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OFFICE MEMORANDUM

DATE: April 1, 2016

TO: Dennis Stachewicz (City of Marquette); Aaron Johnson (MDOT Ishpeming TSC)

FROM: Wes Butch

SUBJECT: Marquette Hospital Relocation Study - Roundabouts with High-Speed Approaches

As you will recall, that a meeting held on February 3, 2016 for this project, there was discussion about the use of roundabouts on road facilities with high speed approaches. This memo provides additional information regarding that topic. It is our understanding that this memo will be distributed to the meeting attendees as supplemental information for their consideration.

For the purposes of this memo, a "high speed" approach is generally considered to be one with a posted speed of 45 mph or greater.

Michigan Roundabouts with High Speed Approaches

Here is a partial list of roundabouts which have high speed approaches within the state of Michigan. Many of these roundabouts have been in place for several years or longer. To our knowledge, all of these locations are functioning well, with safety performance significantly better than would be available through other intersection control types.

- M-115/M-37 in Mesick
- M-37/M-46 near Casanova
- US-41/Front Street in Marquette
- M-43/72nd St/12th Ave near South Haven
- US-127 BL off Ramp in Clare
- US-10 BL/Patrick/Lyon in Midland
- M-11/Remembrance Rd/Wilson Rd in Walker
- M-72/Lautner Road in Acme
- M-72/Village of Grand Traverse main entrance in Acme
- Blue Star Highway/North Shore Dr near South Haven
- Old US-27/Livingston Boulevard in Gaylord

In addition to these locations, a roundabout is being constructed during 2016 at the intersection of US-41/2nd Street in Ishpeming.

Potential Design Treatments for High Speed Approaches, with Research References

Roundabouts located along high-speed facilities often have special design considerations because approach speeds are higher than for urban or local streets. Drivers on these facilities do not necessarily expect to encounter speed interruptions. The primary strategy on high-speed roadways is to make drivers aware of the roundabout with ample distance to comfortably decelerate to the appropriate speed. There are a number of safety treatments that have be utilized on roundabouts with high-speed approaches. Often several treatments are utilized together to optimize awareness of the roundabout.

A brief explanation for treatments recommended for high-speed approaches can be found in NCHRP-672 – Roundabouts: An Informational Guide", 2nd Edition, under section 6.8.5 Treatments for High-Speed Approaches.

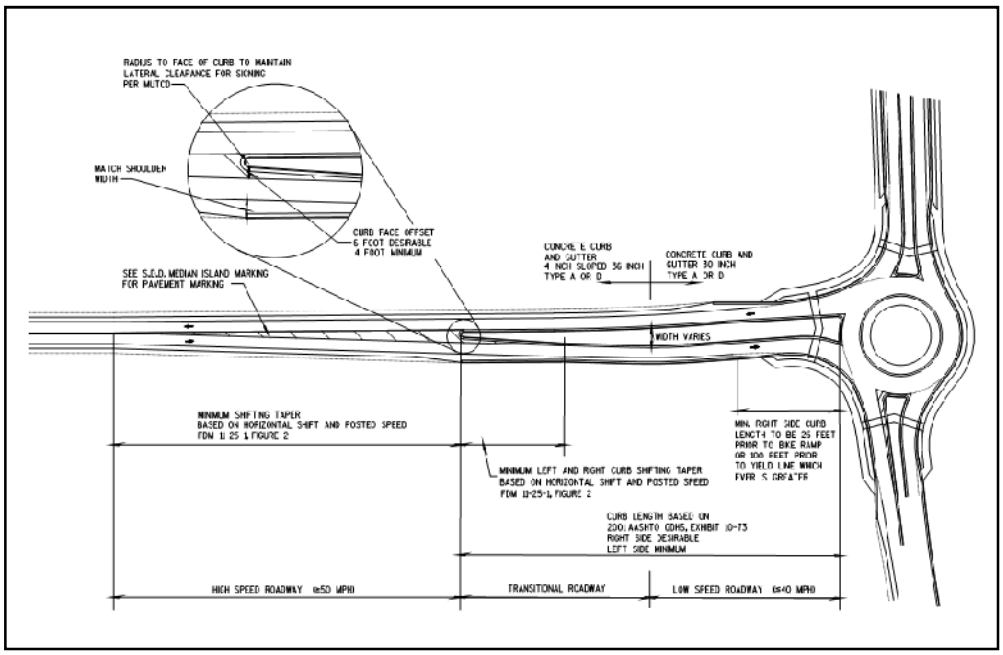
Roundabouts themselves are designed to require that all vehicles slow on approach to the intersection. A collaboration of the FHWA and Iowa State University performed a study and issued Paper #14-5582 "Approach Speed Effects at Rural High-Speed Intersections: Roundabouts vs. Two-Way Stop Control" from August of 2013[1]. This study found the following,

> *The geometric features of a roundabout slow all vehicles approaching and entering an intersection. This reduces speed variances between vehicles on the same approach as well as on the other approaches and significantly reduces the probability of right angle - injury prone crashes. Although, little published research has focused on the overall safety effectiveness of roundabouts on high speed roadways two studies[2,3] show substantial reduction in injury crashes at roundabouts . Isebrands[3] reports the average injury crash frequency was reduced by 84%, average injury crash rate was reduced by 89%, angle crashes were reduced by 86%, and fatal crashes were eliminated at seventeen rural roundabouts with high speed approaches.*

Introducing high-speed approach design features can further improve the safety of a roundabout on high speed roadways. When specifically addressing high-speed approach design for roundabouts, designers look at the roundabout visibility, curbing for the roundabout, splitter island geometry and approach curvature.

The goal of increasing visibility at roundabouts is to make drivers aware that a roundabout is ahead as soon as possible on approach to the roundabout intersection. The first thing that is typically done is to mound up the earthen fill in the center island. It is recommended to slope the fill with the splitter island to no less than a 1:6 slope. Landscaping within the central island further increases visibility and acknowledgement that a roundabout is ahead. The next features that help to increase visibility of a roundabout are the geometry of the splitter islands, advance warning signing and potentially rumble strips.

Rural or otherwise high-speed roadways typically have shoulders with traversable ditch lines along the roadsides. Changes in the roadway's cross section can be an effective means to help approaching drivers recognize the need to reduce their speed. The introduction of curbs and the splitter islands generally give drivers a sense they are entering a more controlled setting, causing them to naturally slow down. Curbs help to improve delineation and to prevent corner cutting, which further helps to ensure low speeds. Many state DOT's have very specific guidelines for transitioning vehicles from a high speed environment (>45 mph), to a low speed environment (25 mph or less). For example, the Wisconsin Department of Transportation (WisDOT) is one of these agencies. Figure 30.12 is from the WisDOT Facilities Development Manual (FDM), Section 11-26-30. The intent of the guidelines is to design extensions to the splitter islands and outer curb lines specifically following the required deceleration distance from the roadway design speed to a stopped condition at the roundabout yield line.



WisDOT – FDM Section 11-26-30.5.18 – Figure 30.12

Splitter islands should generally be extended upstream of the entrance line to the point at which entering drivers are expected to begin decelerating comfortably. Austroads of Sydney Australia states in a "Guide to Traffic Engineering Practice, Part 6: Roundabouts", from 1993, that a minimum length of 200 ft (60 m) is recommended for high-speed approaches. The use of flatter and longer tapers in advance of the splitter islands also provides additional visual cues to drivers of a change in roadway environment. The design of the roundabout entry can also provide visual cues to drivers, in that the entry curves from the splitter island block the view of the central island as drivers approach the roundabout.

The final methods for increasing safety are advance warning signage and rumble strips. The current version of the Michigan Manual for Uniform Traffic Control Devices (MMUTCD) includes standards for roundabout signing. The signing guidelines are the minimum to promote awareness of an upcoming roundabout. Installing flashing beacons can further increase visibility and awareness of a roundabout.

NCHRP Report 613 "Guidelines for Selection of Speed Reduction Treatments at High Speed Intersections" summarizes a before and after study of three speed reduction treatments (rumble strips, peripheral transverse marking, dynamic warning sign) at ten intersections (19 approaches). Results showed that dynamic warning signs reduced the mean speed 1.7 mph, 2.3 mph and 2.8 mph at the following locations, respectively, sign, perception-reaction location (250 ft upstream) and the accident avoidance location; transverse pavement markings reduced overall mean speeds marginally by 0.6 mph.

Rumble strips have been proven to be an effective means to reduce speeds at high-speed approaches for roundabouts. Paper #14-5582 referenced above found a statistically significant reduction of 2.9 to 4.3 mph on roundabout approaches with rumble strips as compared to roundabout approaches without them.

There are several domestic and international studies that show that roundabouts on high speed roadways are safer than stop controlled or signalized intersections. An excerpt from Paper #14-5582,

> *Persaud et al.[4] conducted an empirical Bayes observational before-after study on twenty-three intersections in the United States. The results indicated a 40% reduction in all crashes and an 80% reduction in injury crashes. Five rural, single-lane roundabouts experienced a*

58% reduction in total crashes and an 82% reduction in injury crashes. These crash reductions were consistent with international findings…

…The implementation rate of roundabouts on high speed rural approaches is significantly higher in the last three years due to several states who continue to aggressively construct roundabouts in rural locations. Numerous other states are also quickly realizing the considerable safety benefits of rural roundabouts on high speed roadways and are including roundabouts as viable alternative in the project development process. There are few intersection safety countermeasures that deliver a high a safety yield than as a roundabout. Roundabouts on rural high speed roadways are saving lives.

References

[1]Hillary Isebrands (FHWA), Shauna Hallmark (ISU) and Neal Hawkins (ISU), Paper # 14-5582 Approach Speed Effects at Rural High-Speed Intersections: Roundabouts vs Two-Way Stop Ccontro.l" FHWA and Iowa State University. August 1, 2013.

[2]Rodegerdts, L et al. NCHRP Report 572, "Roundabouts in the United States." Transportation Research Board. Washington D.C. 2007.

[3]Isebrands, H. "Crash Analysis of Roundabouts at High Speed Rural Intersections." Transportation Research Record No. 2096 Journal of the Transportation Research Board. Washington, D.C., 2009.

[4]Persaud B., R. Retting, P. Garder and D. Lord. "Safety Effect of Roundabout Conversions in the United States: Empirical Bayes Observational Before-After Study." Transportation Research Record No. 1751. ransportation Research Board. Washington D.C. 2001.