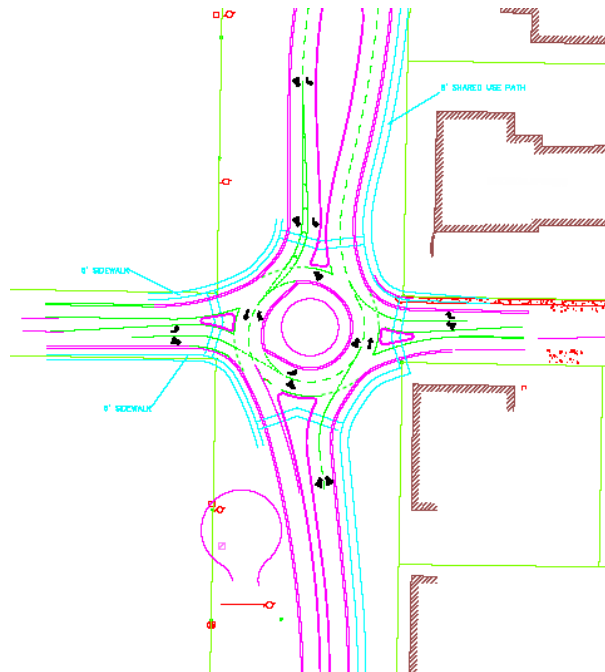


Figure 5: Conceptual Roundabout Layout for the Wal-Mart Super Center in - Monona, WI (Source: MTJ Engineering, LLC)

Accesses in Close Proximity to Roundabouts

Many roadways do not have good access control near intersections. Adjacent driveways and intersections frequently complicate intersection traffic operations and safety. When driveways are near intersections, they are often blocked by queues of traffic waiting at stop signs and signals. This can cause back-ups into parking lots, hinder circulation and create great frustration to drivers and businesses. Left turns from the driveways also become virtually impossible as well as an unsafe movement as drivers become impatient.

Access near roundabouts must be evaluated on a case-by-case basis. Variables such as trip generation, roadway speeds, overall context and ability to provide adequate ingress/egress and site circulation must be evaluated.

Roundabouts offer the ability to serve existing accesses much closer to the intersection than signalized intersections without the associated degradation in operations and safety associated with nearby access at signals. Gas station and convenience store driveways within 100 ft of the yield line are being accommodated.

State Trunk Highway (STH) 78 and STH 92 - Mount Horeb, WI

The Village of Mount Horeb, WI, a bedroom and tourist community in southwest Wisconsin, constructed the first roundabout on a state highway in Wisconsin at the STH 78 and STH 92 intersection in 2004. This location has a constrained urban environment where the horizontal alignment was existing business, and access needs as



Figure 6: STH 78 and STH 92 Intersection Before– Mt Horeb, WI (Source: M. T. Johnson)

shown in Figures 6. and 8. The vertical alignment also posed significant design challenges with a 5% profile grade, as shown in Figure 7. Figure 9 shows the signalized and roundabout alternative considered for the project.



Figure 7: Vertical Profile Challenges – Mt Horeb, WI (Source: Isebrands)



Figure 8: STH 78 and STH 92 Intersection After– Mt Horeb, WI (Source: M. T. Johnson)

The ~130' diameter urban compact roundabout serves at the gateway to the downtown. It provides an efficient flow of traffic and maintained business accesses within 50 ft of the intersection. The existing peak hour volume is ~2,800 vph and the design hour volumes were estimated at 3,500 vph with 8% heavy trucks. During the four years this roundabout has been in operation no crashes have been reported.

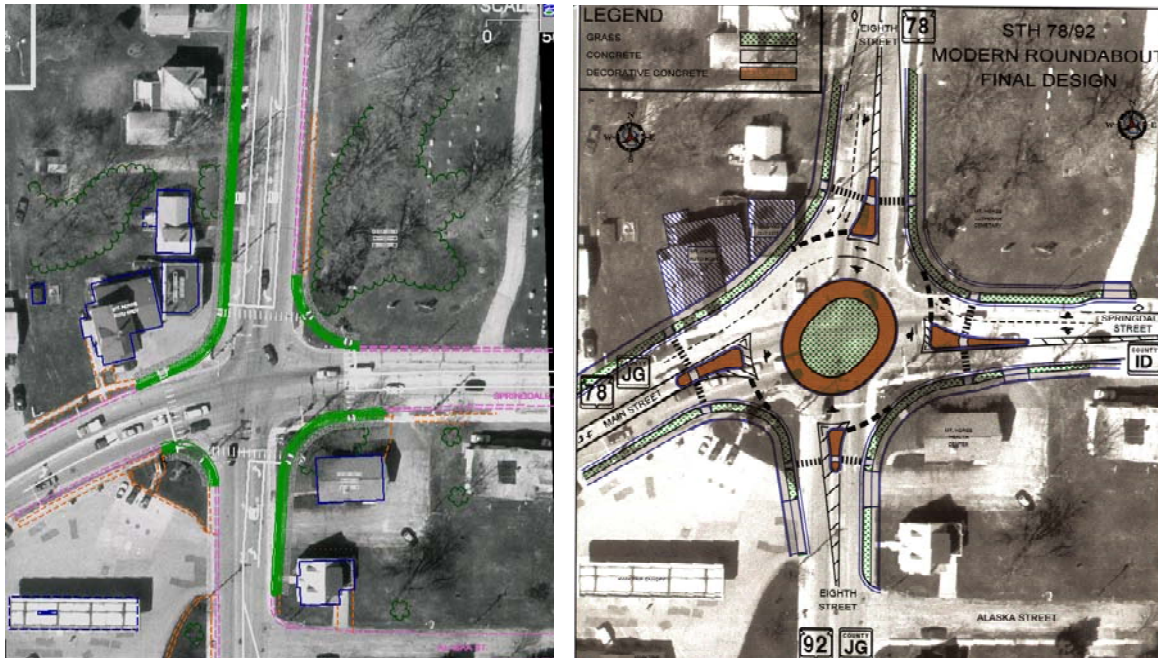


Figure 9: Conceptual Alternative Layouts - STH 78 and STH 92 Intersection
(Source: M. T. Johnson)

Roundabouts in Series

A common concern of roundabouts in series along a corridor is the impact to traffic flow (Isebrands et al, 2008) and compatibility with traffic signals and stop controlled intersections, however, with good engineering analysis, planning and design, roundabouts, signals and stop controlled intersections can coexist adjacent to each other and along the same corridor. Issues such as platoon arrivals, lane-use needs of nearby intersections, or access points must be accounted for and designed accordingly. Lane-balance at entries/exits of roundabouts and lane continuity must be accounted for by the traffic and transportation engineering designer. Roundabouts can also allow for more flexible intersection spacing and access opportunities when used in conjunction with good access management principles.

Providing roadway capacity and safety improvements that accommodate traffic demands for through movement traffic, while also providing good access, is challenging. Often the roadway widening required to accomplish this can severely impact adjacent properties, creating difficult site circulation and businesses access. With conventional signalized alternatives the entire roadway is typically widened to accommodate queuing at the signals whereas with utilization of roundabout intersections the entire roadway need not be widened in many cases.

Although limited in number, several agencies have successfully implemented roundabouts in series and within close proximity to signals and stop controlled intersections in various environments, including commercial corridors, new and redeveloping areas and interchanges.

State Trunk Highway 78/92 - Mount Horeb, WI

As stated above, the STH 78 and STH 92 roundabout in Mt. Horeb, WI was the first of its kind on the state highway system and was considered a success in the Village of Mt. Horeb. The village was impressed with the improved operations at this intersection and went forward with plans to construct four more roundabouts along a newly developing corridor, Main Street/Springdale Street to the interchange with US 18/151.

The flexibility of the roundabouts afforded the opportunity to optimize the layout for a proposed new development and to accommodate existing business along this commercial corridor. The projected traffic volumes were between 25,000 and 30,000 ADT at full build out.



Figure 10: Main Street in Mt Horeb, WI – Before (top); After (bottom) (Source: M. T. Johnson)

The roundabouts, with flared entries, allowed for a narrower roadway cross section than the conventional 5+ lane cross section required for a signalized corridor. The four roundabouts were constructed at the major intersections. U-turns at the roundabouts were a significant advantage for business access along this commercial corridor. Figure 10 shows the before and after photos of the corridor. The roundabouts enabled a narrower corridor, a landscaped median and U-turns to create safer turning movements into and out of the business driveways. Figure 11 shows an aerial view of the corridor.



Figure 11: Series of Four Roundabouts on Main Street/Springdale Street in Mt. Horeb, WI (Source: MTJ Engineering, LLC)

US 23 Lee Road Interchange – Livingston County, Michigan

The proposed 600,000 square foot mixed retail development, ‘Green Oak Village Place,’ in Livingston County, Michigan on the east side of the US 23 Lee Road interchange promised to challenge the engineers. The design must provide acceptable operations of the US-23/Lee Road interchange and the intersections of Lee Road/Whitmore Lake Road and Lee Road/Fieldcrest Road, for both build year traffic conditions through the year 2030 accounting for continued growth in traffic due to planned future development. Figure 12 shows the project area.



Figure 12: US 23/Lee Road Interchange – Michigan (Image Source: Google Maps)

The traffic analysis study showed the resulting traffic volumes from the development would severely impact the ability of the existing interchange to accommodate the increase in traffic. The projected excessive congestion would seriously reduce the access to business driveways and overall circulation between Lee Road and Whitmore Lake Road from cross streets and driveways and contribute to a potential increase in crashes. Frequent queuing back on the off-ramp and the associated backups along Lee Road and at its intersections would negatively impact ramp and freeway operations, thus introducing additional safety hazards into the system.

Seven long range 2030 design alternatives with multiple options were considered for the US-23/Lee Road interchange and the adjacent intersections of Lee Road/Whitmore Lake Road and Lee Road/Fieldcrest Road. These included signalized and reconfigured interchange alternatives. It was determined that only one of the seven alternatives would meet the operational, project cost, and right-of-way constraints and would enable the interchange and adjacent intersections to operate at appropriate levels of service in 2006 at the opening of the 'Green Oak Village Place' development and through year 2030.

Of the seven alternatives evaluated, a proposed partial diamond interchange with a two-lane bridge combined with a double roundabout with two 4-lane entries on the west side and a single 2-lane roundabout on the east side was analyzed and designed. The roundabout alternative was selected as it could provide the future capacity, safety and access needs and requirements for this system of intersections. As shown in Figure 13, there are significant access points serving retail, convenience stores, and fast food restaurants very close to the western most roundabout. The slow approach and exiting speeds, along with gaps created at the roundabout that are carried downstream allow for good access, while also providing safe and required capacity along the adjacent roadways. Some access consolidation and control was proposed, but is often the case this was not politically feasible in this situation.



Figure 13: US 23/Lee Road Interchange – Michigan (Source: aerial photography limited)

Huffman Road – Anchorage, Alaska

Huffman Road is an urban commercial arterial corridor that carries ~35,000 ADT. As shown in Figures 14 and 15, there are numerous conflicting access points, including commercial driveways, and minor stop controlled side streets providing access to a wide variety of businesses and commercial uses along this roadway.



Figure 14: Huffman Road – Anchorage, AK (Source: Google Maps)



The signalized corridor alternative required a five-lane cross section with a 6 ft median to exclude all left turns in/out. It produced greater property and right-of-way impacts, and severely impacted the access to and from many of the businesses along this ~2,000 ft stretch of roadway. Business owners were encouraged by the roundabouts' ability to provide access opportunities, reduce the impacts along their respective store frontages, and protect and enhance the ability to provide customers with safe and efficient ingress/egress. These roadway characteristics enhance these business locations.



Figure 15: Huffman Road – Anchorage, AK – Existing (left) Google Map; Proposed (right) (Source: MTJ Engineering LLC)

This project illustrates the distinct advantages of a roundabout on an urban corridor. The roundabout provides the ability to maintain a narrower roadway section (two through lanes WB and one lane EB) with a median and left turns at key access points. Additionally, the roundabout alternative provided the Alaska DOT with an acceptable

through movement level of service, as well as safety and mobility for this multi-purpose state highway for existing and long-range traffic.

Access to Minor Roadways and Driveways

Minor driveway and roadway access near roundabouts must be evaluated on a case-by-case basis. Roadway volumes, context, trip generation all must be considered to determine the appropriateness of these access points. Private entrances (i.e. a driveway to a home) often do not generate more than 10 trips a day and the impacts may be negligible to the operation of a low to moderate capacity roundabout and may be accommodated (if no other option exists) as direct access. Other design treatments for access points within the splitter island area include provisions for a flush designed and drop portion of the splitter island to allow the access turns.

Martin Luther King Blvd (MLK) – City of Springfield, OR

The Martin Luther King, Jr. Parkway provides a new four-lane arterial connection from downtown Springfield, OR to the gateway area projected to carry ~50,000 ADT. It serves as a much needed travel link for these areas and completes an arterial link from Beltline Road to OR126. The intersection of Pioneer Parkway and Hayden Bridge Way and Martin Luther King Boulevard in Springfield, OR is the State of Oregon’s first urban multi-lane roundabout. The design year traffic is projected to be ~5,700 vph. The project was constructed in 2006 and is shown in Figure 16.



Figure 16: MLK Boulevard - Springfield, OR (Source: Brian Barnett, City of Springfield Traffic Department)

It was critical that access be maintained to an established residential neighborhood via a fifth 'minor' leg of the roundabout that serves ~13 homes to provide good neighborhood circulation. Additionally, residential access is accommodated 125 ft from the roundabout on the east leg and small commercial driveway within 100 ft on the west leg. These accesses are shown in Figure 17.



Figure 17: Springfield, OR (Source: Brian Barnett, City of Springfield Traffic Department)

Summary

Roundabouts are now recognized as a viable intersection design alternative. The significant differences and advantages roundabouts provide in some situations related to transportation planning and access management, are just beginning to be developed and applied. Roundabout applications on our roadway systems can provide significant advantages to operational and safety principles which are, as of yet, not clearly understood or documented in industry planning and access management standards. Most of the transportation industry's roadway planning standards are aimed at the needs and requirements dictated by signalized intersections and roadways.

Roundabouts provide flexibility for accesses at and near intersections as well as along a corridor. Furthermore, roundabouts offer the ability to meet the safety, capacity and operational objectives of a roadway while also providing access and site circulation opportunities not typically available with signalization.

As transportation professionals, we are responsible for the difficult and challenging task of balancing the competing needs of and users of the transportation system which are often in sharp competition. Achieving one goal or objective often conflicts with other objectives. The projects discussed in this paper are examples where modern roundabout have achieved balance between safety and roadway capacity, with the needs of adjacent land uses and users of the roadway.

References

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