USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 180TUY2.2

Evaluation of Heavy Vehicles on Capacity Analysis for Roundabout Design

By

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DISCLAIMER

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TECHNICAL SUMMARY

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Introduction

Roundabouts are growing in popularity across the United States. They are advantageous in intersection design for several reasons, the most compelling of which is their improved level of safety at intersections. As they become more common, it is important to be able to design a roundabout to the projected demands of an intersection and have it perform as expected. This requires not only a reliable system of calculations to determine flow rates from the roundabout's physical parameters, but also substantial statistical data to show the effects of parameters such as driver behavior characteristics and vehicle type (Isebrands and Retting).

Heavy vehicles have a much larger effect on the flow of a roundabout than a passenger car, and therefore they must be accounted for in the design (Transportation Research Board). Very few studies have looked at the effect of heavy vehicles on the flow of a roundabout. In Chapter 21 of the Highway Capacity Manual, roundabouts are addressed and a passenger car equivalent (PCE) factor of 2.0 is suggested for all heavy vehicles (Transportation Research Board).

The purpose of this research is to study the passenger car equivalent factor for heavy vehicles. Experience suggests that heavy vehicles, particularly semi-trucks, have a greater impact on a roundabout than two passenger cars in urban areas. It is expected that the impact of heavy vehicles on the functionality of the roundabout will vary with demand. The objective of this research is to provide support for the current 2.0 PCE or determine new heavy vehicle equivalence for the design of roundabouts.

Findings

The recorded data was analyzed using the following two equations.

$$v_{pce} = \frac{v}{f_{HV}} \quad \text{Eqn 2.1}$$

$$f_{HV} = \frac{1}{1+P_T(E_T-1)} \quad \text{Eqn 2.2}$$

v= total flow rate entering the roundabout (veh/hr)
v_{pce}= flow rate of passenger cars entering the roundabout (veh/hr)
f_{HV}= heavy vehicle adjustment factor
P_T= percentage of trucks
E_T= passenger car equivalent for heavy vehicles

The total flow rate ,including heavy vehicles, (v) for all entering traffic was determined by summing the number of vehicles for each minute of recorded footage, then dividing by the total number of minutes analyzed and multiplying by 60 to achieve vehicles per hour. Because the flows for the entering traffic on each approach were not steady at capacity for long periods of time, it was assumed that analyzing flows for each 15 minute period would provide data which was closest to at capacity flow rates. To calculate this flow rate, the 15 minute period with the highest vehicles entering was found and multiplied by 60 to calculate vehicles per hour. The flow rate for passenger cars only (v_{pce}) was calculated in the same manner as the flow rate for all traffic, except the minutes with trucks present was removed from the vehicle count. This allowed a maximum flow rate without the influence of heavy vehicles to be calculated. Percentage of trucks (P_T) was determined by dividing the total number of heavy vehicles (heavy vehicles being those rated by the FHWA Vehicle Classification System as 9 or higher) by the total number of vehicles during the observation period. The results of these calculations are displayed in Table 2.1. Using Equation 2.1 the heavy vehicle adjustment factor (f_{HV}) was calculated using the flows for both the passenger cars (v_{pce}) and the total vehicular flow when trucks were present (v). The passenger car equivalent for heavy vehicles (E_T) was then calculated, using Equation 2.2, for each approach leg using the heavy vehicle adjustment factor (f_{HV}) and the percentage of trucks (P_T). Finally, a weighted heavy truck passenger car equivalent average was calculated. The weight for the average was applied according to the flow rate with only passenger cars. The weighted average was used to reduce the influence of moving the average due to extreme high or low flows at the intersection. An overall weighted passenger car equivalent of 3.37 was determined.

Table 2.1: Calculations of each entrance to the roundabout

2015 Data					
	Westbound	**Eastbound**	**Northbound***	**Southbound**	**Average**
Flow Rate with Presence of Heavy Vehicles	540	413	--	600	518
Flow Rate with Only Passenger Cars	632	600	592	772	649
Percent Heavy Vehicles	0.12	0.15	0.00	0.10	0.09
F_{HV}	0.85	0.69	--	0.78	0.77
E_T	2.38	4.11	--	3.87	3.45

2016 Data					
	Westbound	**Eastbound**	**Northbound***	**Southbound**	**Average**
Flow Rate with Presence of Heavy Vehicles	344	478	--	540	454
Flow Rate with Only Passenger Cars	476	620	612	704	603
Percent Heavy Vehicles	0.21	0.15	0.00	0.11	0.12
F_{HV}	0.72	0.77	--	0.77	0.75
E_T	2.82	3.02	--	3.73	3.19

*No Heavy Vehicles on 2015 or 2016 Northbound Approaches

Weighted E_T Average** for All 6 Approach Data = 3.37

** Weighted according to Flow Rate with Only Passengar Cars

The purpose of this study was to determine the passenger car equivalent for heavy vehicles in a roundabout. This was calculated because it was believed that the given value in the Highway Capacity Manual 2010 might be too low at 2.0. The data supported this hypothesis and a weighted average passenger car equivalent of 3.37 was calculated for the roundabout. This value is considerably (69%) higher than the given value of 2.0 in the current design manual.

Recommendations

More research is needed to verify the results of this report, however, this research is a good indication that heavy vehicles have an effect on the flow of a roundabout larger than the equivalent of 2 passenger cars. The restrictions of the data collection to only a single location is prohibitive to the validity of the results. However, the data was collected approximately a year apart with similar results. Therefore, the researchers recommend repeating the study at a variety of roundabouts with moderate heavy truck traffic to better understand the impacts of heavy vehicles on roundabout capacity and flow analysis. Furthermore, queue monitoring and dissipation following the presence of a heavy truck may be measureable variables that correlate with flow impacts.

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