Road Classification According to Driver Population

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A proposed model for classification of rural roads according to driver population characteristics is described. The driver population is distinguished by such traffic stream characteristics as trip purpose and trip length distribution, and the basic assumption made in the analysis is that the different traffic flow patterns observed at road sites result from different mixes of these characteristics. The highway systems of the provinces of Alberta and Saskatchewan are investigated for the purpose of developing and testing the model. The model suggests the application of some standard computational and statistical techniques to develop master patterns of traffic flow in order to recognize the driver population of a given road site. The proposed model is simple to apply and its data requirements can easily be satisfied by the types of data collection programs normally undertaken by highway agencies. Also, it is believed to be more objective and comprehensive than the existing methods used for the same purposes. The road classification resulting from the model could be used as an important criterion for many highway planning and design functions. Some examples of its application are *(a)* rationalization of provincewide traffic-counting programs, *(b)* design hourly volume considerations, *(c)* highway improvement programming, and *(d)* highway capacity analysis.

Road classification is important for administration, planning, design, and operation of facilities. Systems for classifying roads are numerous, and the class definitions vary depending on the purpose of classification. Some examples of classification systems used are *(a)* according to jurisdiction and funding—federal, provincial, and municipal roads—and *(b)* according to type of road function—freeways and expressways, arterials, collectors, and local roads. Several of the common classification systems are presented in the Institute of Transportation Engineers handbook (*1*, pp. 599–604) and Roads and Transportation Association of Canada (RTAC) *(2, 3)* publications.

Many of the provincial or state highway agencies also classify roads according to volume characteristics, such as temporal volume variations and other traffic stream characteristics. This type of road classification is frequently used in traffic volume estimation, design hourly volume (DHV), and peak-hour traffic considerations. There exists a diversity of definitions, systems, and procedures for this type of road classification both in Canada and abroad. Consequently a considerable input of subjective judgment is used in various planning and designing activities that pertain to different types of roads.

Recently, the variable "driver population" or user's perspective has been considered a significantly important factor in an increasing number of highway planning and design functions. An interesting example of this is the new (1985) edition of the Highway Capacity Manual (HCM) (*4*, p. 3–17), which suggests the use of an adjustment factor (f_p) to reflect the influence of driver population on highway capacity calculations. Some other examples of areas in which the road use (the terms "road use" and "driver population" are used interchangeably to reflect the traffic stream characteristics) variable has appeared to be an important factor are *(a)* design hourly volume considerations *(5–7)*, *(b)* cost-effective sizing and upgrading of two-lane rural highways *(7)*, and *(c)* rationalization of traffic monitoring *(8–12)*.

The main objective of this paper is to offer an improved method of classification, based on trip purpose and trip length distribution and temporal volume variations, that would lead to a better understanding of the road user's perspective and hence provide further insight into planning and design of road facilities from the users' point of view.

The proposed method suggests the use of standard computational and statistical techniques and therefore is expected to yield more objective and statistically credible groupings of road sites than do existing methods. Another objective of this paper is to recommend more specific values (compared with the 1985 HCM) of the factor f_p to be used in the capacity analysis for different types of driver populations. The aim here is to provide a sound basis for engineering judgment that must be exercised by the analyst in selecting an exact value of f_p from the wide range of choice presented by the new HCM.

BRIEF REVIEW OF THE STATE OF THE ART

Before an alternative method of road classification is presented, it is worthwhile to review various procedures that are presently used in Canada and abroad and to describe briefly matters that are interrelated with classification of road sites according to driver population.

Traffic Monitoring and Classification of Road Sites

Grouping of permanent traffic counter (PTC) sites is required for such traffic-monitoring purposes as the estimation of average annual daily traffic (AADT) from sample counts. The most commonly used method of grouping PTCs is that recommended by the Bureau of Public Roads (BPR) *(13)*. In this method, the counters are grouped on the basis of monthly traffic factors, which are defined as the ratio of the AADT to the average weekday traffic of the month. The BPR method utilizes a manual ranking system in which the PTCs are listed in ascending order of monthly factors.

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For each month, a group of counters is determined so that the difference between the smallest and the largest factor does not exceed a range of 0.20 in the values of the factors. In other words, the criterion of grouping is a subjectively and arbitrarily chosen value of ±0.10 from the assumed mean. The final grouping of counters in this method is supposed to be such that all or as many as possible of the same counters fall into the same group each month.

The provincial highway agencies in Canada use a variety of methods for grouping their PTC sites *(14,15)*. Some of them use classifications that are similar to the BPR method. Others employ different grouping criteria and class definitions that are largely arbitrary and subjective in nature. One agency has more than 150 PTCs but it has not carried out any specific classification of these sites.

Bellamy *(16)* used a cluster analysis technique in an attempt to classify temporal variations in traffic flows at the 50-point PTC sites in Britain. From the results of the cluster analysis, the study found that it was difficult to decide what grouping of the sites was most appropriate. Because the cluster analysis grouping could not be regarded as conclusive, the study was reconciled by using a largely subjective method that was quite similar to the BPR method. Four descriptive classes of road sites suggested in the study were *(a)* urban and commuter, *(b)* nonrecreational low flow, *(c)* rural long distance, and *(d)* recreational.

DHV Considerations and Classification of Road Sites

Highway authorities and researchers recognize the importance of road use in estimating the DHV for a new facility or upgrading an existing facility *(1;5–7;17*, pp. 170–175). In this regard, the ITE handbook *(1)* identifies different highway routes by such types as "urban through route," "suburban through route," "main rural route," "secondary rural route," partially recreational route," and "highly recreational route." Figure 4.9 of the handbook shows the conventional presentation of highest hourly volumes for different types of highway routes. No systematic and clear definitions of such route classes are available in the literature.

Highway Capacity Analysis and Driver Population

Research work on highway capacity analysis conducted in the past few years indicates that capacity as well as service flow rates for other levels of service are significantly affected by traffic stream characteristics. The new HCM *(4)* recognizes this factor and uses an adjustment factor called f_p in the calculation of highway capacity. An adjustment factor (f_p) of 1.0 is assigned to "weekday or commuter" traffic. A range of f_p of between 0.75 and 0.90 is suggested for use in the cases of "other" types of traffic streams.

The range of adjustment factor (f_p) suggested by the HCM is substantial. The use of such a wide range (i.e., 0.75 to 0.90 or 0.75 to 0.95) for "other" types of facilities will require great caution on the part of the analyst. Classification of road sites according to traffic stream characteristics would be useful for conducting comparative field studies and selecting an appropriate value of the factor for accurate capacity analysis.

Limitations of the Existing Classification Methods

It is apparent that the existing methods of grouping road sites are generally arbitrary, and, consequently, opinions differ on the number and best definition of classes. A considerable input of subjective judgment is used not only in factoring a sample count to estimate the AADT but also in various planning and design activities pertaining to different types of roads. As a result of this, significant differences exist among Canadian provinces in the way they carry out certain transportation functions. An example of this is the use of more than 150 PTCs by the province of Quebec compared with only 21 PTCs used by Ontario.

The previously mentioned limitations of the existing classification and the need to consider driver population in capacity analysis suggest that more effort is needed to investigate the classification of road sites. The central theme of this research is to develop a systematic and objective method of road classification according to type of road uses. The analysis presented here includes consideration of temporal variations in flows at given roadway locations and information, such as trip purpose and trip length distribution, to explain these variations.

STUDY DATA

The primary highway system of the province of Alberta was investigated for the purpose of this study. The permanent traffic counters located on the system provided seasonal, daily, and hourly patterns of traffic. An analysis of monthly and daily variations in traffic flows was carried out over a number of years. The analysis appeared to show that at a number of PTC sites there were some differences between the patterns for different years, but these differences did not show an overall systematic trend with time. As a result of the analysis, it was considered preferable to use the monthly and daily traffic data average over a period of 5 years. Considering the reliability of the available Alberta PTC data, a total of 52 counter sites were selected for the study.

From the past origin-destination surveys conducted by Alberta Transportation, trip purpose and journey length information corresponding to some of the counter locations in the province was available. This type of information was used to rationalize the proposed method of classification of the road sites.

For the purpose of testing the proposed method of road classification, a total of 28 PTC sites located on the highway system of the province of Saskatchewan were also investigated on the basis of their seasonal, daily, and hourly variations in traffic flows.

MODEL OF ROAD CLASSIFICATION ACCORDING TO DRIVER POPULATION

The parameter f_p, driver population, used in the new HCM refers to trip purpose characteristics, such as commuter and recreational. Another traffic stream characteristic that could be important from the point of view of capacity calculation or other transportation functions is the trip length distribution aspect of the driver population. This study utilizes both trip purpose (e.g., commuter, recreational) and trip length distribution (e.g., urban, regional, interprovincial) as the descriptors of the driver population.

The basic assumption made in the development of the proposed model, called the DRIPOP model hereafter, is that the difference in traffic flow patterns observed at road sites results from different mixes of trip characteristics. The high morning and afternoon peaks are due to the high number of home-to-work and work-to-home trips in urban areas. High weekend traffic is associated with high weekend social and recreational trips. Also, the higher traffic volumes in certain months, such as July and August, can be related to summer holidays and long-distance tourist recreational trips.

Development of Master Traffic Patterns

The objective of this step of the DRIPOP model is to group the volume distributions of road sites and obtain the typical or "master" patterns of traffic flow. The patterns that result from this step provide input to the final classification of roads according to driver population.

Hierarchical Grouping

The hierarchical grouping method is used mostly in behavioral research. The purpose of this method is to compare a set of N objects (e.g., 52 road sites in this study) each measured on K different variables (e.g., 12 monthly traffic factors) and group them in such a manner that groups are similar in their values of the K variables.

In this paper no attempt is made to explain the hierarchical grouping method in detail. Instead, the basic premise and the main criteria for this method are briefly described with reference to the classification of roads. There are several sources of information on the hierarchical grouping procedure, and particular reference may be made to Veldman (*18*, pp. 308–317) and Ward (*19*). A FORTRAN computer program of the hierarchical grouping is provided in Veldman (*18*). The procedure carried out in this step for grouping the sample road sites is adopted from a paper by Sharma and Werner (*20*).

The hierarchical grouping of the road sites is based on the premise that the maximum amount of information is available when the N sites are ungrouped. Hence the grouping process begins by defining each of the N sites as a "group." The first step in grouping reduces by one the number of groups by selecting two groups that produce the least amount of within-group error. The remaining $N - 1$ groups are then reduced in number by a series of step decisions until all the sites are put in a single group. Each step of the process systematically reduces the number of groups by one.

The errors associated with successive stages of the grouping process indicate the marginal "cost" of reducing the number of groups by one. The error at a particular stage of grouping is greater than or equal to the error associated with the previous stage of grouping.

It has to be emphasized here that this method is primarily descriptive and does not indicate specifically what the optimum number of groups is for the study objectives. However, the errors associated with the successive stages of the grouping process will usually reveal a "knee-of-curve" range of grouping stages that is especially worthy of study. By applying this procedure and plotting the results (Figure 1), the errors associated with the groupings of the 52 road sites on the basis of the 12 monthly factors of this study can be shown. It appears from this figure that the optimum number of groups lies somewhere between 20 and 5 because a substantially large increase in error is observed in this range and beyond.

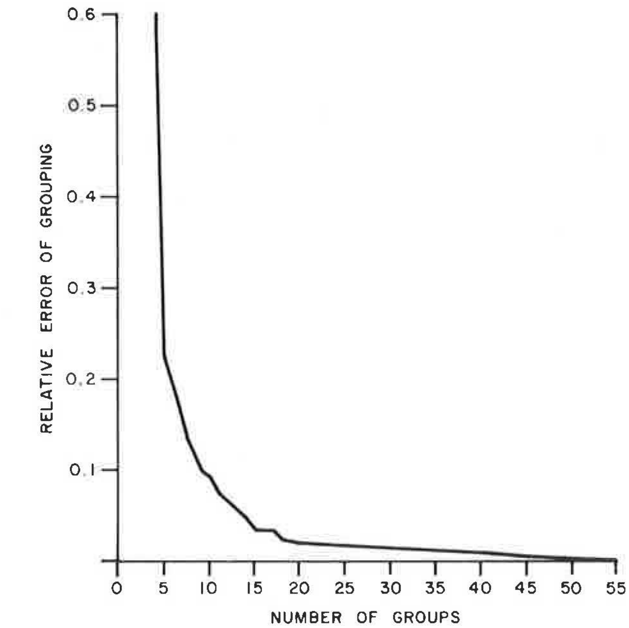

FIGURE 1 Incremental errors associated with the hierarchical grouping of monthly traffic factors.

Seasonal Traffic Patterns

One important advantage of the hierarchical grouping technique is that it provides the analyst with the opportunity to analyze the resulting groups at any chosen stage of the process. Referring to Figure 1, for example, an analyst might consider analyzing subjectively the patterns at the stage of 20 groups, and after a critical examination he might decide, even without performing any statistical analysis, to stop the hierarchical grouping at that stage. Such a large number (i.e., 20) might be considered quite appropriate by some agencies for grouping PTCs for obtaining monthly factors for estimating AADT. But if the objective is to obtain a smaller and more manageable number of road classes, the analyst might need to explore the entire range of grouping encompassing the knee-of-curve portions of the grouping errors such as shown in Figure 1.

Statistical comparisons, such as Scheffe's S-method of multiple comparisons of group means (*21*, pp. 53–73) or simple t-tests can help in the determination of the most appropriate number of master patterns of traffic distribution. For this purpose the study sites can be assumed to have been selected at random from the point of view of statistical theory (*16,22*).

The significance of differences among the group means can be established on the basis of group comparisons for each month of the year in the case of seasonal patterns. However, there is a need to exercise caution in that the F-tests computed for the S-method or t-tests used in comparing the mean monthly factors can be artificially and unreliably significant. The experience gained in this study indicates that the patterns should be considered different when the tests are significant for 5 or more months at a 95 percent confidence level.

The application of hierarchical grouping and statistical comparisons for the purpose of Alberta road classification resulted in four distinct major patterns at the level of seven groups (Figure 1) of the hierarchical process. These four major patterns, shown in Figure 2, account for nearly 95 percent of the study sites. The rest of the study sites included in the remaining three groups appear to represent special patterns, such as Site C 162 that exhibits a winter peak due to a large number of ski trips in winter months. The plots of patterns for the special cases are excluded from Figure 2 to avoid overcrowding the figure.

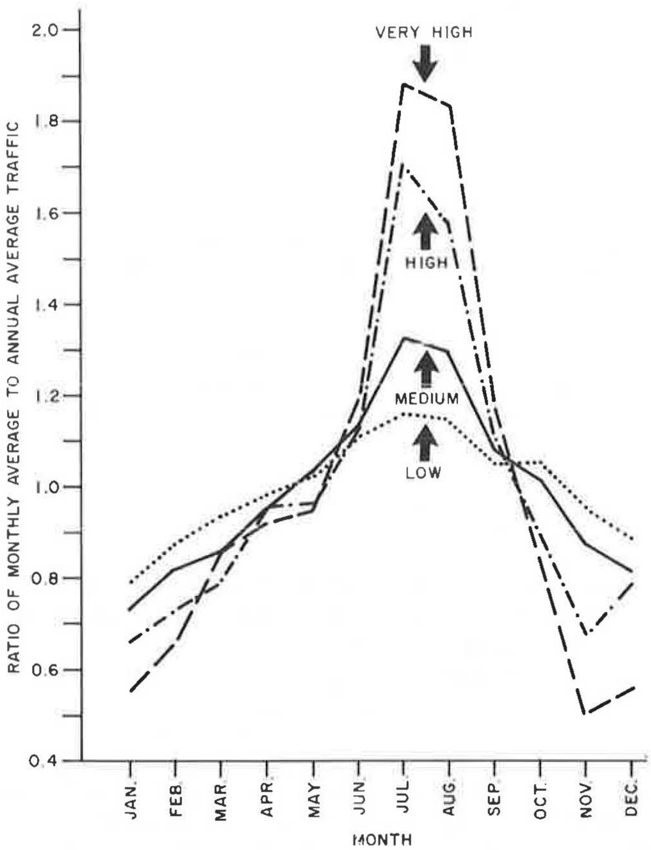

FIGURE 2 Average monthly traffic factors for the four major patterns of seasonal variation.

For the sake of simplicity of presentation, the four major patterns of seasonal variation are called "low," "medium," "high," and "very high." The magnitude of the seasonal variation exhibited by the master patterns of Figure 2 can be explained by the variation in trip purpose at road sites. However, because these master patterns should be used along with the daily and hourly variations and the trip length distribution, their explanation is postponed until a road classification is proposed.

Daily and Hourly Patterns

The different seasonal traffic patterns that resulted from the previous step were further analyzed systematically in terms of their ability to represent a more specific categorization of the Alberta roads. The study sites assigned to a particular master seasonal pattern indeed exhibited discernible and consistent patterns of daily and hourly variations in traffic flows. It became evident from this that the temporal variation patterns could be reliably and systematically related to different types of road uses.

The experience of working with the study data indicated that it is best to analyze daily and hourly characteristics during the months, such as May to August, inclusive, when the volumes are expected to be most stable *(9,23)* and they represent average to heaviest traffic conditions. Another reason to select such months is that most of the rural traffic data collection programs (e.g., seasonal and short-period sample counts) that can be helpful in the proposed road classification are undertaken during these months.

The relative magnitudes of traffic volume when averaged over all 7 days were carefully investigated to distinguish various types of roads. But the observations made in this study clearly indicated that it would be equally effective and simpler to use the Sunday volume factor for July—the month of the heaviest traffic volume. The Sunday factor, used as an indicator of the master daily pattern for the road classification, was defined as the ratio of average Sunday volume to the average weekday volume where the weekdays included Tuesday, Wednesday, and Thursday. The hierarchical grouping technique was used to group all of the study sites into three groups, which are defined as follows.

Daily Variation Pattern	*Sunday Factor in July*
Low	Lower than 1.1
Medium	1.1–1.4
High	Higher than 1.4

The relative Sunday volume of traffic can be taken as an indicator of weekend social-recreational trips. A high Sunday factor would result when Sunday traffic is much heavier than average weekday traffic volume. The road sites that carry large volumes of commuter and business trips on weekdays and do not serve an appreciable number of weekend social-recreational trips would be expected to exhibit a low Sunday factor. But it may be noted that a low (or medium) Sunday factor may also be exhibited by those roads that carry large numbers of weekend recreational trips. An example of such a case is when the road carries a large number of summer holiday or tourist trips that continue throughout the week. The increased level of weekday traffic due to the tourist trips tends to lower the Sunday factor.

The distributions of traffic volume by hour of the day often describe the peak demands for service. The morning and afternoon peak-hour periods on weekdays represent home-to-work and work-to-home trips, respectively. Consideration of such peaks during the weekdays could help to better understand the classification of roads.

Figure 3 shows three typical patterns of hourly volumes identified in this study for summer weekdays in July. These patterns are *(a)* commuter pattern, in which the morning and afternoon peaks are quite clearly visible; *(b)* partly commuter pattern, in which only moderate increase in traffic is experienced during the peaks; and *(c)* noncommuter pattern, in which the morning and afternoon peaks are not visible.

Considerations of Trip Characteristics and Classification of Roads

The basic assumption made in the analysis for the proposed DRIPOP model is that the difference in overall flow patterns

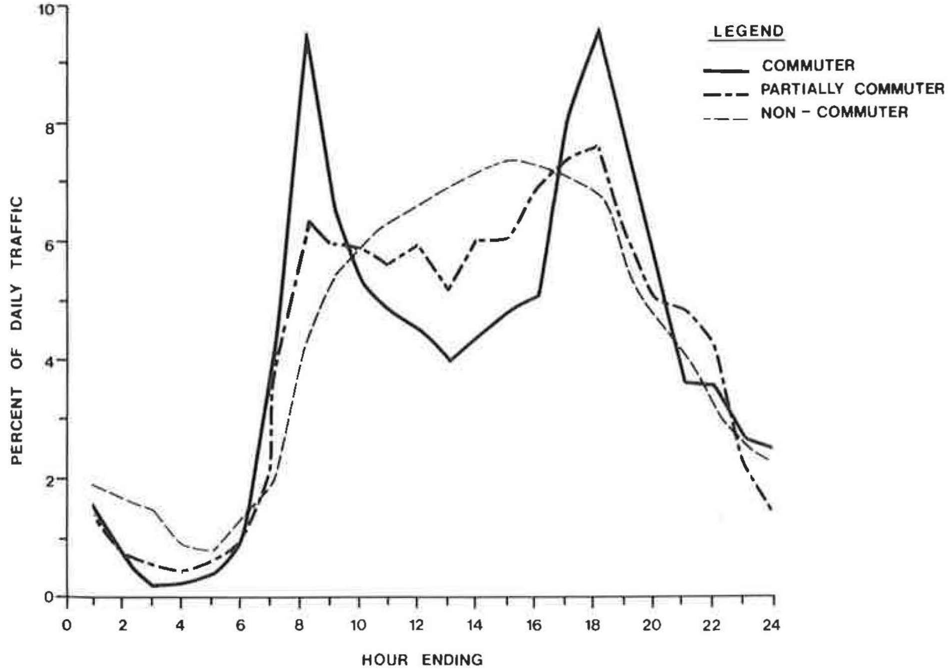

FIGURE 3 Typical patterns of hourly traffic volume during summer weekdays.

observed at road sites results from different mixes of trip characteristics. As mentioned earlier, trip purpose and trip length information was available from past origin-destination surveys by Alberta Transportation for a limited number of study sites. Trip purpose data were used to verify the temporal volume variations that provide the basis of the classification of roads, and trip length distribution information was used to determine whether the road uses were mainly local, regional, or interregional and long distance in nature.

The various trip purposes were grouped in two broad categories: work-business purposes, the number of trips for which is not considered to vary much throughout the year, and social-recreational trips, for which the amount of travel obviously increases during certain seasons of the year, such as the summer months. Table 1 gives the available data in percentages of work-business and social-recreational trips for a limited number of study sites of different seasonal groups.

The seasonal variation in traffic volumes, as shown in Figure 2, can be easily explained by the corresponding variation of trip purposes given in Table 1. The lowest seasonal variation in the case of the low group is due to a high proportion of weekday work-business trips and the associated low or medium Sunday factor. The progressively high seasonal variation for the other sites is due to the higher proportion of social-recreational trips and the associated weekend (Sunday) traffic volumes. The very high seasonal variation in the case of Site C 114 can be attributed to the high number of both weekend and holiday recreational trips during the summer months. Note that the presence of holiday or tourist recreational trips that continue during the weekdays will tend to decrease the relative magnitude of weekend traffic that is represented by the Sunday factor in this study.

The cumulative trip length distribution provided further insight into the classification of roads. Figure 4 shows typical patterns that may be used to describe the trip length characteristics of road sites. These patterns can be grouped into three broad types: *(a)* regional road sites, *(b)* interregional road sites, and *(c)* long-distance road sites. A majority of regional trips would take less than 60 min travel time. The interregional and long-distance patterns would exhibit longer trip length distributions.

TABLE 1 TRIP PURPOSE AT SOME STUDY SITES DURING SUMMER WEEKDAYS

Road Site	Seasonal Variation Group[a]	Daily Variation (July Sunday) Pattern[b]	Trip Purpose (%) Work-Business	Social-Recreational
C 9	Low	Low	83	17
C 66	Low	Low	74	26
C 72	Low	Low	81	19
C 75	Low	Low	82	18
C 138	Low	Low	77	23
C 144	Low	Low	81	19
C 42	Low	Medium	62	38
C 93	Low	Medium	68	32
C 15	Medium	Low	62	38
C 18	Medium	Low	37	63
C 39	Medium	Medium	64	36
C 57	Medium	High	56	44
C 63	Medium	Medium	60	40
C 36	High	High	39	61
C 114	Very high	Medium	28	72
C 165	Very high	High	27	73

[a]Based on master patterns as shown in Figure 2.
[b]Based on the July Sunday factor.

The data in Table 2 put in perspective the resulting classification of the Alberta road sites based on the temporal volume patterns that represent the trip purpose variable and the trip length distribution. This classification is mainly a function of traffic stream characteristics during the summer months when most of the predominant road uses, such as work-business trips, social-recreational trips, and tourist trips, are present in the traffic stream. It may be noted that the eight road classes listed in Table 2 are significantly different from each other in at least one consideration.

Regional commuter routes are located in the commutershed areas of major urban centers and serve predominantly work-busi-

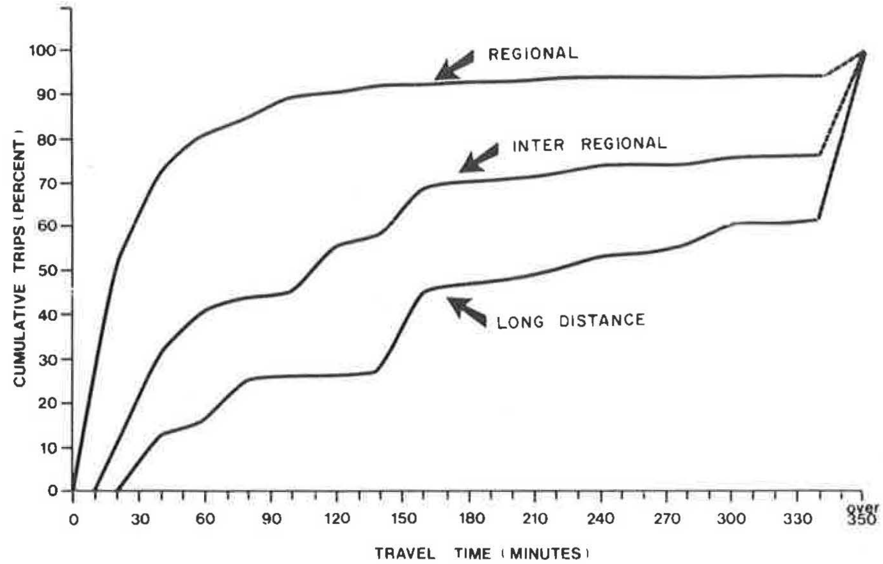

FIGURE 4 Typical trip length distributions for the different types of road sites.

ness trips. This group also serves medical, shopping, and social-recreational trips. The distinguishing road uses for the regional recreational and commuter routes are social-recreational trips on weekends and commuter and other types of regional trips on weekdays. These roads are also found in the commutershed areas.

Interregional and long-distance roads are located outside the major commutershed areas and carry a large proportion of tourist or holiday recreational trips during the summer months. A large amount of weekend social-recreational traffic is carried by long-distance and recreational routes in addition to the usual long-distance trips. Those major highways are included in the highly recreational group, which carries large numbers of both weekend and tourist recreational trips during summer months.

The rural commuter and business group includes low-volume (AADT in the range of from 1,000 to 1,500) rural roads that do not carry many social-recreational trips. Farm-to-market roads are included in this group.

These patterns of roads would be expected to result from the application of the DRIPOP model to any provincial highway system. But there will be some special routes that serve the needs of a specific community or region. Some examples of Alberta's special routes identified in this study are *(a)* winter resource supply route (e.g., site C 162); *(b)* regional resource development commuter route (e.g., Site C 153); and *(c)* summer-winter recreational route (e.g., Site C 162). The temporal volume patterns of this group are expected to be variable.

The urban commuter group, patterns of which are well known to traffic analysts, is not included in the description because the study data obtained from Alberta Transportation did not contain any sites in urban centers. However, urban commuter routes can be easily recognized by low seasonal variation (lower than regional commuter), low Sunday, and very prominent morning and afternoon peak periods.

Another point that can be made here is that the roads identified in this classification are major facilities that carry traffic volume in an AADT range of 1,000 or higher. Roads with lower traffic volumes tend to show generally unstable flow patterns and therefore are not recommended for classification by this method.

TABLE 2 ROAD CLASS DEFINITIONS BY TRAFFIC STREAM CHARACTERISTICS

	Temporal Volume Characteristics			
Road Class	Seasonal Variation Group[a]	Daily Variation (July Sunday) Pattern[b]	Hourly Variation Pattern[c]	Trip Length Distribution[d]
Regional commuter	Low	Low	Commuter	Regional
Regional recreational and commuter	Low, medium	Medium	Partly commuter	Regional and interregional
Interregional	Medium	Low, medium	Noncommuter	Interregional
Long distance	Medium	Low	Noncommuter	Long distance
Long distance and recreational	High	High	Noncommuter	Long distance
Highly recreational	Very high	Low, medium	Noncommuter	Long distance
Rural commuter and business	Low	Low	Partly to noncommuter	Variable
Special	Variable	Variable	Variable	Variable

[a]As shown in Figure 2.
[b]The Sunday factor as defined previously.
[c]As shown in Figure 3.
[d]As shown in Figure 4.

Classification of Roads Using Seasonal Traffic Counts

The basic requirements of the DRIPOP model are the master patterns of temporal variations in traffic volume. The trip purpose information in the preceding development of the Alberta road classes was used only to rationalize some of the volume patterns. It is not necessarily a required type of data input. Similarly, the actual data on trip length distribution are also not essential because highway authorities generally know whether road uses of their systems are local, regional, or provincial and interprovincial in nature.

The PTCs that are employed by nearly all highway agencies are the sources of the information needed to develop the master patterns of volume variations. A highway agency can also classify its roads by taking seasonal traffic counts because, when carefully programmed, such sample counts can provide a reasonably good estimate of monthly, daily, and hourly patterns. The variation patterns that result from the sample counts can be matched with the master patterns to classify the study sites into a road group.

TESTING AND APPLICATIONS OF THE DRIPOP MODEL

Application of the DRIPOP Model to Saskatchewan Highways

At present, the Traffic Analysis Section of Saskatchewan Highways and Transportation classifies the provincial roads into *(a)* Trans-Canada Highway, *(b)* rural highways, *(c)* resort highways, *(d)* urban streets, and *(e)* municipal roads. The rural highways class is further divided into two groups according to the volume of traffic: greater than 600 AADT and less than 600 AADT. The resort roads are separated into two AADT ranges: more than 2,000 AADT and under 2,000 AADT. The context and objectives of such classification are the same as those of the DRIPOP model.

The master patterns of seasonal, daily, and hourly volume patterns were developed for the 24 PTC sites in Saskatchewan, and the road sites were reclassified using the DRIPOP model. The resulting classes were found to be quite similar to the classes for Alberta highways. From the reclassification of roads it became evident that the existing method of classifying count sites on Saskatchewan highways is arbitrary and subjective in nature. The DRIPOP model showed one major discrepancy in the grouping of count sites in Saskatchewan. The four PTC sites on the Trans-Canada Highway should be in two groups instead of one. Two of the sites exhibit traffic patterns that are related to the regional commuter group, and the other two sites fall into the long-distance group. The highway agency has already rectified this discrepancy by regrouping the road sites.

Examples of Some Recent Applications of the DRIPOP Model

The experience gained from the development of the DRIPOP model and the increased understanding of various road classes according to driver population have provided a better comprehension of several aspects of highway planning and design functions. Sharma *(24)* showed that the traffic stream characteristics of the road site being surveyed are among the most important considerations for rationalization of short-period manual counts on rural highways. He concluded that the duration and schedule of counting could vary significantly from one type of road to another and still achieve the same accuracy of counts. For example, a 4-hour afternoon (2:00 p.m. to 6:00 p.m.) count at a regional commuter site would yield approximately the same accuracy of counts as a 12-hr (7:00 a.m. to 7:00 p.m.) count at a long-distance and recreational site.

Sharma et al. *(7)* studied the design hourly volume concept and upgrading of two-lane rural highways from the perspective of driver population. It was concluded in the study that *(a)* the driver population is a significant variable that must be considered for appropriate sizing of roads from both economic and users' perspectives; *(b)* to provide a more uniform service to the users of various road facilities it would be more appropriate to use different highest volume hours for designing different types of roads (e.g., 15th to 20th highest hour for a recreational site to 50th highest hour for a regional commuter site); and *(c)* the AADT values at which typical two-lane rural roads would need upgrading can vary from 1,750 to 2,500 for highly recreational routes and from 6,500 to 8,500 for commuter routes.

Yet another example in which the understanding of roads according to driver population proved beneficial was the prediction of design hourly volume as specified by the 30th highest hourly volume. One commonly used model *(6)* in which the 30th hour volume *(Y)* is estimated as a function of AADT (e.g., $Y = 41.0 + 0.12$ AADT for Alberta highways) produces systematic errors of prediction *(25)*. It grossly underestimates the dependent variable for recreational and highly recreational routes and overestimates it for regional commuter and rural business and commuter facilities. As an alternative, Westermann *(25)* suggests a significantly improved method of prediction that is derived from a clear understanding of the road classes proposed in this paper. This model for Alberta highways is $Y = 45 + 0.087X$, where X is the average Sunday volume of traffic in July.

Driver Population Factor in the New HCM

The most interesting application of road classification according to traffic stream characteristics is its potential use in highway capacity analysis. The driver population factor (f_p) is an important adjustment factor that should be applied in capacity calculations. The new HCM *(4)* recommends a value of f_p equal to 1.0 for commuter sites and a range of f_p of between 0.75 and 0.90 for other types of traffic streams.

It is believed that the proposed classification of road sites can provide an excellent basis for making engineering judgments about the selection of a particular f_p-value from the range suggested by the new HCM. The drivers who commute every weekday for regular work-business trips can be assumed to be familiar with the subject facility and its environs. Weekend or tourist recreational trip makers are expected to be much less familiar with the regional or long-distance routes on which such trips are made. Thus, both the trip purpose and the trip length distribution would be expected to influence the selection of an appropriate f_p-value. The value of f_p to be selected can be assumed to decrease when trip purpose changes from commuter to recreational. It can also be assumed to decrease when the trip length distribution changes from urban to regional and long distance. Table 3 gives the suggested values of f_p, which it is hoped can be used as a guide in exercising engineering judgments in selecting a specific f_p-value. It may also be added

TABLE 3 RECOMMENDED CAPACITY ADJUSTMENT FACTOR FOR THE CHARACTER OF THE TRAFFIC STREAM

Traffic Stream Type	Factor (f_p)
Urban commuter	1.0[a]
Regional commuter	0.95
Regional recreational and commuter	0.90
Interregional	0.85
Long distance	0.85
Long distance and recreational	0.80
Highly recreational	0.75

[a]Value recommended by the new HCM.

here that the proposed classification can help in selecting sample highway segments to further study the effect of the driver population on highway capacity analysis.

SUMMARY AND CONCLUSIONS

In this paper a model, DRIPOP, for classification of roads according to traffic stream characteristics is proposed. The basic assumption made in the analysis for the DRIPOP model is that the differences in overall flow patterns observed at road sites result from different mixes of trip purpose and trip length characteristics.

The DRIPOP model includes the application of the standard computational technique of hierarchical grouping, and it also suggests the use of standard statistical methods of group comparisons. The use of such computational and statistical techniques helps to develop the master patterns of temporal volume variation, which are the main criteria of road classification according to driver population. Note that the model is intended to be used for classifying major highways that carry traffic volumes in excess of 1,000 AADT.

The proposed method of grouping road sites on the basis of temporal variations and road use characteristics is more objective and comprehensive than the conventional methods. It can enable highway agencies to group roads into distinct classes that are significantly different from each other. Also, the model is simple to apply and its data requirements can easily be satisfied by the regular types of traffic data collection programs undertaken by highway agencies. Road sites can be classified by seasonal traffic counts where traffic is counted a few times a year for periods of from 48 hr to several weeks in length.

The analysis and classification of count sites using the DRIPOP model can help to rationalize and economize the permanent traffic counting program. The DRIPOP model can be used for monitoring and reviewing count site classifications with respect to time. If, over a period of time, a particular road is suspected to have undergone a significant change in traffic flow characteristics, the DRIPOP model can help to reassign the count site to a proper class. Also the DRIPOP model can help to identify count sites that are not required or to identify areas where additional count sites are required. Seasonal and short-period traffic counts can also be rationalized with the understanding and application of this model.

In addition to its application for rationalizing the various traffic-counting programs, the road classification that results from the DRIPOP model could be an important criterion in many other highway planning and design functions. Some examples of such functions are *(a)* design hourly volume considerations, *(b)* highway capacity analysis, and *(c)* highway improvement programming.

Another important finding is that the DRIPOP model produces similar road classes for Alberta and Saskatchewan highways on the basis of temporal volume fluctuations and trip characteristics. The similarity of road classes for the two provinces has implications for a standard classification of provincial highways according to traffic stream characteristics.

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Developing Link Performance Functions Using Highway Performance Monitoring System Data Files

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The principal objective of this paper is to propose a practical approach to developing highway performance functions and estimating annual truck activities using Highway Performance Monitoring System (HPMS) data files. This approach was applied to the Interstate highways. A highway performance function was defined as the relationship of average travel speed (or average travel time, operating speed) versus volume-to-capacity (V/C) ratio. A preliminary analysis was initially performed to summarize collected HPMS data and to revise data inconsistencies in HPMS data records. The revised HPMS data records were further analyzed and used to test underlying assumptions of the proposed approach. Because of substantial variation of traffic flow patterns in different time periods, especially the difference between the nighttime period and peak-hour and off-peak-hour periods, it was proposed to average traffic conditions for developing link performance functions in a 16-hr period, including both peak-hour and off-peak-hour periods. An expansion factor was then used to provide an estimate of average daily traffic volume by vehicle type. The relationship of average travel speed versus V/C ratio by average highway speed and total number of through lanes, as reported in the 1985 Highway Capacity Manual, was used as a basis for developing specific highway performance functions. It was found that in the year 2000 Texas would have 10 billion vehicle miles traveled (VMT) by local and intercity truck traffic on the existing Interstate highways. It was also predicted that there would be 89 billion VMT of truck traffic on the Interstate highways in the United States in the year 2000.

The impetus for this research was the need to develop highway performance functions for the highway segments (links) on a national designated highway network to facilitate the operations of large combination vehicles. This research stems from a research project at the Center for Transportation Research, the University of Texas at Austin *(1)*. Hence, the principal objective of this paper is to propose a practical approach to developing highway performance functions and, for the purpose of providing a preliminary analysis of national truck activities on the designated network, estimating annual truck activities by using, in part, the Highway Performance Monitoring System (HPMS) data files *(2)*.

The format of an HPMS data record includes variables needed to characterize the roadway segment: identification, operation, travel, geometry and configuration, traffic/capacity, environmental, and so forth. As indicated, each record characterizes one highway segment. Some variables, such as traffic and operations, may vary over time and some may not be uniform within an HPMS highway section. For instance, the geometric design of a highway section may be made up of several different highway grades and curvatures in the HPMS record. In this research the variables for highway infrastructure are assumed consistent over time; however, annual average daily traffic (AADT), operating speed, and volume-to-capacity (V/C) ratio vary over time.

In general, the average time taken for a driver to traverse a highway section depends on several factors. These factors may include, for example, section length, access control, longitudinal and vertical alignment, speed limits, traffic volume, traffic components, highway capacity, driver's behavior, vehicle characteristics, weather conditions, and traffic control devices. Most, if not all, of these factors may vary over time. In this research, the following factors were considered: traffic volume, traffic components, highway capacity, number of through lanes, topology, average highway speed, speed limit control, and time. These factors were considered important in deriving highway performance functions (i.e., the relationship of operating speed versus V/C ratio) using collected HPMS data. The basis for this derivation is the 1965 and the 1985 Highway Capacity Manuals (HCMs) *(3,4)*. The newly published 1985 Highway Capacity Manual updates speed-flow relationship

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