# An Analysis of Heavy Vehicle Impact on Roundabout Entry Capacity in Japan

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**Abstract**

Impact of heavy vehicles on roundabout entry capacity is generally considered through a heavy vehicle adjustment factor $f_{HV}$ which is calculated by heavy vehicle percentage and passenger car equivalent (PCE hereafter) value. The PCE value of trucks is generally set as 2.0 and estimated based on several considerations such as entry capacity and move-up time. All of these considerations are influenced by local driver behavior and geometry conditions. Thus, this paper aims to estimate entry capacity considering the characteristics of heavy vehicle behavior in Japan by microscopic simulation. Then based on the simulation results, the PCE value is also examined. Through the simulation study it is found that entry capacity is reduced when heavy vehicle percentage increases. Moreover, estimated PCE results show that the PCE value of entry flow increases when circulating flow increases but decreases when circulating flow is in high level. Also it is found that PCE of entry flow is lower than that of circulating flow which has priority at roundabouts.

*Keywords:* Roundabout, Capacity, Heavy vehicle, Simulation, PCE

## 1 Introduction

Heavy vehicles perform differently from passenger cars due to their characteristics such as size and acceleration. At roundabouts, entry capacity is usually estimated in a unit of passenger cars and the impact of heavy vehicles is generally considered through the adjustment factor $f_{HV}$. In Highway Capacity Manual (HCM hereafter) 2010 (HCM, 2010), this adjustment factor is considered for entry flows (after entering roundabout) which form circulating flow in front of the subject entry. Since circulating flows have priority at roundabout entries, SIDRA (SIDRA for roundabouts, 2011) also considers the impact of heavy vehicle on the entry flow of the subject entry through adjusting the gap acceptance parameters (critical gap and follow-up time) under the condition with heavy vehicles.

The adjustment factor $f_{HV}$ is generally estimated by two parameters, heavy vehicle percentage $P_T$ which is calculated by field data and passenger car equivalent (PCE hereafter). The PCE represents the number of passenger cars that one heavy vehicle is equivalent to. For applying in practice, PCE is commonly recommended to be a fixed value, i.e. in HCM 2010, PCE=2.0 for trucks. The PCE can be

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estimated from several approaches such as flow rate, density and move-up time. All of these considerations are influenced by local driver behavior. Moreover, since vehicles enter roundabouts based on gaps available in the circulating flow, the PCE of subject entry flow should have different value from the PCE of circulating flow. Thus, it is necessary to examine the PCE value at roundabouts based on Japanese situations considering the applicability of PCE.

This paper first aims at estimating roundabout entry capacity considering the impact of heavy vehicles through applying microscopic simulation. Input parameters of the simulation such as speed of vehicles and gap acceptance behavior are calibrated by using field data observed in Japan. Based on the estimated entry capacity from the simulation study, PCE values of heavy vehicles under the Japanese conditions are calculated.

## 2  Literature Review

In HCM 2010 (1), the entry capacity of single-lane roundabout is estimated by Equation (1).

$$c_{e,pce} = 1,130 \exp(-1.0 \times 10^{-3}) v_{c,pce} \tag{1}$$

where $v_{c,pce}$ : circulating flow rate (pc/h)

$c_{e,pce}$ : lane capacity, adjusted for heavy vehicles (pc/h)

Circulating flow is formed by flows from other entries. The impact of heavy vehicle is considered on these entry flows as shown in Equation (2).

$$v_{i,pce} = \frac{v_i}{f_{HV}} \tag{2}$$

where $v_{i,pce}$ : demand flow rate for movement $i$ (pc/h) of other entries

$v_i$ : demand flow rate for movement $i$ (veh/h) of other entries

$f_{HV}$ : heavy vehicle adjustment factor

Then, circulating flow is directly counted as pc/h. The factor $f_{HV}$ is estimated by heavy vehicle proportion and passenger car equivalent which is shown in Equation (3).

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \tag{3}$$

where $P_T$ : proportion of demand volume that consists of heavy vehicles

$E_T$ : passenger car equivalent (PCE) for heavy vehicles

In HCM 2010, $E_T$ is set as 2.0. By using the adjusted circulating flow (pc/h), entry capacity is counted as pc/h. However, the impact of heavy vehicles on the subject entry flow is not considered.

SIDRA estimated the impact of heavy vehicles also on the subject entry flow through adjusting gap parameters of critical gap $t_c$ and follow-up time $t_f$ under the condition with heavy vehicles. The adjusting formulas are shown in Equations (4) and (5).

$$t_f{}' = \frac{t_f}{f_{HV_e}} \tag{4}$$

$$t_c{}' = \frac{t_c}{f_{HV_e}} \tag{5}$$

where $t_f{}'$ : follow-up headway adjusted for heavy vehicle effects in the entry stream