Updated Roundabout Analysis Methodology

In 1998, the Transportation Planning Analysis Unit (TPAU) working as part of the Roundabout Task Group selected the interim roundabout methodologies of the SIDRA method (updated Australian method) combined with the German G2 method to be used on ODOT roundabouts.

Since then, the National Cooperative Highway Research Program (NCHRP) has published the long-awaited Report 572, "Roundabouts in the United States" which includes the actual operational statistics of constructed roundabouts in this country. Unlike the earlier Highway Capacity Manual (HCM) Lower and Upper methods, the NCHRP Report 572 method is based on a statistically correct number of sites and observations so that definitive conclusions could be made. Procedures based on this report will be included in the next update of the HCM Chapter 17 in 2010. TPAU has decided to make the NCHRP Report 572 method the new replacement roundabout methodology. When HCM 2010 is released, modifications to TPAU's procedures may be necessary to stay consistent. Table 1 gives a comparison of the new Report 572 method with the current interim methodologies.

Table 1. Roundabout Method Comparisons

Issue	SIDRA	German G2	NCHRP Report 572
Compared to the other two methodologies in this table, the estimated entry capacities are high, medium or low when the circulating flows are low	High	Med	Low
Compared to the other two methodologies in this table, the estimated entry capacities are high, medium or low when the circulating flows are high	Low	Low	Low
Variations in roundabout geometry can be assessed	Yes	Some	Some
Methodology based on adequate sample size	Yes	Yes	Yes
Application for multi-lane roundabouts	Yes	Yes	Yes
Gap acceptance (GA) or empirical (EMP)	GA	EMP	EMP
Can variables be modified to match Oregon/US driver behavior?	Yes	No	Yes

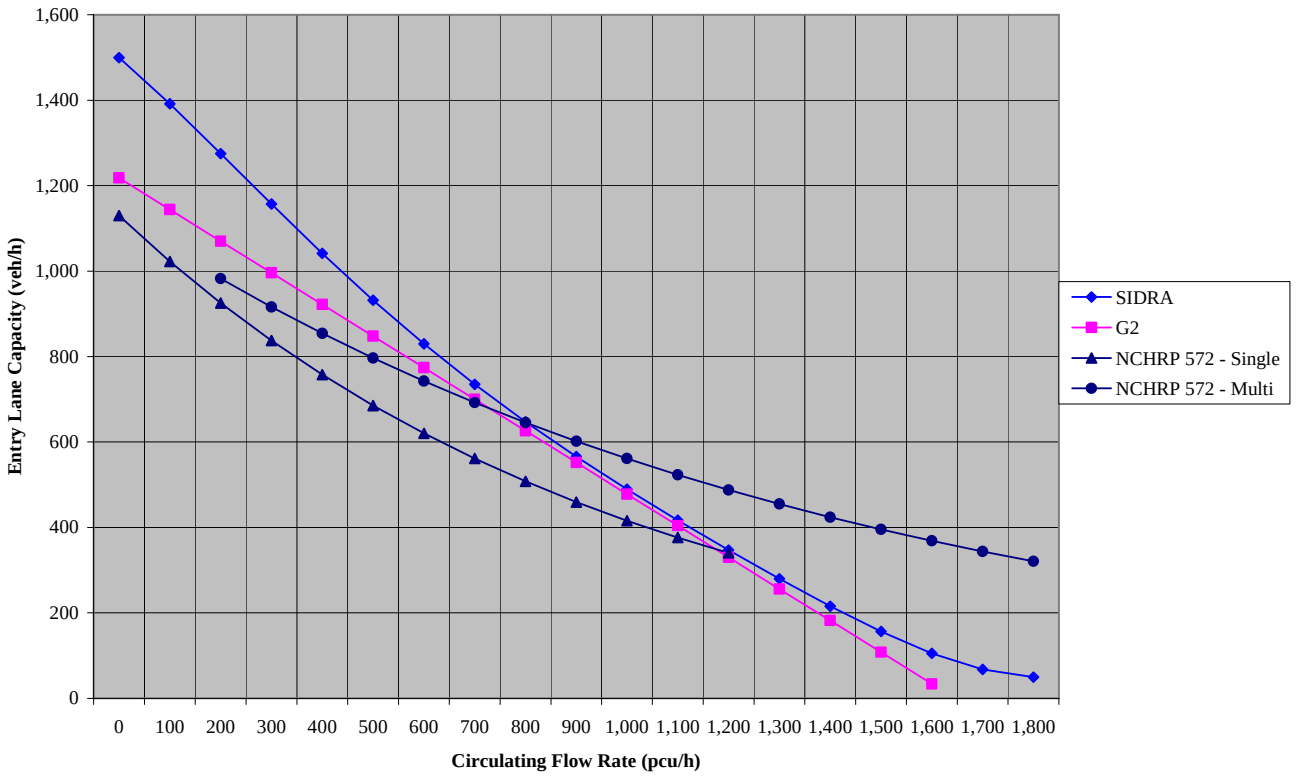
The Report 572 method is a simple equation, similar to the G2 method. After analysis of the data, the NCHRP research indicated that this was sufficient and no other equation factors were needed. The only important geometric component is whether a roundabout is single-lane or multi-lane.

This method allows some flexibility by varying the number of circulatory or approach lanes to allow for roundabouts that are not completely multilane. Bypass lanes can be modeled by removing the bypass lane volumes from the approach volumes. This method does not support more than two circulatory or approach lanes as there are only a few constructed U.S. sites with more than two circulatory lanes or two approach lanes.

Other geometric components such as lane width and island diameter do not have a significant effect when compared to driver behavior. Driver behavior has the largest effect on roundabout capacity. This method has the ability to further adjust the coefficients based on driver behavior, tailoring the equation to a specific area or region.

Figure 1 compares the entry lane capacity to circulating flow rates for each methodology. It shows that the entry lane capacity calculated from the NCHRP Report 572 method is much more conservative than the SIDRA or G2 methods for low circulating volumes. The Report 572 method with high single lane volumes is very close to the SIDRA and G2 methods. Even for low volumes, the entry lane capacity of a multilane roundabout is still lower than the lane capacity of a single-lane roundabout under the SIDRA and G2 methods.

Figure 1. Roundabout Capacity Methodologies



The roundabout data from Report 572 shows that U.S. drivers use roundabouts much more conservatively than international drivers. Thus, the resulting realized roundabout capacity is much lower than what is calculated with international methods. Choosing the SIDRA and German G2 methods was conservative, but a choice that was correct as these methods, especially the German G2, are relatively close to the NCHRP Report 572 method.

NCHRP Report 572 Method

The general equation is as follows:

$C = A * \exp(-B * v_c)$

C = Entry capacity (passenger car units per hour; pcu/h)
$A = 3600 / t_f$
$B = (t_c - t_f /2)/ 3600$
v_c = Conflicting (circulating) flow (pcu/h)
t_f = Follow-up headway (s)
t_c = Critical Headway (s)

Volumes and resulting capacities are in passenger car units per hour (pcu/h), therefore approach volumes in vehicles per hour (vph) must be converted using a heavy vehicle factor and the appropriate truck-passenger car equivalency factor, E_t. The truck equivalency factor varies depending on the approach conditions (two-lane, multi-lane, signalized, etc). See HCM Chapter 16 for signalized intersections, Chapter 17 for unsignalized intersections, Chapter 20 for two-lane highways, and Chapter 21 for multilane highways. Volumes should also be adjusted by the appropriate peak hour factor (PHF).

Conflicting flow is defined as the circulating flow that conflicts with the subject entry flow. This is the flow that the entry flow must yield to. The data used to calculate the equation supports circulating flows up to 1,200 pch for a single-lane roundabout and from 200 pcu/h to about 1,800 pcu/h for a two-lane roundabout. The equation curves can be extrapolated beyond the limits shown in Figure 1, but caution should be taken.

Average values of the A and B coefficients are used in the general equation forms. There is capability of the user to customize the equation to fit driver behavior in an area. The NCHRP research indicated that there does not appear to be strong correlation between the values of t_c and t_f with changing driver familiarity over time. Changes in the A and B coefficients are likely to be small. Obtaining t_c and t_f values for A and B will require a statistically correct number of observations at multiple roundabouts in the same general area which will result in an intensive effort. Unless indications are that the average coefficient values are inadequate, the default values should be used.

Single Lane Roundabout Capacity

For general use at single lane roundabouts the equation is:

$C = 1130 * \exp(-0.0010 * v_c)$

Two-Lane Roundabout Capacity

For two-lane roundabouts, the critical entry lane is used. The critical entry lane is defined as the entry lane with the highest volume. This is determined by field observation and/or traffic count turning movements. If there is only one lane available for a particular turning movement, then all of that traffic is assigned to that entry lane. If there are multiple lanes available for a particular turning movement, then the traffic is distributed equally across the available lanes. The critical lane is generally the right lane of a roundabout entry. When calculating circulatory flow, use the entire flow in both circulatory lanes (as in single-lane roundabouts) as entering vehicles tend to yield to vehicles in both circulatory lanes.

For general use for the critical lane of a multilane entry for a two lane circulatory roadway the equation is:

$C_{crit} = 1130 * \exp(-0.0007 * v_c)$

C_{crit} = Entry capacity of critical lane (pcu/h)

Certain two-lane roundabouts may not be completely two-lanes and may have single-lane sections. These sections should use the single-lane equation.

V/C Ratio & Level of Service

Once C or C_{crit} is obtained, the volume-to-capacity (v/c) ratio of the legs can be calculated.

v/c_{leg} = v (pcu/h) / C (pcu/h)

There is no overall v/c for a roundabout, so all approach legs must be calculated. The reported v/c for the roundabout will be the highest calculated approach leg v/c. The maximum required v/c for a roundabout is generally 0.80 on state highways. If any of the calculated approach leg v/c's are over 0.80, then the roundabout should not be constructed.

However, the required v/c ratio for proposed roundabouts will be determined by the State Traffic Engineer with consultation from Region Traffic. This determination is based on functional class, highway designation, traffic characteristics and system continuity.

Level of service (LOS) for a non-state highway roundabout follows the same approach delay methodology used in unsignalized intersections as shown in HCM Chapter 17. The individual approach LOS thresholds are also the same as unsignalized intersections. As with v/c, an individual LOS for each approach should be calculated for each approach with the highest LOS controlling. Consideration should be given to the applicability or flexibility of local LOS standards.

Queuing

The NCHRP Report 572 method uses the same queuing model as used in unsignalized intersections in the HCM. This queuing model seriously underestimates the queues at major street left turns and minor right turns at unsignalized intersections. The minor right turn in a roundabout is equivalent to the unsignalized intersection version with slightly less delay at the yield-controlled approach. The Report 572 mentions that this queuing model may not predict higher level of delays probably because there is a higher likelihood of a vehicle being stopped on the approach with higher circulating flows.

TPAU has researched the queuing method issue and concluded that the Two-Minute Rule should be used for unsignalized intersections. Until further evaluation can be made, the Two-Minute Rule shall be also be used for queue calculations for roundabouts.