Passenger Car Equivalents for Uninterrupted Flow: Revision of Circular 212 Values

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ABSTRACT

As part of an overall federal effort to allocate road user taxes, a number of recent studies have been directed toward the calibration of passenger car equivalent (pce) values for trucks. These studies have provided the opportunity to review the pce values for uninterrupted flow contained in Transportation Research Board Circular 212, "Interim Materials on Highway Capacity." The results of these efforts and their implications for highway capacity analysis are reviewed. Specific recommendations for revisions of the pce values of Circular 212 are made.

A passenger car equivalent (pce), in highway capacity analysis terms, is the number of passenger cars that is roughly the equivalent of one truck, bus, or recreational vehicle under prevailing roadway and traffic conditions. The use of such equivalents is central to highway capacity analysis where mixed traffic streams are present, and the calibration of these values can have a significant impact on capacity analysis computations. As part of an overall federal effort to allocate road user taxes, there have been a number of recent studies specifically focused on the calibration of pce values for trucks. Although these efforts have provided a large quantity of useful data with which to compare pce values currently in use, they have not simplified this complex issue. Because many of these studies were directed to the development of economic equivalents for the purposes of road user tax allocations, there was no direct association with pce's for capacity analysis. Further, the exact definition of equivalent is not consistently interpreted, either in the capacity analysis literature or in these studies, making comparison of results difficult indeed.

An attempt is made herein to address the overall issue of equivalency and to use the available information to provide more realistic pce values for uninterrupted flow, specifically for use in capacity analysis.

APPROACHES TO PCE CALIBRATION FOR UNINTERRUPTED FLOW

There have been a wide variety of philosophies applied to the development of pce values. These are presented briefly here and are more fully discussed in the final report of a recent FHWA-sponsored study (1).

Equivalents for trucks in the 1965 Highway Capacity Manual (HCM) (2) are based on the Walker method, named for Powell Walker who developed the calibration methodology. This method relates pce's on two-lane highways to the relative number of passings of trucks by passenger cars versus the number of passings of passenger cars by other passenger cars. For multilane highways, the method was modified to account for the delay to other vehicles caused by trucks. Equivalent delays caused by trucks on grades were computed using grade-performance curves and were used as the basis for equivalents.

Since the 1965 HCM, numerous other techniques have been applied. The Institute for Research conducted a study of urban freeways and based pce calibrations on relative spatial headways between trucks and passenger cars versus those between pairs of passenger cars (3). Craus modified the equivalent delay principle of the Walker method for application to two-lane highways (4).

Uninterrupted flow pce values presented in Circular 212 (5) are based on the output of a multilane simulator developed at the Midwest Research Institute (6). Described in detail in a paper by Linzer et al. (7), the approach taken produced equivalents resulting in pce volumes consuming the same proportion of the roadway's capacity as the actual mixed traffic volume. In more analytic terms, the effective volume-to-capacity (V/C) ratio was held constant.

Cunagin and Messer (1), in one of the federally sponsored pce efforts for road user tax allocation, used a combination of the Walker method and the equivalent delay principle, with minor modifications in specific analytics to match the data collection effort. The difference between economic pce values and those used in capacity analysis is highlighted here. In the final report on NCHRP Project 3-28A, "Two-Lane, Two-Way, Rural Highway Capacity" (8), Messer uses different pce values than those calibrated for two-lane highways in the tax allocation study.

In the latter work, a new concept was used: Equivalents were calibrated to produce pce volumes that operate at the same average speed as the actual mixed traffic stream.

Because of the wide variance in pce philosophies adopted by researchers, it is difficult to directly compare numerical results. Unfortunately, there was no uniform understanding of what a pce meant before these studies were undertaken, and indeed the intended use of results also varied. Three of the concepts, however, appear to have direct relevance to highway capacity analysis:

1. The equal speed concept appears to be most relevant. Because level of service criteria for capacity analysis are based on performance parameters, it is logical that pce values should relate to those same performance parameters. For the two-lane highway work noted previously, speed is the principal criterion for designation of levels of service. Thus, conversions from mixed to pce volumes would not alter the performance parameters defining level of service. If this principle were to be extended to the uninterrupted flow procedure of Circular 212, it would suggest that pce's be based on equal densities, because density is the principal parameter defining level of service. It must be noted that none of the other concepts for pce's

reviewed here guarantees that the equivalent pce volume operates at the same performance levels as the actual mixed traffic stream.

2. The spatial headway approach is also of some interest. Average spacing and density are related on a one-to-one basis, and spatial headway could be argued to be a surrogate (more easily measured) parameter for density. Use of space is also of direct interest in capacity analysis.

3. The constant V/C ratio approach used in developing the Circular 212 values is relevant in its own right, because V/C values are related to speeds and densities. Further, the proportion of capacity used and the proportion still available are critical pieces of information. However, while V/C ratios are held constant, equivalent traffic streams may not operate at the same speed and density as the actual mixed traffic stream. The speed-flow-density relationships shown in Circular 212, which were used in the development of level of service criteria, are for ideal conditions (i.e., a pce traffic stream with ideal geometrics on the highway). Introduction of trucks or other non-passenger cars into the traffic stream alters this relationship. Thus, if V/C is held constant in calibrating pce's, speed and density are not. Conversely, if speed or density or both are held constant, V/C is not. In the Circular 212 approach, constant V/C values may be relevant, but the interpretation of level of service criteria, when applied to mixed traffic streams, is unclear.

Unfortunately, it will not be possible to reconcile these three approaches as new capacity techniques are developed in anticipation of a third edition of the Highway Capacity Manual. The data bases are incompatible and do not allow revision of the results of these studies in a single format. Thus, elements of all three principles will survive in new techniques.

AN APPROACH TO MULTILANE PCEs

The pce values of Circular 212 have been the subject of much discussion and lively debate since their appearance in 1980. These discussions have centered on whether the values are too high or too low, and whether the truck performance curves used in their calibration are representative for capacity analysis purposes.

Performance curves in the circular are for a truck with a weight-to-horsepower ratio of 300 lb/hp, and are taken from a study of such characteristics conducted at Pennsylvania State University (9). Although general agreement on the crawl speeds shown for 300 lb/hp trucks has been achieved, there is some dispute over the critical length of grade needed to reach that crawl speed. The Pennsylvania State curves agree closely with those adopted by St. John (10) in his studies at the Midwest Research Institute (when both are adjusted to reflect a 55 mph maximum speed). Studies by the California Department of Transportation (11), however, show crawl speeds significantly in excess of those used in Circular 212, as well as critical grade lengths approximately 500 feet longer than those in the circular. The California study is based on mixed traffic streams, with no single, characteristic, weight-to-horsepower value represented. The California curves, however, agree almost exactly with St. John's curves for a truck with a weight-to-horsepower ratio of 125 lb/hp.

The critical issue, therefore, appears not to be whether the performance curves for the 300 lb/hp truck adopted in Circular 212 are accurate but whether the selection of 300 lb/hp is appropriate for capacity analysis. The California study suggests that a 300 lb/hp truck is considerably less powerful that the average truck. Recent studies at the Texas Transportation Institute (8) and by St. John (12) produced similar results, reporting 170 lb/hp and 150 lb/hp as median values for multilane truck populations. The Pennsylvania State study focused on passing lane design and used the 300 lb/hp truck, explicitly noting that this represented a typical heavy truck.

It appears, therefore, that the average truck population on multilane uninterrupted flow facilities is in the 125-170 lb/hp range, not the 300 lb/hp used in Circular 212. A further issue remains: Is the average or median weight-to-horsepower ratio appropriate for use in capacity analysis? Cunagin and Messer (1) suggest that heavier trucks have a greater negative impact on operations than do lighter trucks. Although the pce values of Circular 212 can be analytically modified to reflect a different typical weight-to-horsepower ratio, they cannot be adjusted to reflect a truck population with a mix of weight-to-horsepower ratios. Thus, a mix of trucks with an average weight-to-horsepower ratio of 150 lb/hp would be expected to have a more negative impact on operations than a truck population in which all trucks had a ratio of 150 lb/hp.

Considering these points, the following recommendations are made:

1. The pce values for normal truck populations should be based on performance characteristics of a 200 lb/hp truck.

2. In keeping with the approach of Circular 212, pce values for nonstandard truck populations should also be provided--light truck populations would be represented by a 100 lb/hp truck, heavy truck populations by a 300 lb/hp truck.

Note that the 200 lb/hp truck is the assumed norm in the 1965 Highway Capacity Manual. It is emphasized, however, that the performance curves for such a truck in the 1965 manual indicate substantially poorer performance than current studies, and that the concept behind the development of pce values in the 1965 Highway Capacity Manual differs greatly from the three primary concepts presented herein.

It should also be noted that, as in the 1965 Manual, the same pce values are recommended for use for freeways and for normal multilane highways. All pce studies show no substantial difference for these types of facilities.

TRUCK PCEs ON INDIVIDUAL GRADES

Figures 1-3 show the performance characteristics of 100 lb/hp, 200 lb/hp, and 300 lb/hp trucks on extended upgrades. They were taken from St. John and Kobett (10) and modified to reflect a maximum truck speed of 55 mph, as in Circular 212.

Passenger car equivalent values, E_T, can be adjusted to reflect new typical weight-to-horsepower ratios in the following manner:

1. For a given percent grade and length of grade, the final speed of trucks is found from Figure 1, 2, or 3.

2. The performance curves of Circular 212 are entered to find (a) the length of grade of the same percent as in step 1, which results in the same final speed of trucks as in step 1, and (b) the percent grade of the same length as in step 1, which results in the same final speed of trucks as in step 1.

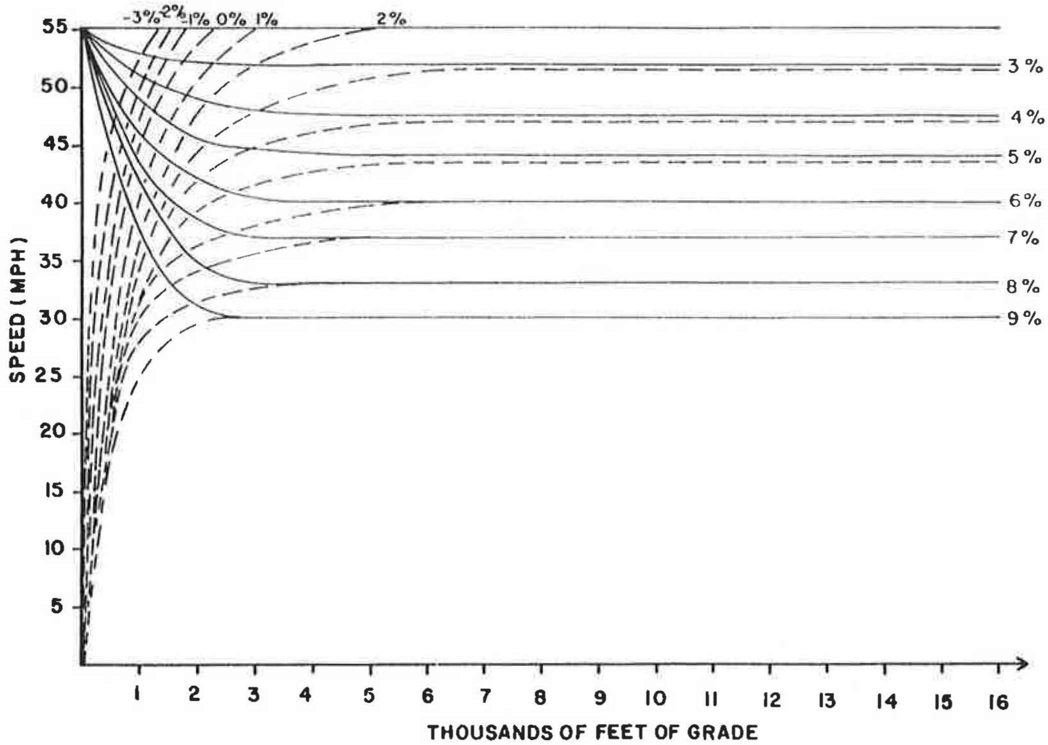

FIGURE 1 Performance curves for a 100 lb/hp truck (*10*).

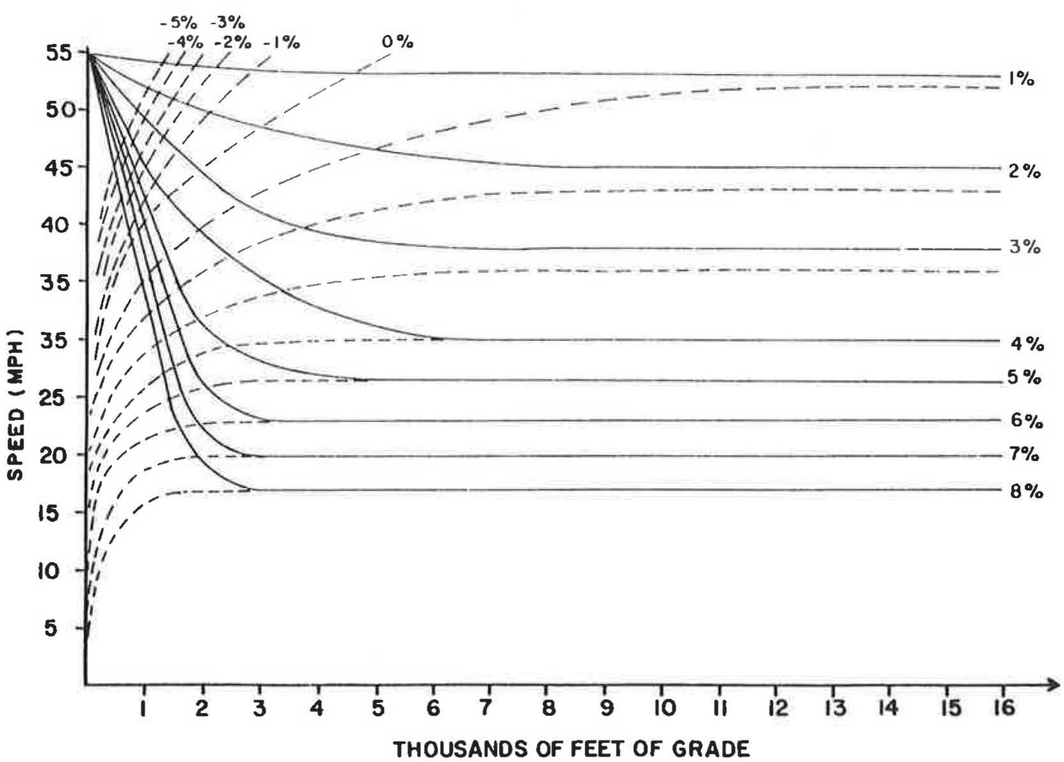

FIGURE 2 Performance curves for a 200 lb/hp truck (*10*).

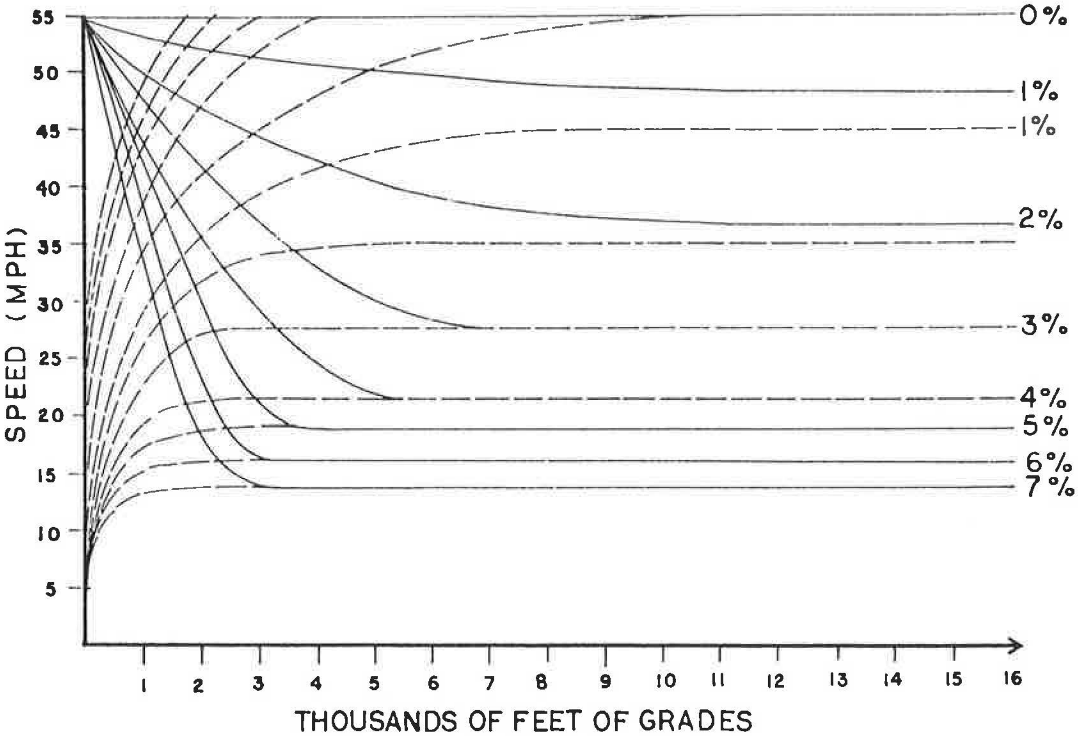

FIGURE 3 Performance curves for a 300 lb/hp truck (*10*).

3. The pce table of Circular 212 is entered with the grade-length conditions of 2(a) and 2(b). The two pce values thus found are averaged and rounded to the nearest integer, with the result being the revised equivalent for the condition described in step 1.

The pce values that result from this analysis for trucks are given in Tables 1-3 and are recommended by the authors for use in revised highway capacity analysis procedures.

RECREATIONAL VEHICLE PCEs ON INDIVIDUAL GRADES

The pce values for recreational vehicles (RVs) in Circular 212 were based on a typical weight-to-horsepower ratio of 60 lb/hp. Recent studies indicate that this also may have been too high a value. Canadian studies have reported average ratios for RVs in the 30-35 lb/hp range. Further, in their equivalence studies, Cunagin and Messer have found that pce's for RVs range from about 1/3 of the corresponding truck pce at high values of E_T to about

TABLE 1 Passenger Car Equivalent Values for 100 lb/hp Trucks

Grade (%)	Length (mi.)	E_T 4-Lane Freeways								6-8 Lane Freeways							
Percent Trucks		2	4	5	6	8	10	15	20	2	4	5	6	8	10	15	20
≤ 2	All	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	0-1/4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	1/4-1/2	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3
	1/2-3/4	4	4	4	4	3	3	3	3	4	4	4	3	3	3	3	3
	3/4-1	5	4	4	3	3	3	3	3	5	4	4	4	3	3	3	3
	>1	6	5	5	5	4	4	4	3	6	5	5	4	4	4	3	3
4	0-1/4	4	4	4	3	3	3	3	3	5	4	4	4	3	3	3	3
	1/4-1/2	5	5	5	4	4	4	4	4	5	4	4	4	4	4	4	4
	1/2-1	6	5	5	5	4	4	4	4	6	5	5	4	4	4	4	4
	>1	7	6	6	5	4	4	4	4	7	5	5	5	4	4	4	4
5	0-1/4	6	5	5	5	4	4	4	3	6	5	5	5	4	4	4	3
	1/4-1	8	7	7	6	5	5	5	5	8	7	7	6	5	5	5	5
	>1	9	7	7	6	5	5	5	5	8	7	7	6	5	5	5	5
6	0-1/4	7	5	5	5	4	4	4	4	7	5	5	5	4	4	3	3
	1/4-1	9	7	7	6	5	5	5	5	8	7	7	6	5	5	5	5
	>1	9	7	7	7	6	6	5	5	9	7	7	6	5	5	5	5

NOTE: If a length of grade falls on a boundary value, use the equivalent for the longer grade category. Any grade steeper than the percent shown must use the next higher grade category.

TABLE 2 Passenger Car Equivalent Values for Normal Truck Populations (200 lb/hp)

Grade (%)	Length (mi.)	E_T 4-Lane Freeways								6-8 Lane Freeways							
Percent Trucks		2	4	5	6	8	10	15	20	2	4	5	6	8	10	15	20
<1	All	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	0-1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	1/2-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	≥1	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3
2	0-1/4	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3
	1/4-1/2	5	4	4	3	3	3	3	3	5	4	4	3	3	3	3	3
	1/2-3/4	6	5	5	4	4	4	4	4	6	5	5	4	4	4	4	4
	3/4-1 1/2	7	6	6	5	4	4	4	4	7	5	5	5	4	4	4	4
	≥ 1 1/2	8	6	6	6	5	5	4	4	8	6	6	5	4	4	4	4
3	0-1/4	6	5	5	5	4	4	4	3	6	5	5	5	4	4	4	3
	1/4-1/2	8	6	6	6	5	5	5	4	7	6	6	6	5	5	5	4
	1/2-1	9	7	7	6	5	5	5	5	9	7	7	6	5	5	5	5
	1-1 1/2	9	7	7	7	6	6	5	5	9	7	7	6	5	5	5	5
	≥ 1 1/2	10	7	7	7	6	6	5	5	10	7	7	6	5	5	5	5
4	0-1/4	7	6	6	5	4	4	4	4	7	6	6	5	4	4	4	4
	1/4-1/2	10	7	7	6	5	5	5	5	9	7	7	6	5	5	5	5
	1/2-1	12	8	8	7	6	6	6	6	10	8	7	6	5	5	5	5
	≥ 1	13	9	9	9	8	8	7	7	11	9	9	8	7	6	6	6
5	0-1/4	8	6	6	6	5	5	5	5	8	6	6	6	5	5	5	5
	1/4-1/2	10	8	8	7	6	6	6	6	8	7	7	6	5	5	5	5
	1/2-1	12	11	11	10	8	8	8	8	12	10	9	8	7	7	7	7
	≥ 1	14	11	11	10	8	8	8	8	12	10	9	8	7	7	7	7
6	0-1/4	9	7	7	7	6	6	6	6	9	7	7	6	5	5	5	5
	1/4-1/2	13	9	9	8	7	7	7	7	11	8	8	7	6	6	6	6
	1/2-3/4	13	9	9	8	7	7	7	7	11	9	9	8	7	6	6	6
	≥ 3/4	17	12	12	11	9	9	9	9	13	10	10	9	8	8	8	8

NOTE: If the length of grade falls on a boundary value, use the equivalent for the longer grade class. Any grade steeper than the percent stated must use the next higher grade category.

1/2 at low values of E_T. Based on these results, reductions in the Circular 212 values for E_R are recommended, as given in Table 4.

PASSENGER CAR EQUIVALENTS FOR BUSES ON INDIVIDUAL GRADES

The subject of bus performance on grades has not received any research attention since the early 1960s, and there is no new data on which to base revisions to the pce values in the 1965 Highway Capacity Manual. These values were transferred to Circular 212 and will doubtless carry over to any additional revisions, barring new data. As in the past, where bus percentages are small compared with trucks or RVs, numerical procedures would recommend that buses be considered as trucks.

PASSENGER CAR EQUIVALENTS ON GENERAL FREEWAY SEGMENTS

The Institute for Research study (3) produced a set of pce values for a broad range of vehicle types on urban freeways essentially at level grade. The results of this study point to two important factors:

1. Passenger car equivalent values are shown to vary based on volume levels, increasing with increasing volume, and
2. Passenger car equivalent values on level grades appear to be generally lower than the 2.0 and 1.6 values in Circular 212 for trucks and buses (which were taken directly from the 1965 Highway Capacity Manual).

The first point is a vexing one. Values for pce's in the study ranged from 1.1 for several vehicle types at low volumes to 2.0 for tractor-trailers at high volumes. The adoption of pce values varying with volume would present serious problems in capacity analysis procedures, greatly complicating computations. Further, the study addressed level terrain but did not extend to rolling or mountainous terrain. None of the studies that address pce's on specific grades showed significant variation with volume. Because the design benefits of smaller pce values at low volumes would be minimal, it is recommended that constant pce values with volume be used for relevant vehicle types on level terrain.

The Institute for Research study does, however, suggest that the pce values used in the 1965 Highway Capacity Manual and in Circular 212 are higher than necessary. For example, the maximum pce value of 2.0 applies only to tractor-trailers under the highest volume conditions. Maximum pce values for single-unit trucks are 1.5 or 1.6, depending on the number of axles, and the maximum pce value for buses is 1.6. Pickup trucks and vans were found to be the same as passenger cars. On the basis of these results, slight reductions in the level terrain pce values of Circular 212 appear to be in order. The extension of these reductions to rolling and mountainous terrain is not automatically indicated. The current values are generally consistent with the revised pce's for grades of the percent and length usually present in such terrains, and it is therefore recommended that they be retained. Table 5 gives the recommended values for pce's on extended uninterrupted flow segments.

TABLE 3 Passenger Car Equivalent Values for 300 lb/hp Trucks

Grade (%)	Length (mi.)	E_T 4-Lane Freeways								E_T 6-8 Lane Freeways							
Percent Trucks		2	4	5	6	8	10	15	20	2	4	5	6	8	10	15	20
<1	All	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	0-1/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	1/4-1/2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	1/2-3/4	4	4	4	4	3	3	3	3	4	4	4	3	3	3	3	3
	3/4-1	5	4	4	4	3	3	3	3	5	4	4	4	3	3	3	3
	1-1 1/2	6	5	5	5	4	4	4	3	6	5	5	4	4	4	3	3
	>1 1/2	7	5	5	5	4	4	4	3	7	5	5	5	4	4	3	3
2	0-1/4	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3
	1/4-1/2	7	6	6	5	4	4	4	4	7	5	5	5	4	4	4	4
	1/2-3/4	8	6	6	5	5	4	4	4	8	6	6	6	5	5	4	4
	3/4-1	8	6	6	6	5	5	5	5	8	6	6	6	5	5	5	5
	1-1 1/2	9	7	7	7	6	6	5	5	9	7	7	6	5	5	5	5
	>1 1/2	10	7	7	7	6	6	5	5	10	7	7	6	5	5	5	5
3	0-1/4	6	5	5	5	4	4	4	3	6	5	5	5	4	4	4	3
	1/4-1/2	9	7	7	6	5	5	5	5	8	7	7	6	5	5	5	5
	1/2-3/4	12	8	8	7	6	6	6	6	10	8	7	6	5	5	5	5
	3/4-1	13	9	9	8	7	7	7	7	11	8	8	7	6	6	6	6
	>1	14	10	10	9	8	8	7	7	12	9	9	8	7	7	7	7
4	0-1/4	7	5	5	5	4	4	4	4	7	5	5	5	4	4	3	3
	1/4-1/2	12	8	8	7	6	6	6	6	10	8	7	6	5	5	5	5
	1/2-3/4	13	9	9	8	7	7	7	7	11	9	9	8	7	6	6	6
	3/4-1	15	10	10	9	8	8	8	8	12	10	10	9	8	7	7	7
	>1	17	12	12	10	9	9	9	9	13	10	10	9	8	8	8	8
5	0-1/4	8	6	6	6	5	5	5	5	8	6	6	6	5	5	5	5
	1/4-1/2	13	9	9	8	7	7	7	7	11	8	8	7	6	6	6	6
	1/2-3/4	20	15	15	14	11	11	11	11	14	11	11	10	9	9	9	9
	>3/4	22	17	17	16	13	13	13	13	17	14	14	13	12	11	11	11
6	0-1/4	9	7	7	7	6	6	6	6	9	7	7	6	5	5	5	5
	1/4-1/2	17	12	12	11	9	9	9	9	13	10	10	9	8	8	8	8
	>1/2	28	22	22	21	18	18	18	18	20	17	17	16	15	14	14	14

NOTE: If the length of grade falls on a boundary value, the equivalent corresponding to the longer grade category is used. Any grade steeper than the percent shown must use the next higher grade category.

TABLE 4 Passenger Car Equivalent Values for Recreational Vehicles

Grade (%)	Length (mi.)	E_R 4-Lane Freeways								E_R 6-8 Lane Freeways							
Percent RV's		2	4	5	6	8	10	15	20	2	4	5	6	8	10	15	20
<2	All	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	0-1/2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	≥ 1/2	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3
4	0-1/4	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
	1/4-3/4	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3
	≥ 3/4	5	4	4	3	3	3	3	3	4	4	4	4	3	3	3	3
5	0-1/4	4	3	3	3	3	3	3	3	4	3	3	3	2	2	2	2
	1/4-3/4	5	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
	≥ 3/4	6	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4
6	0-1/4	5	4	4	4	3	3	3	3	5	4	4	3	3	3	3	3
	1/4-3/4	6	5	5	4	4	4	4	4	6	4	4	4	4	4	4	4
	≥ 3/4	7	6	6	6	5	5	5	5	6	5	5	5	4	4	4	4

NOTE: If a length of grade falls on a boundary condition, the equivalent from the longer grade class is used. Any grade steeper than the percent shown must use the next higher grade category.

COMPUTATION OF ADJUSTMENT FACTORS FOR HEAVY VEHICLES

In Circular 212, values of E_T, E_R, and E_B are converted to a multiplicative adjustment factor that is applied to a maximum service volume under ideal conditions:

$$f_{HV} = 100/[100 + P_t(E_T-1) + P_r(E_R-1) + P_b(E_B-1)]$$

where f_{HV} is the multiplicative adjustment factor; P_t, P_r, and P_b are the percentages of trucks, RVs, and buses in the traffic stream; and E_T,

TABLE 5 Passenger Car Equivalent Values for Extended Freeway Segments

FACTOR	TYPE OF TERRAIN		
	Level	Rolling	Mountainous
E_T for trucks	1.7	4.0	8.0
E_B for buses	1.5	3.0	5.0
E_R for RV's	1.6	3.0	4.0

E_R, and E_B are the pce values for trucks, RVs, and buses, respectively.

Cunagin and Messer (1) suggest another approach that was applied to the two-lane highway work at Texas A&M. The point is made that the composite effect of various types and classes of non-passenger cars on the traffic stream may not be the same as the algebraic combination of individual impacts, as suggested in the preceding equation. Their suggested formulation is

$$f_{HV} = 100/[100 + P_{HV}(E_{HV} - 1)]$$

where P_{HV} is the total percentage of heavy vehicles in the traffic stream, and E_{HV} is the pce for all heavy vehicles in the traffic stream for the existing mix of traffic. There is some logic to this latter approach, but values of E_{HV} must be calibrated for various mixes of trucks, RVs, and buses. The rural two-lane highway procedure developed at Texas A&M for NCHRP tabulates the pce's for a standard mix of trucks and RVs (buses are treated as one or the other, depending on conditions). An equation is provided to adjust this value to a mix other than the norm.

The data bases used for multilane pce's in Circular 212 and herein do not permit the direct calibration of values for various mixes of heavy vehicles. For this reason the algebraic approach used in the circular will be needed until the latter approach is investigated further.

SUMMARY AND CONCLUSION

A review of the various approaches to calibration and interpretation of pce values in highway capacity analysis has been presented. The recommended revisions to pce values for multilane uninterrupted flow currently in use are based on an evaluation of the latest research and data and should result in improved accuracy of analysis procedures for these types of facilities.

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