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SOME PRELIMINARY CONSIDERATIONS IN THE ESTIMATION OF PASSENGER CAR EQUIVALENTS

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1 Introduction

The presence of large vehicles in the traffic stream reduces the capacity of the freeway. In effect, each truck displaces several passenger cars in the flow and hence the effects of a heavy vehicle may be equated to an equivalent number of passenger cars added to the traffic stream, defined as Passenger Car Equivalent (PCE) of the heavy vehicles.

2 Identification of flow regions

The concept of identifying different traffic flow regions on flow-density-speed (q-k-v) curve (Fig.1 for q-k curve, Fig.2 actual data set), is essential as the PCE

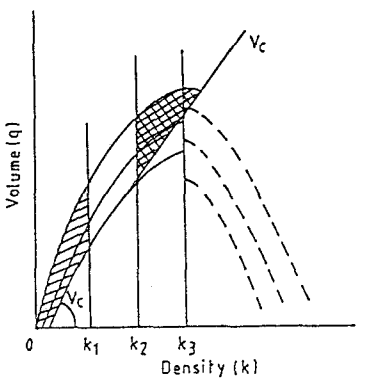

Fig.1, Classification of Traffic Flow States

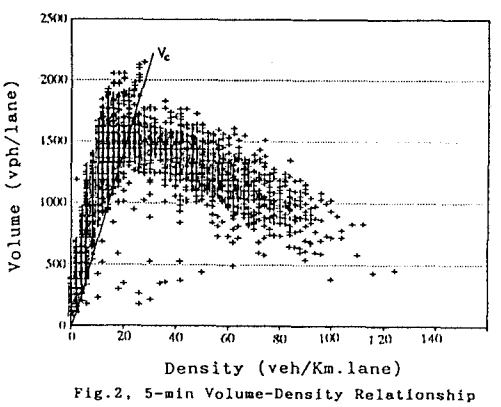

Fig.2, 5-min Volume-Density Relationship

for equal flow rate but different flow regions should be different. The complete free flow region can be identified from density, k_1, alone where as, near the critical region i.e. the flow near capacity, a factor of critical velocity, V_c, above which is the free flow region, should also be considered to differentiate between the free flow and the congested region.

3 Passenger Car Equivalents

PCE values have been used primarily in the framework of traffic capacity procedures. PCE values are employed as a device to convert a traffic stream composed of a mix of vehicle types into an equivalent traffic stream composed exclusively of passenger cars. Such values permit the specification of capacity in terms of PCE and provide the basis for development of procedures to express any traffic stream composition into equivalent PCE volume.

The term PCE was first introduced in the 1965 Highway Capacity Manual. Since then, there have been a wide variety of philosophies applied to the development of PCE values, the concept and the application of which, are different giving different results.

The criterion used to estimate PCE in the Highway Capacity Manual is the relative number of passings of trucks by passenger cars in relation to the number of passings of passenger cars by passenger cars; the specific method, known as **Walker Method.**

The **equivalent delay method** of estimating PCE considers the difference between the delay caused by heavy vehicles to standard passenger cars and the delay caused by slower passenger cars to standard passenger cars.

A combination of Walker and equivalent delay method was used by CUNAGIN and MESSER (1982), applying Walker method for lowest volume level corresponding to level of service (LOS) A, and the equivalent delay method for highest volume levels corresponding to LOS E.

Simulation methods was also used (LINZER, ROESS, McSHANE, 1979) for PCE estimation which duplicates the real characteristics of mixed traffic flow. The concept of PCE used was the constant V/C (Volume to Capacity) ratio approach, that is to keep the effective value of V/C constant for

any given level of service for two flows. A mathematical model to estimate PCE values was first developed by HUBER (1982), for vehicles under free-flowing, multilane conditions with a simple deterministic (Greenshield's) model of traffic flow. A measure of impedance as a function of traffic flow was used to relate mixed traffic stream and the stream with passenger cars (basic vehicles) only. PCE values were obtained by equating the flow rates for basic and mixed streams at some common level of impedance such that these flow rates will produce identical measures of level of service. A common measure of impedance suggested was the average travel time (Fig.3) for individual vehicle over a length of roadway. Other alternates were the time of occupancy (total travel time) and the travel time of basic vehicle in basic and mixed streams.

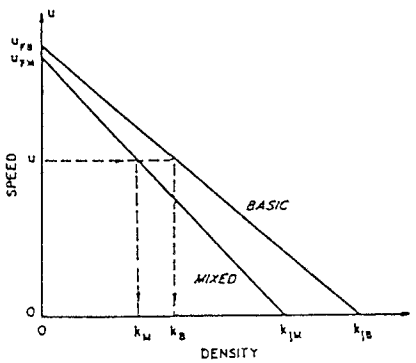

Fig.3, PCE by equal average travel time

KRAMMES and CROWLEY used the basic concept used by HUBER for PCE estimation, but applied the spatial headway concept.

4 Considerations on Possible Analysis

Thus, there have been basically three approaches that appear to have direct relevance to highway capacity analysis: the equal average speed concept, the spatial headway approach and the constant V/C approach. Again, as the capacity analysis procedures are based on LOS concept, and the parameters that are used to define LOS reflect the factors that influence the driver's perception, the same parameters should be used to compare passenger cars and trucks and to estimate PCE for the case of traffic flow and capacity analysis, (ROESS and MESSER, 1984).

The V/C ratio approach was relevant only when LOS was defined by V/C ratio. HUBER's mathematical model becomes an interesting approach at this concern. The assumption of equal total travel time (equal densities) for two different flows, one with basic vehicles only and the other with mixed traffic, implies that each heavy vehicle is replaced by the passenger car and the effect is then analyzed. Similarly, the equal average travel time sets the same average speed (Fig.3) for the two flows. But, keeping LOS constant means that any flow on basic vehicle curve should correspond to the flow on mixed curve for same LOS. If the densities are set to equal for two flows, the LOS can not be guaranteed to be equal since the average speed of the mixed flow will increase after replacing the heavy vehicles by basic vehicles. Conversely, if the speed is set equal, the density for two flows no longer corresponds to the same LOS. The purpose thus becomes to analyse such that when the mixed vehicle curve is converted to basic vehicle curve using PCE value, each and every point on this curve should be identical to an ideal basic curve in terms of speed, density and the flow rate. If the simple linear model of traffic flow is considered, three basic conditions for PCE analysis can be chosen, which are the free flow condition, at capacity condition and the jam condition. If these three points on the two curves are set to coincide, the LOS and other traffic flow parameters can be assumed to be equal in all respects for any points in the curve.

5 Concluding Remarks

Since PCE was first introduced in the 1965 Highway Capacity Manual, many research effort has been directed toward the estimation of PCE. However, due to different concepts and applications, still there is no clearly defined theoretical basis for PCE estimation. Some preliminary considerations in PCE estimation for the purpose of capacity analysis has been attempted. However, evaluation of different approaches and new concept is planned to be studied further.

6 References

1. ROESS & MESSER(1984), PCE for Uninterrupted flow: Revision of Circular 212 Values, TRR No.971
2. HUBER(1982), Estimation of PCE for Trucks in Traffic Stream, TRR No.869
3. CUNAGIN & MESSER(1982), PCE for Rural..TRR No.905