CLASSIFICATION OF PROVINCIAL HIGHWAYS IN CANADA ACCORDING TO ROAD USE CHARACTERISTICS

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A Thesis in the Faculty
of Engineering

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering
CONCORDIA UNIVERSITY
Montreal, Quebec.

August 1982

ABSTRACT

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An improved method of road classification is suggested for use by provincial or state highway agencies. The proposed classification is based on temporal volume variations, and road use characteristics, such as trip purpose, and trip length distribution. The primary highway system of the province of Alberta, Canada, is investigated for the purpose of this study.

The proposed method is more objective, comprehensive, and statistically credible than the existing methods. It involves the application of such standard computational and statistical techniques as (i) Hierarchial Grouping, and (ii) Scheffe's S-Method of multiple group comparisions. The analysis presented in this study is expected to provide highway agencies a better understanding of individual routes in their road network systems. The proposed method has implications for a standard classification of roads on a provincial and national basis. Such a classification can lead to an overall consistency in planning and design of roads for both economy and safety purposes.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

The author wishes to express his gratitude and deep appreciation to Dr.S.C.Sharma for his valuable counsel, comments. criticism, and especially for his constant encouragement during the course of this study.

I am also thankful to the former Chairman and Professor Dr. M.S.Troitsky and Dr. G.A.Jacobson for their valuable time in reviewing the thesis.

I am highly greatful to Alberta Transportation for providing the necessary data for this study.

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NOMENCLATURE

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$E(i,i')$ = Potential error associated with the grouping of objects i and i'

N = Number of set of objects

K = Number of different variables

$(V_j)_i$ = Value of variables j for object i, and

$(V_j)_{i'}$ = Value of variables j for object i'.

ABBREVIATIONS

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AADT = Annual Average Daily Traffic

ASDT = Annual Summer Daily Traffic

BPR = U.S.Bureau of Public Roads

C = Counter

COM = Commuter Type

CR = Commuter-Recreational

CRT = Commuter-Recreational-Tourist

DHV = Design Hour Volume

G = Group

HREC = Highly Recreational

ITE = Institute of Transportation Engineers

MCC = Mannual Classified Counts

MTC = Ministry of Transportation & Communications

PTC = Permanent Traffic Counter

RTAC = Roads and Transportation Association of Canada

WACHO = Western Association of Canadaian Highway Officials

STC = Seasonal Counting (portable counters)

TOUR = Tourist.

CHAPTER I

INTRODUCTION

CHAPTER 1

INTRODUCTION

From past traffic counting experience it is known that volume at a given roadway location varies from hour to hour, day to day, and month to month throughout the year. These variations of traffic volume are cyclical in nature and reflect the hourly, daily, and seasonal trip-making patterns of road users. The basic presumption made in this analysis to classify roads is that the differences in temporal flow patterns observed at road sites result from different mixes of trip characteristics, such as trip purpose, and trip length distribution.

Road classification is important for administration , planning, design, and operation of the facilities. Systems for classifying roads are numerous, and the class definitions vary depending on the purpose of classification. Examples of various classification systems used in Canada are: (i) according to jurisdiction and funding - federal, provincial, and municipal roads; and (ii) 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 (ITE, 1976) and Roads and Transportation Association of Canada publications (RTAC, 1965, 1982).

The provincial or state highway agencies also classify roads according to the type of road uses. Under this system, the most distinctive criteria of classification are: (i) temporal variations in traffic volumes; (ii) average annual daily traffic (AADT); and (iii) trip purpose and trip length characteristics of road users. Some examples of different road uses are - "urban and/or commuter", "rural long distance", "non-recreational low flow", "partially recreational", and "highly recreational" (Bellamy,1978; ITE, 1976). Conventionally, such type of classification is frequently used for the purposes of (i) traffic volume surveys, e.g., for estimating AADT from sample counts, and (ii) the design hourly volume (DHV) considerations for a new road facility.

It is recognized within the transportation community (RTAC, 1982; Western Association of Canadian Highway Officials (WACHO), 1980) that, in any of the above road classification contexts, there exists a diversity of definitions, systems and procedures which are in evidence across Canada. Consequently, a considerable input of subjective judgement is used in various planning and design activities pertaining to different types of roads.

Although a single classification system satisfactory for all purposes would be advantageous but has not been found practical. The main objective of this study is to offer a improved method for classifying rural road sites according to type of uses. The proposed method utilizes some standard computational and statistical techniques, and therefore it is expected to yield a more objective and statistically credible groupings of road sites as compared to the existing methods.

This study first presents a brief review of classification of road sites as used by the provincial agencies in Canada. Then, study data and the proposed method including results of analysis are described. The thesis concludes with the presentation of conclusions and recommendations.

CHAPTER II

STATE OF THE ART

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Before presenting the new method of approach for road classification, it is necessary to review the various procedures which are currently used in Canada and abroad. The following briefly describes matters that are inter-related to classification of road sites.

2.1 Traffic Monitoring and Classification of Road Sites

The average annual daily traffic moving over a particular highway, commonly called the AADT, is a measure of service of that highway to its users. As mentioned earlier, the traffic volumes vary from hour to hour, day to day, and month to month, but it is primarily the AADT and certain other traffic peaking characteristics, such as peak-hour factor, that are used in planning and designing of roadway facilities.

Several traffic counting programs are undertaken by provincial and local agencies to obtain values of AADT on road sites. The most commonly used programs are (a) Continious counting by Permanent traffic counters (PTCs); (b) Seasonal counting by Portable counters (STCs), in which counts are taken few times a year for periods from 48 hours to 2 weeks in length; and (c) Manual classified counts (MCCs), in which manual counts of traffic are taken and classified by vehicle type, these are undertaken for less than a day.

Only PTCs provide the true values of AADT under perfect operating conditions. However, installing and maintaining PTCs on every section of roadway would be prohibitively expensive. For this reason, the idea of a sample traffic count into an estimate of AADT has been univerally accepted and used by the roadway authorities.

The usual method for estimating AADT from sample counts (e.g., STCs and MCCs) is that advocated by the U.S.Bureau of Public Roads (BPR, 1965). In general BPR method involves (a) grouping toghether the PTC sites into similar patterns of monthly traffic variations, (b) determining average expansion factors for each groups; (c) assigning road sections that do not have PTCs to one of these groups, and (d) applying the appropriate average expansion factor to sample count to produce an estimate of AADT.

The grouping of PTCs (or road sites where PTCs are located) constitutes a major step in the development of the proposed system of road classification.

The most commonly used method of grouping PTCs is that recommended by BPR (1965). In this method, the counters are grouped on the basis of monthly traffic factors, which are defined as the ratio of 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 the monthly factors. For each month, a group of counter is determined so that the difference between the smallest and the largest factor does not exceed the range of 0.20 in the values of factors. In otherwords, the criterion of grouping is a subjective and arbitrarily chosen value of plus or minus 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 would fall into the same group for each of the months.

The provincial highway agencies in Canada utilize a variety of methods for grouping their PTC sites. Following is a brief description of such methods based on the 1980 WACHO conference and personal communications with the province of Ontario and Quebec.

British Columbia - The province of British Columbia maintains approximately 35 PTCs, whose patterns are classified by using a factor: 30th highest hourly volume/AADT. The officials of this province identify the resulting groups as follows:

> "Urban" counters are reliably identified by factors of 0.1 or so, while "Rural" (highly recreational) sites may reach 0.3 or higher. "Mixed" locations exhibit a factor in the neighbourhood of 0.2. Classification is also done by seasonal variation using both the temporal location of the annual peak and its size relative to the "off-season" flows.

Alberta - Alberta Transportation has 73 PTCs in its annual program of traffic volume studies. There existed no specific classification of the PTCs sites prior to the initiation of the present study. The seasonal, daily, and hourly patterns were used to be visually inspected and recognized in a subjective manner with some consideration to the ASDT (annual summer daily traffic) factors.

Saskatchewan - Saskatchewan Highways and Transportation employs 31 PTCs which are conceptually grouped into following classes: (a) Trans-Canada Highway; (b) Resort Highways; (c) Urban Highways; (d) Sub-Urban Highways; and (e) Rural Highways. The counters are also grouped into four AADT ranges: (a) under 600; (b) 600 to 1500; (c) 1500 to 2000; and (d) over 2000.

Manitoba - The province of Manitoba carries out continious counting at 31 permanent stations. The grouping of these permanent counting stations is done on the basis of weekday average factors which are defined for every week from May to October as the ratio of AADT to the average Monday-Thursday traffic volume. The general criterion of grouping PTCs in Manitoba is that the week day average factor of any member of the group should be within ± 0.15 of the group average. In some cases, however, the procedure allows counter to be out of the ± o.15 criterion and still includes it in the group.

Ontario - Ministry of Transportation and Communications (MTC) studied the traffic patterns of its 21 PTC sites in 1975. An approach similar to that of the BPR method was used in the investigation (Miller, 1975). The criteria of such classification were 24 fortnighly traffic factors and the permissible grouping error in the range of ± 0.10 from the mean value. Based on that study following seasonal patterns are identified in Ontario (MTC, 1979):

(i) low variation, or commuter traffic;
(ii) intermediate variation, consisting of a blend of all types of traffic; and
(iii) high variation, including recreational and tourist traffic distinguished by weekend to weekday relationship.

These patterns are further subdivided into a total of 14 categories on the basis of DHV expressed as a percentage of AADT. Table 1 lists all such catagories.

Quebec - Ministere des Transports uses over 150 PTC locations for continous counting. No specific classification of these counter sites has been carried out by this province.

Table 1. Seasonal traffic patterns and classification of road sites in Ontario (MTC, 1979)

Seasonal Traffic Pattern	Specific Categories of Road Sites	
	Category	$\frac{DHV}{AADT} \times 100$
Low Variation of Commuter	Urban Commuter	10.1
	Suburban Commuter	12.8
	Commuter	11.1
Intermediate Variation	Intermediate Commuter	10.9
	Commuter Recreation	13.1
	Intermediate Recreation	14.9
	Commuter-Touritst-Recreation	11.3
	Intermediate Tourist	15.9
High Variation-Tourist	Low Tourist	14.1
	Tourist	17.4
	High Tourist	22.8
High Variation-Recreation	Low Recreation	24.7
	Recreation	25.1
	High Recreation	28.6

Other Canadian Provinces and Territories - It is believed that the other highway agencies utilize classification methods generally similar to one of the methods described before.

It is worthwhile to mention here a study by Transport and Road Research Laboratory, in which Bellamy (1978) 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 type of grouping of the sites was most appropriate. Because the cluster analysis grouping could not be regarded as conclusive, the study reconciled with a largely subjective method that was very similar to the BPR method. Four descriptive classes of the road sites, as suggested in that study were (1) Urban/commuter, (2) non-recreational low flow, (3) rural long distance, and (4) recreational.

2.2 DHV considerations and Classification of Road Sites

The DHV is the volume of traffic during one hour of the year that is used as an acceptable operating condition for design purposes. The basic premise is that facilities should be designed to provide a specified level of service during most of the hours it is being used. The 30th highest hourly volume is commonly used by a number of agencies as the DHV for rural roads. The basis for such practice is that when hourly volumes are ranked and plotted for a year, the volume changes rapidly for the highest 30 hours, but changes much more gradually after the highest 50 hours. This is referred to as "knee-of-curve" concept.

Highway authorities have recognized importance of road use in determining the DHV for a new facility or upgrading an existing facility. In this regard, ITE Handbook identifies different highway routes by such types as, "Urban through routes", "Partially recreational route", and "Highly recreational route". Figure 1, adopted from ITE Handbook shows convential presentation of highest hourly volumes for different types of highway routes. Highway planners and design engineers know that the distinction among route classes, such as in Figure 1, is arbitrary, and difference of opinion exists as to the precise signatures of "Highest hourly volumes" for various road uses (Whol and Martin, 1967).

2.3 Limitations of the Existing Methods of Classification

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

The foregoing suggests that more effort is needed to investigate the classification of road sites on a more objective basis. The central theme of this research is to develop a systematic and objective method of road

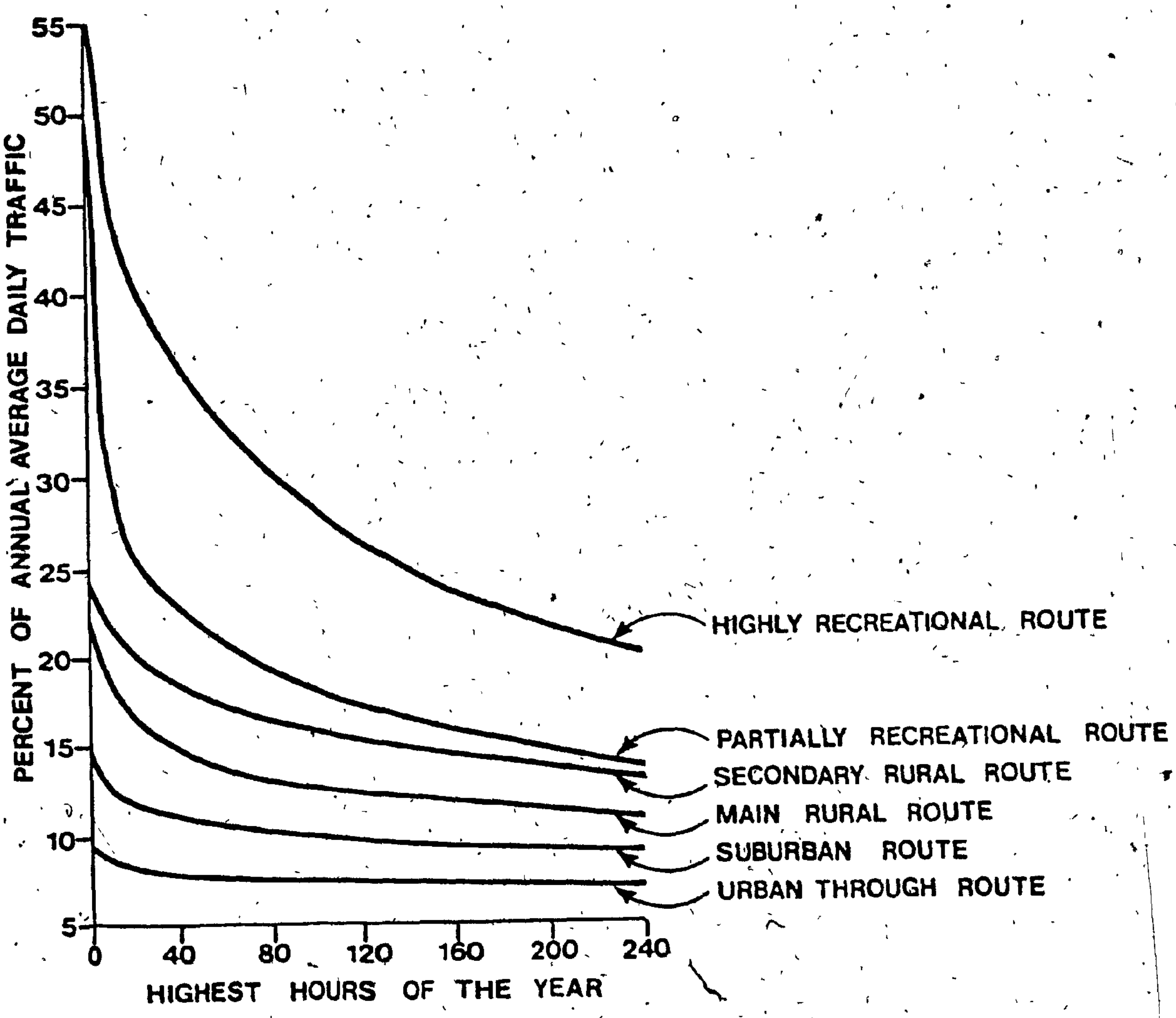

Figure 1. Hourly volumes on various types of routes as found during hours of highest volume on these routes.
[Source: ITE, 1976]

classification according to road use characteristics. The analysis carried out in this study includes considerations of temporal variations in flows at given roadway locations and such information to explain these variations as trip-purpose and trip-length distribution.

CHAPTER III

STUDY APPROACH AND ANALYSIS

CHAPTER III

STUDY APPROACH

The primary highway system of the province of Alberta is investigated for the purpose of this study. Alberta Transportation employs approximately 50 PTCs throughout its province. All PTCs , with the exception of one are located on the primary highways. The one exception is located on a secondary or regional road.

Considering the reliability of the avilable Alberta PTCs data, a total of 45 counter sites were selected for this analysis. The data for the analysis were taken from the years 1977 and 1978. All the necessary data for analysis were avilable for these two years.

From past origin-destination surveys conducted by Alberta Transportation, trip-purpose and journey-length information were avilable corresponding to some of the counters under investigation. This type of information is used to rationalize the proposed method for classification of the road sites.

3.1 Description of Proposed Method and Results

The description of the proposed method and its results have been divided into three steps: The first step deals with the Hierarchical Grouping of the study sites on the basis of their seasonal traffic patterns, the second step with the analysis of daily and hourly variations in traffic flows, and the final step deals with the consideration of trip characteristics and classification of road sites.

3.1.1 Step 1: Hierarchical Grouping of the Roads According to Seasonal Traffic Patterns

The basic objective of this step is to classify road sites into an optimum number of seasonal traffic patterns. The patterns resulting in this step are used as input ot the subsequent steps in the method.

The Hierarchical Grouping method is used in behavioral research. The purpose of this method is to compare a set of N objects (e.g., 45 road sites in this study) each of which 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. The seasonal traffic pattern in this analysis was defined by the 12 monthly factors which are the ratios of the average daily traffic in a month to the AADT for a given roadway location.

There are several sources of information avilable on hierarchical grouping procedure and particular references are made to Veldman (1967) and Ward(1963). Hence, it is not attempted in this thesis to explain in full detail the hierarchical grouping method. Instead, the basic premise and the main criteria for this method are described with reference to the classification of roads. The procedure carried out in this step for grouping of the sample road sites is adopted from " Improved Method of Grouping Province-Wide Permanent Traffic Counters" (Sharma and Werner, 1981). The following briefly describes the use of Sharma and Werner method in the context of the road classification.

The hierarchical grouping of the road sites is based on the premise that the maximum amount of information is avilable 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 which 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 basis of hierarchical grouping process is a matrix of potential error terms for each possible pair of road sites. This error term is defined as follows:

$$E(i,i') = \sum_{j=1}^{K} \{(V_j)_i - (V_j)_{i'}\}^2/2 \qquad \ldots\ldots \quad (1)$$

Where,

$E(i,i')$ = Potential error associated with the grouping of sites i and i'

$(V_j)_i$ = value of jth monthly traffic factor for site i

$(V_j)_{i'}$ = value of jth monthly traffic factor for site i'

K = number of monthly traffic factors included in the analysis.

The pair of sites with minimum $E(i,i')$ forms a single group reduceing the number of groups to N-1. The subsequent stages of the process use the error function (equation 1) and weighted mean average error of combining two individual groups in such a way (Veldman, 1967) that within-group errors are maintained and minimized in the process.

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(Appendix-I).

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 range of grouping stages that is especially worthy of study. By applying the above procedure and plotting the results, Figure 2, shows the errors associated with the groupings of the 45 road sites in the present case study. It appears from this figure that the optimum number of road groups lies somewhere between 10 and 6 because a substantially large increase in error is observed in this range and beyond.

3.1.2 Optimum Number of Road Groups According to Seasonal Traffic Variation

The optimum number of road groups could be determined by carrying out standard statistical tests for comparing the mean monthly factors of groups resulting from the hierarchical grouping. In this study, Scheffe's S-method of multiple comparisions of group means (Scheffe, 1964) was used for the number of groups ranging from 6 to 10.

The study sites were assumed to have been selected at random from the point of view of statistical theory. Such an assumption has been considered reasonable by other studies (Bellamy, 1978; Petroff, 1956) in analyzing traffic data.

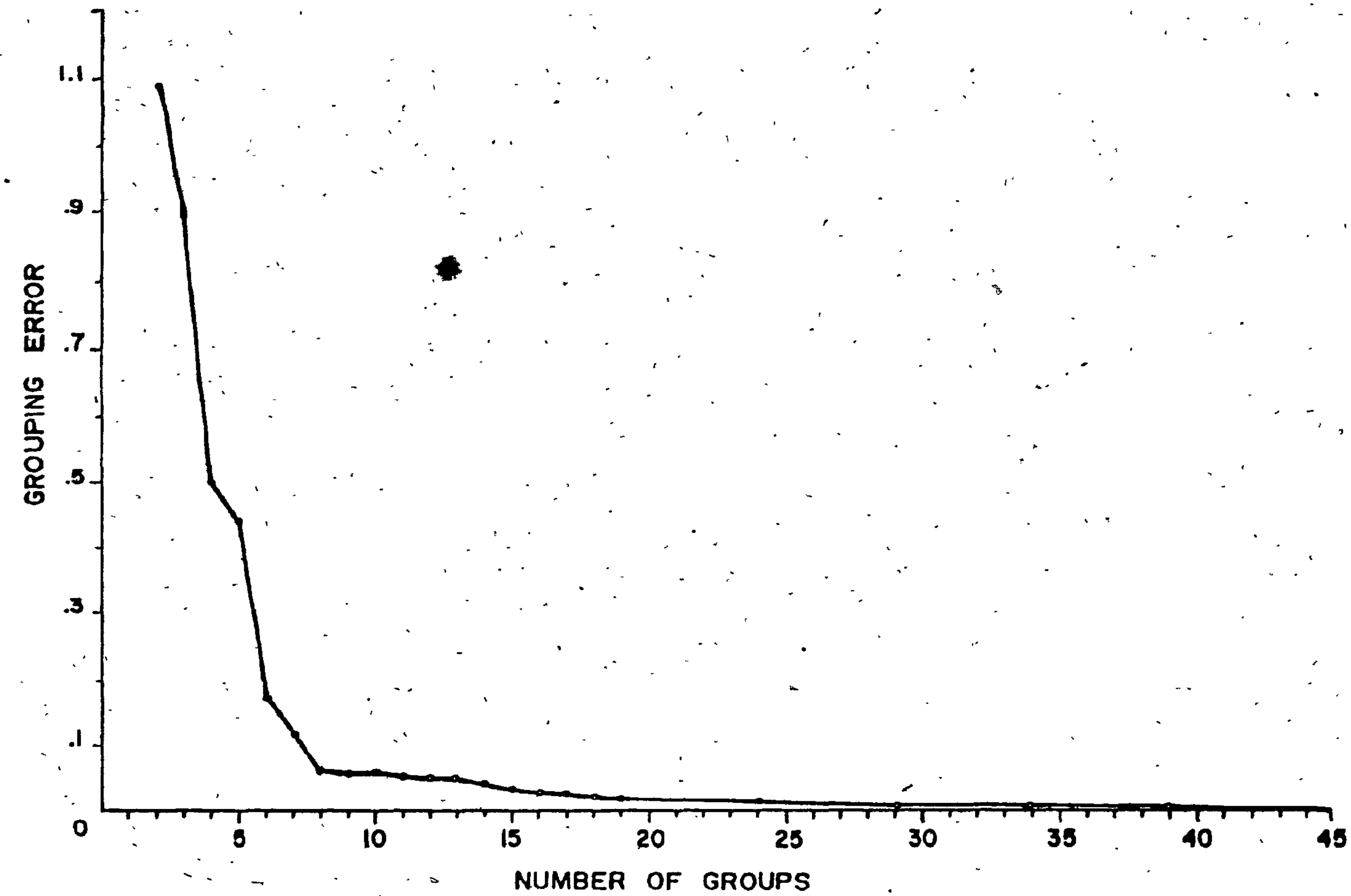

Figure 2. Incremental errors associated with the hierarchical grouping of study sites.

Figure 3 shows the hierarchical grouping at three stages of the process: at Ng = 9, at Ng = 8, and at Ng = 7, where Ng is the number of groups at any stage. Each road group in the figure is represented by a circle enclosing a certain number of dots, which are equal to the number of sites in that group; e.g., group 1 (G1) contains six sites. It can be seen that G3a and G3b are combined to form G3 when the grouping process reduces the number of groups from nine to eight and G4 and G5 are grouped to G4a in the next reduction stage of the hierarchical grouping.

The multiple group comparisons were performed only for those groups which contained more than two sample sites. Following is a summary of results obtained from the analysis:

1. At Ng = 9, G3a and G3b were not significantly different from one another at the 95% confidence level.

2. At Ng = 8, there were significant differences among all the major groups (G1, G2, G3, and G4) at a 95% confidence level.

3. At Ng = 7, the within-group error for G4a was significantly higher in comparision with G4. This resulted from the inclusion of G5 (site C36) with G4 sites.

4. At Ng = 6, the grouping process combined G1 and G2, which had already been found significantly different from one another.

The reduction in number of road groups from nine to eight in the hierarchichal process appears to be desirable , since G3a and G3b are not significantly different from each other. It is also apparent that the number

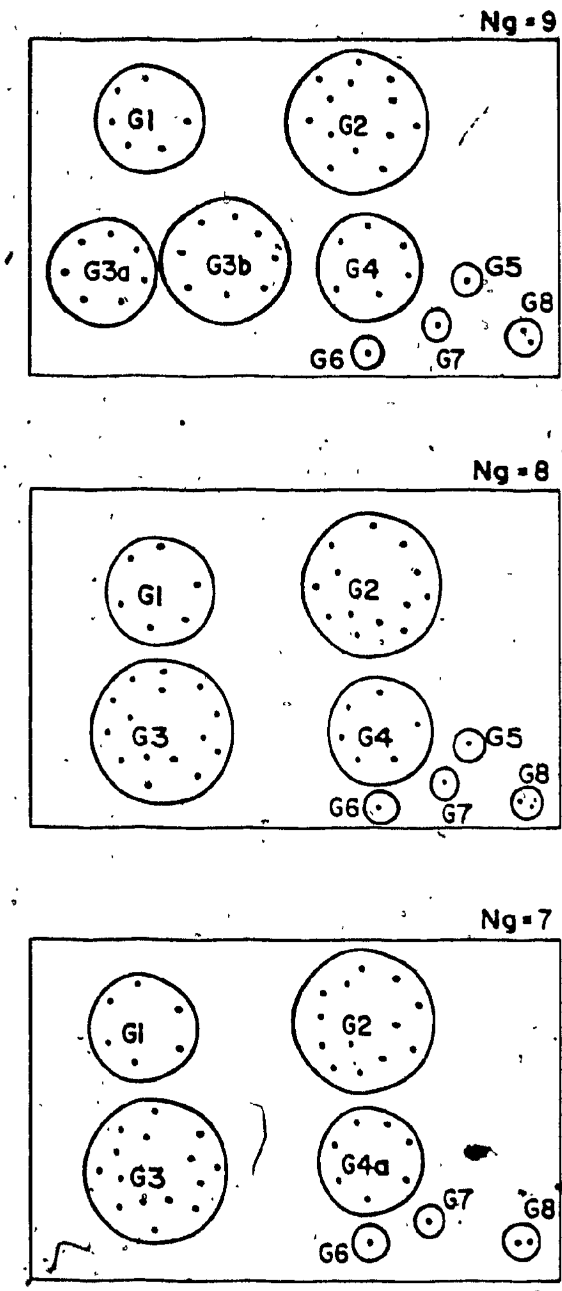

Figure 3. Pictorialization of the hierarchical grouping at a number of groups ranging from nine to seven.

of groups should not be smaller than eight because any reduction beyond this stage results in either an unacceptably high within-group error or a grouping of dissimilar sites. Thus, the most appropriate number of groups in the present case appears to be eight.

It should be added here that the significance of difference among the group means was established on the basis of group comparisons for each month of the year. The various group contrasts differed significantly from each other for a number of months at the 95% confidence level; for example, the group contrast G1-G2 differed for 4 out of 12 months.

The number of months that showed a significant difference for the other contrasts were 7 for G1-G3, 8 for G1-G4, 4 for G2-G3, 7 for G2-G4, and 4 for G3-G4. All the groups were found to have equal mean monthly factors for the month of May.

There is a need to exercise caution, that is the F-tests computed for the S-method in comparing the mean monthly factors can be artificially and unreliably significant. The experience gained in this study indicates that the road groups should be considered different if the F-tests are significant for three or more months at a 95% confidence level.

The average monthly factors of the eight hierarchical groups are depicted in Figure 4. The four major groups, i.e. groups G1, G2, G3, and G4, which account for nearly 90% of the study sites are included in Figure 4(a). For the sake of simplicity of presentation, the remaining groups, containing one or two sites, are shown seperately in the figure.

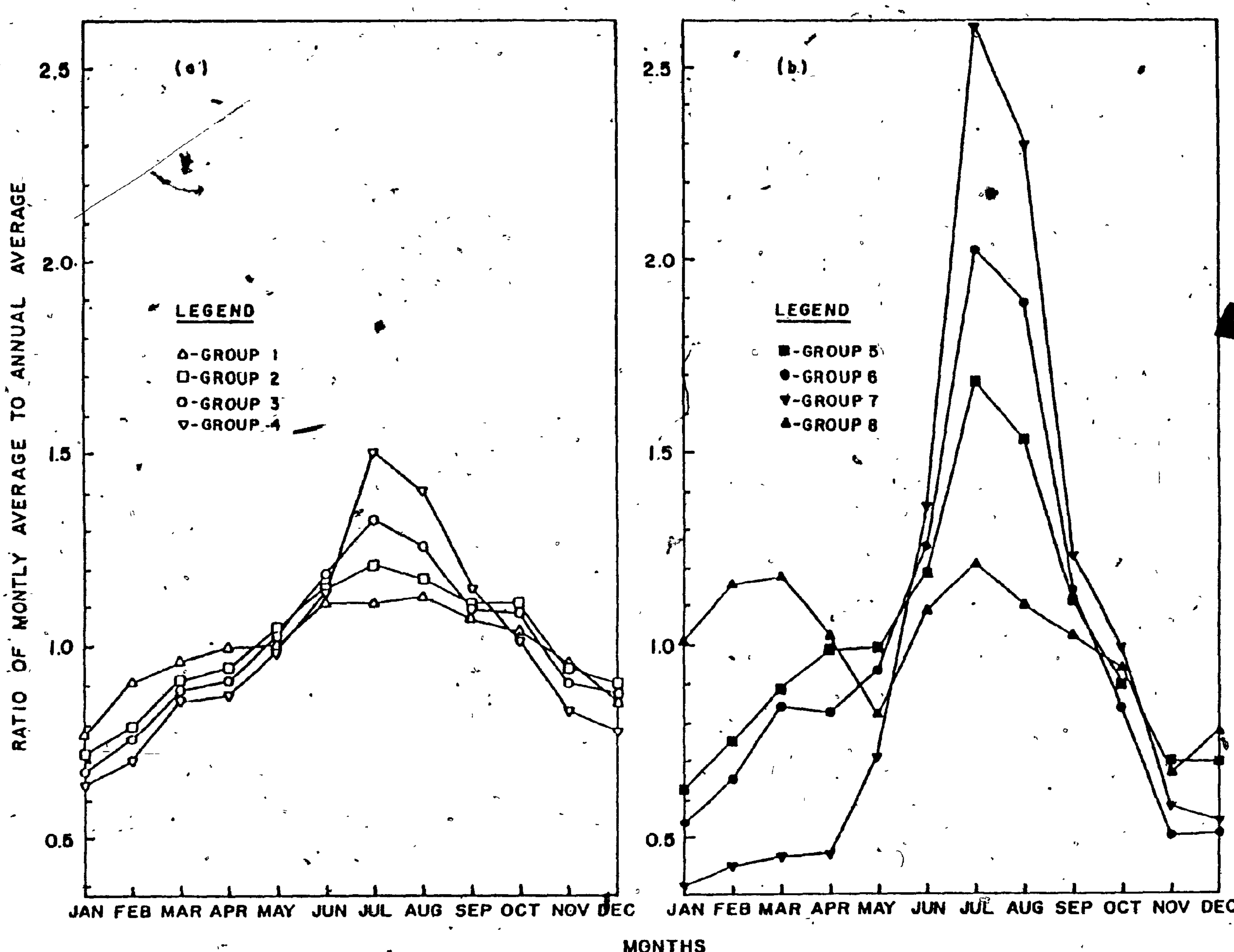

Figure 4. Average monthly factors for different groups of roads.

In the subsequent discussion, these groups resulting from the above hierarchical grouping and statistical analysis of seasonal traffic variation are simply refereed to as " group 1 ", " group 2 ", etc.,.

3.1.3 Analysis of Daily and Hourly Variations in Traffic Flows

The different road groups that resulted from the hierarchical grouping and statistical comparisons of mean monthly traffic factors were further analyzed systematically in terms of their ability to represent a more specific categorization of the provincial road system in Alberta. The study sites assigned to a particular group in Figure 4 exhibited discrenible and consistent patterns of daily and hourly variations in traffic flows. It became evident from this that the temporal variation patterns could be objectively and systematically related to different types of road uses.

The daily and hourly charcteristics were examined for the months of May to August, inclusive. There were mainly two reasons for this: (a) because most stable values of traffic volume are expected during this period (Morris, 1950; Phillips, 1980) and (b) because most of the data collection programs (e.g., Origin-Destination surveys, STCs and MCCs) that would be helpful in the present study are undertaken in Canada during these months.

The relative magnitudes of daily traffic volume, such as shown in Figure 5, can be used to distinguish various types of roads according to their predominant use. It should be noted that the plots in this figure include the daily traffic patterns of typical sites from each of the four major groups, i.e., G1, G2, G3,

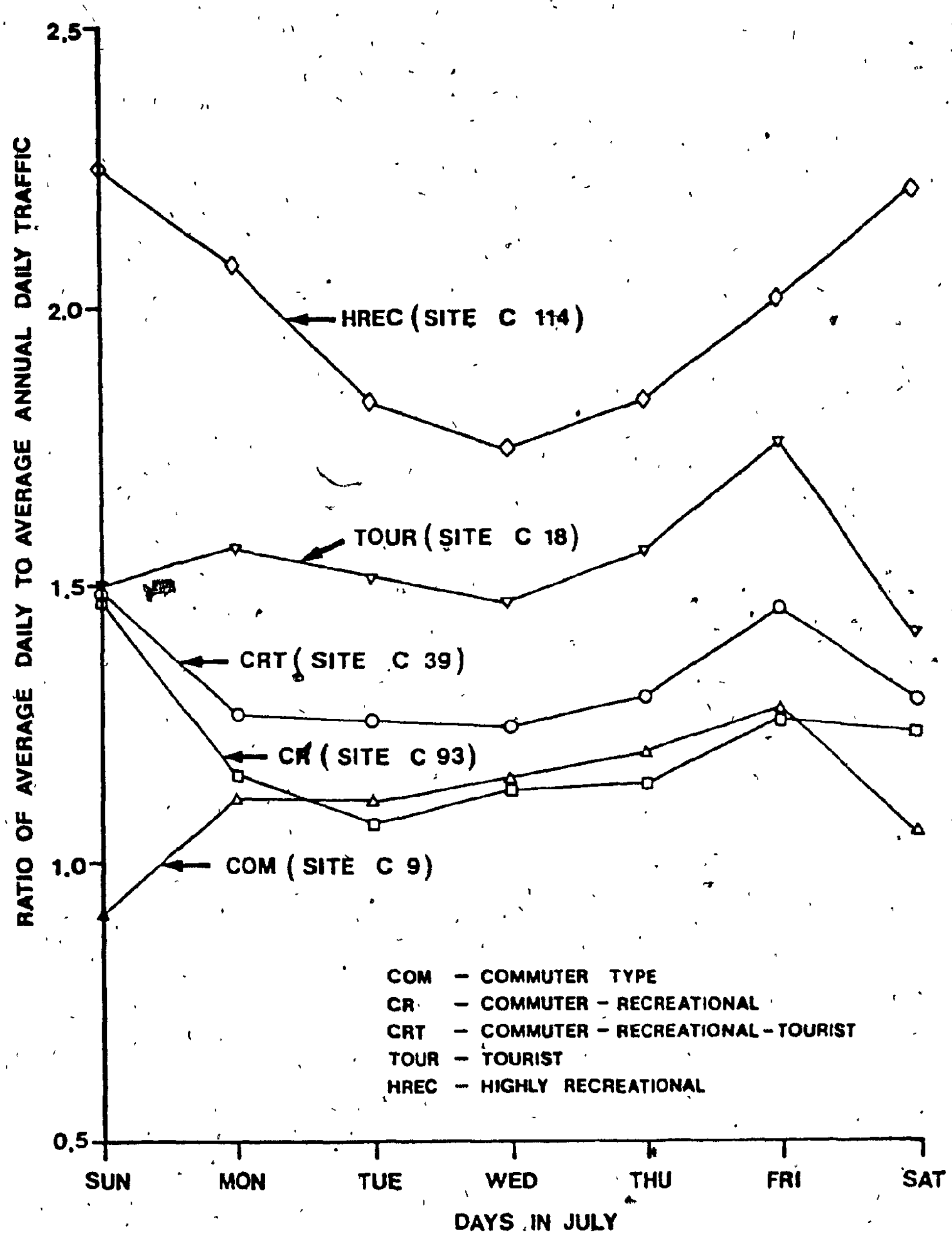

Figure 5. Average daily traffic patterns corresponding to various road uses.

and G4, and site 114 from group G6. For the sake of simplicity of presentation, the daily patterns of group G5, G7, and G8 are excluded from this figure since their similarity to the daily patterns of the groups already shown in figure. Also note that the month of July is considered here, because, it is July (or August) in Canada when most of the important road uses, such as work-business trips and social-recreational trips, are present in the traffic. Following daily traffic patterns, according to predominent road uses during the summer months, are evident from figure 5:

Commuter Type (COM) - Site C9 associated with the low seasonal variation of group G1 has lower weekend traffic, and therefore it represents a commuter type of daily pattern.

Commuter-Recreational (CR) - Site C93 belongs to group G2 and has high weekend volume. Its weekday patterns are similar to that of C9. Road sites such as C93 carry largely commuter traffic during the weekdays and they also serve as weekend-recreational routes.

Commuter-Recreational-Tourist (CRT) - Site C39 represents seasonal variation of group G3. This road site serves recreational trips at weekends and significant amount of tourist (or summer holiday) traffic throughout the week. Regional commuter is also a component of traffic at this site.

Tourist (TOUR) - In the case of site C18, the weekday volumes are generally equal to or even higher than the weekend volumes. Site C18 can be identified as tourist-recreational. This site is associated with the high seasonal variation of group G4.

Highly Recreational (HREC) - The pattern of site C114 represents highly recreational road use during the summer months. Such routes have very high magnitudes of both weekend-recreational and tourist-recreational activities. Site C114 is an example of group G6.

The groups G5 and G7 showed daily patterns similar to C114 and were identified as highly recreational sites.

The study sites contained in the group G8 are special cases whose characteristics are briefly mentioned later.

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

Figure 6 shows three typical patterns of hourly volumes as identified in this study for the summer weekdays. These patterns are: (a) commuter pattern, where the morning and afternoon peaks are very clearly visible; (b) partially commuter pattern, where only moderate increse in traffic is experienced during the peaks; and (c) non-commuter pattern, where the morning and afternoon peaks are not visible.

The analysis of hourly variations also revealed that G1 (having lowest seasonal variation) actually included two different types of routes: (1) suburban or local commuter routes (e.g., site C9) which were recognized by the morning and afternoon peaks; and (2) low volume (AADT less than 1500) rural

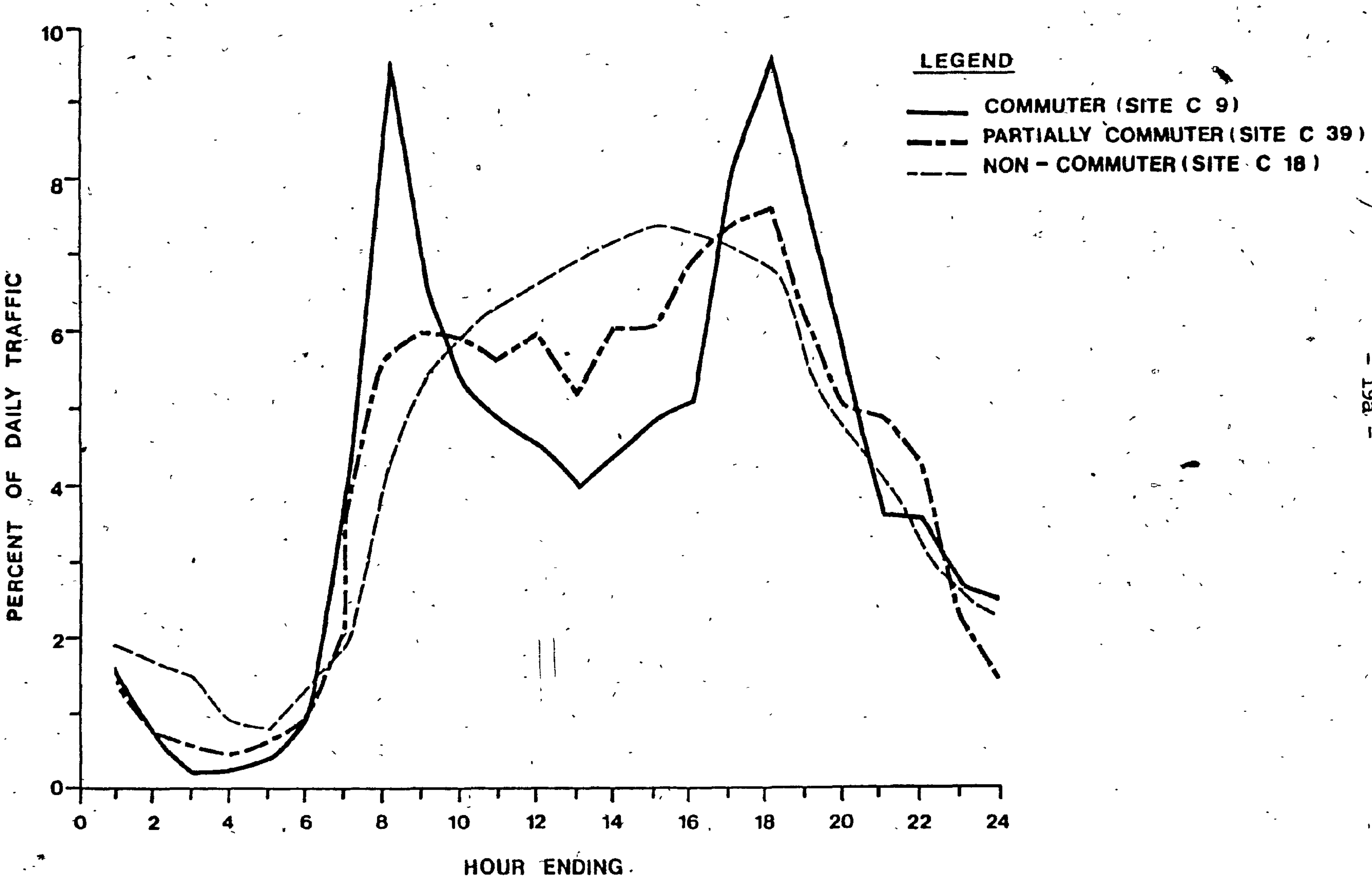

Figure 6. Typical patterns of hourly traffic volume during summer weekdays.

roads, e.g., site C144, which exhibited non-commuter hourly pattern as shown in Figure 6.

The study sites contained in group G2 also exhibited a commuter type of hourly pattern. Partially commuter patterns were noted for the sites of group G3. All the remaining road sites showed non-commuter hourly patterns.

It is also worthwhile to briefly consider the " Highest hourly volume" characteristics of different types of roads. The highest hourly volume curves are the percentages of AADT plotted in decreasing order of magnitude against hours of the year, as shown in Figure 7. Traditionally, design hourly volumes are often selected from a consideration of these highest hourly volume curves for the year. A brief examination of the highest hourly volumes of the different PTCs under consideration is carried out here in the context of the functional classification of roads.

From past experience, it is conceptually known that, in general, the road use charcteristics of a given route affect the size of the highest hourly volumes expressed in terms of the percentage of AADT. This generalization appeared to be supported by the highest hourly patterns for various types of roads observed in this study. For example, the high demands for travel on recreational sites (e.g., C36, C114) during only a few periods of the year accounted for a large proportion of the total annual traffic, but on predominately commuter sites (e.g., C9, C93) the total annual volumes were more evenly distributed throughout the hours of the year.

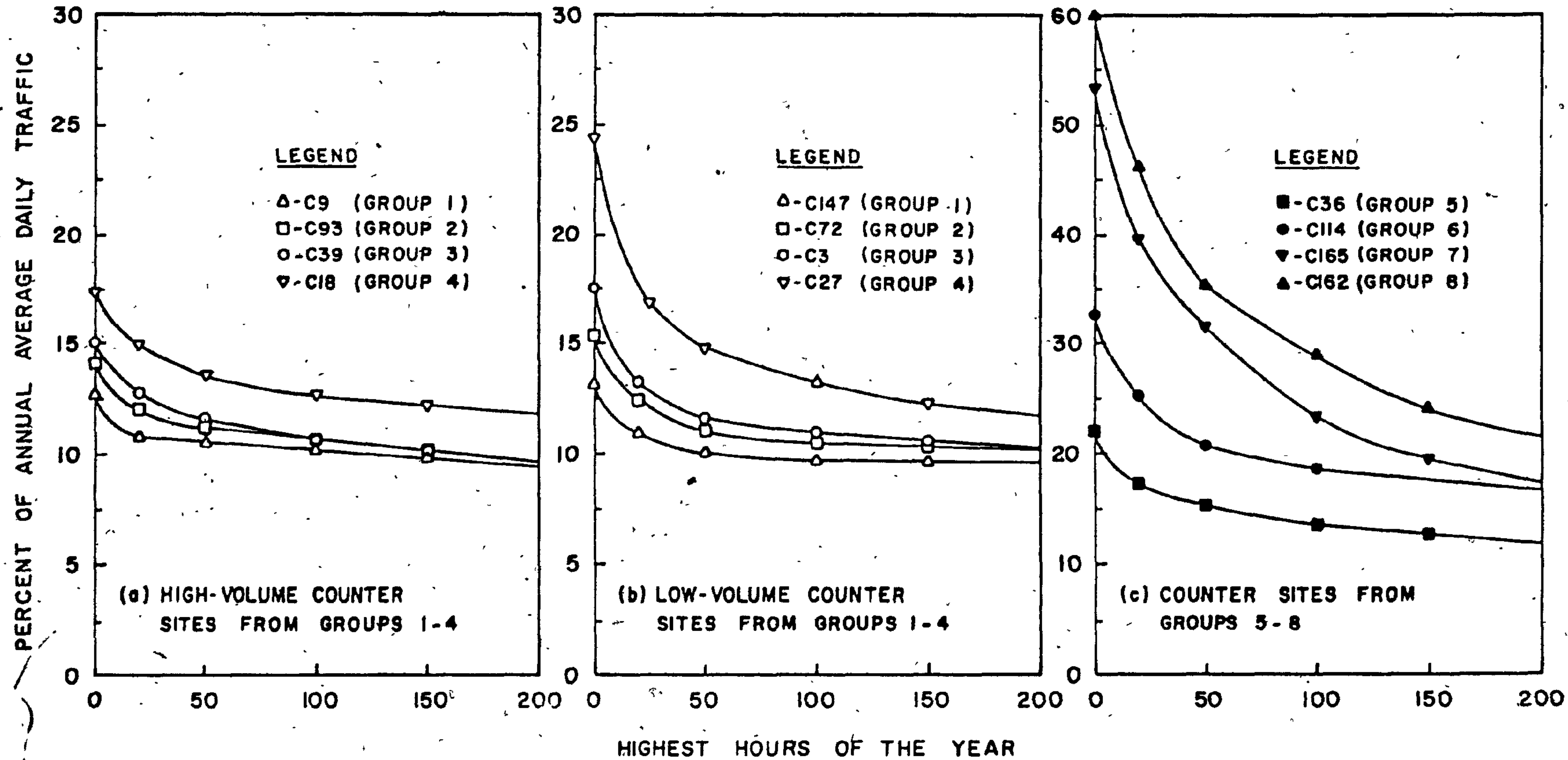

Figure 7. Graph of percent of AADT against hours of the year

The volume of traffic also affects the highest hourly characteristics (Whol and Martin, 1967). In fact, a comparison of highest hourly plots in this study indicated that, for a given class of road sites, the roads with higher volumes of traffic experience lower peaking than the roads with lesser volume. The experience gained from the present investigation suggests that, even though, the highest hourly patterns may be helpful in identifying various road uses, they cannot be used as a single criterion to objectively group the routes according to road uses.

3.1.4 Step 3: Consideration of Trip Characteristics and Classification of Roads

The basic presumption made in the preceeding analysis was that the diff-rence in overall flow observed at road sites resulted from different mixes of trip characteristics. As mentioned earlier, trip purpose and journey length information was available from the past Origin-Destination surveys by the Alberta Transportation for a limited number of study sites only. Trip purpose data was used to verify the classification of roads as suggested in steps 1 and 2, and trip-length distribution information was used to determine whether the road uses were mainly local, regional, or provincial/interprovincial in nature.

The various trip purposes were grouped into two broad categories: Work-Business trips, where the number of trips is not considered to vary much throughout the year; and Social-Recreational trips, where the amount of travel obviously increases during certain seasons of the year, such as the summer months. Table 2 includes the avilable data in percentages of work-business and social-recreational trips for a limited number of study sites of different seasonal groups and road uses during the summer weekdays.

The seasonal variation in traffic volumes, as shown in Figure 4, can easily be explained by the corresponding variation of the trip purposes in Table 2. The lowest seasonal variation in the case of group G1 is due to the very high proportion of work-business trips for this group. The progr-essively high seasonal variation for the road sites of other groups can be attributed to the increasingly high proportion of social-recreational trips for those groups.

The road uses, that were suggested in step 2 by considering the daily and hourly characteristics, can easily be related to the observed trip purposes in Table 2. While relating the road uses to trip purposes, one should, however, note that the trip-purpose distribution for G1 and G2 roads is generally similar because both groups serve mainly commuter traffic during weekdays.

The cummulative trip length distribution provided further insight into the classification of roads. Figure 8 illustrates some typical patterns which may be used to describe the trip length characteristics of road sites. These patterns can be grouped into three broad types: (a) local/regional road sites, (e.g., C9), (b) regional/provincial road sites, (e.g., C39), and (c) provincial/interprovincial road sites, (e.g., C18). A great majority of

Table 2. Trip purpose information at some study sites during summer weekdays

Road Site	Seasonal Variation Group[1]	Daily Variation Group[2]	Trip Purpose, %	
			Work-Business	Social-Recreational
C9	G1	COM	83	17
C66	G1	COM	80	20
C75	G1	COM	82	18
C144	G1	COM*	81	19
C147	G1	COM*	78	22
C12	G2	CR	75	25
C72	G2	CR	81	19
C93	G2	CR	72	28
C117	G2	CR	79	21
C120	G2	CR	78	22
C138	G2	CR	77	23
C15	G3	CRT	62	38
C60	G3	CRT	64	36
C132	G3	CRT	58	42
C18	G4	TOUR	37	63
C36	G5	HREC	39	61
C114	G6	HREC	36	64

[1]based on seasonal traffic variations as shown in Figure 4

[2]based on daily patterns as shown in Figure 5

*low volume rural roads which also exhibit commuter type of daily variation

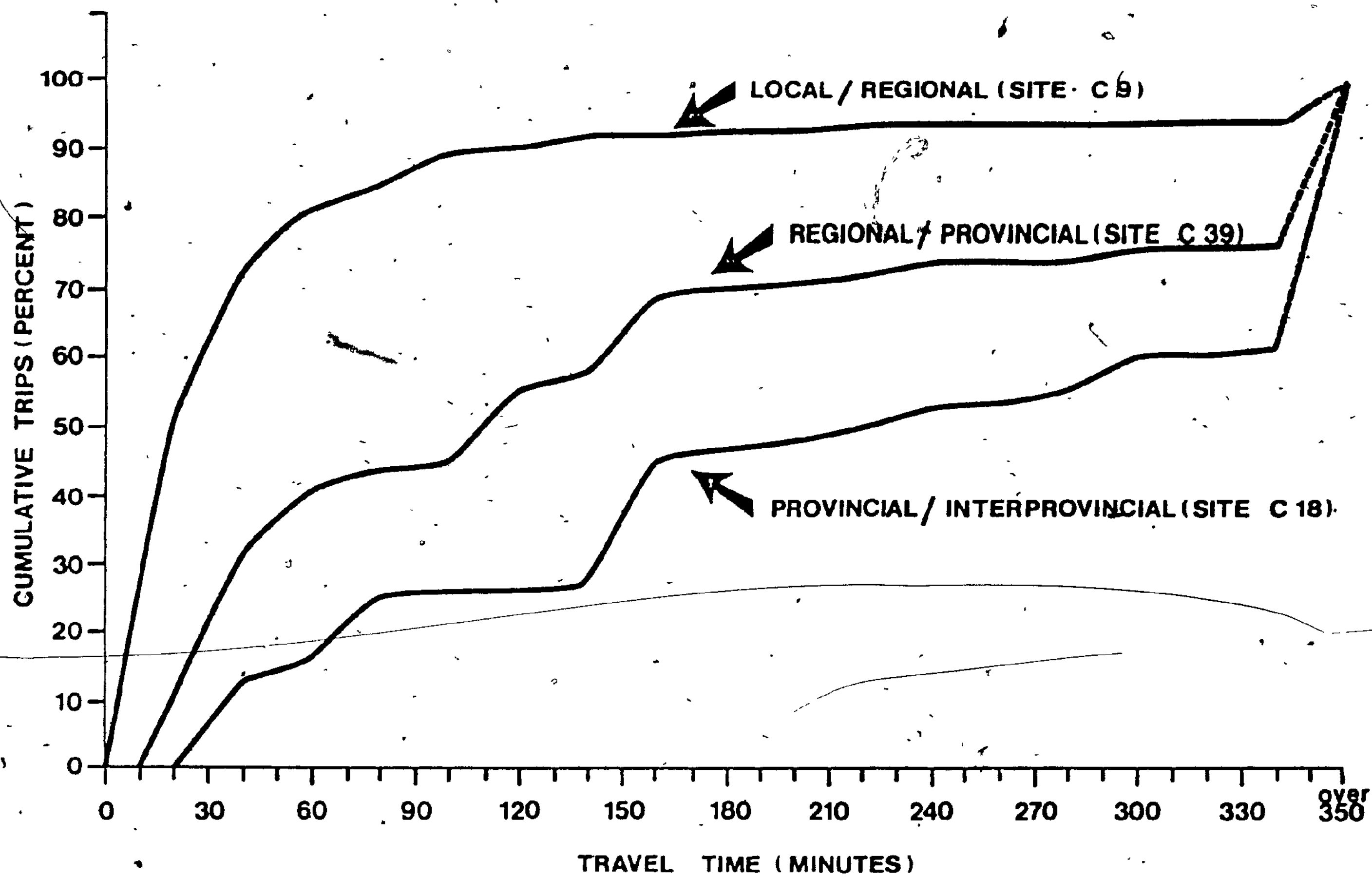

Figure 8. Typical trip length distribution of road sites.

local/regional trips are smaller than 60 minutes of travel time. The provincial and interorivincial patterns exhibit longer trip-length distribution.

Based on the foregoing description of the proposed method, Table 3 shows the classification of road sites in perspective. The final classification of study sites, as listed in this table, is based on the temporal volume distributions and road use characteristics. The groups G5, G6, and G7, each containing only one study site, i.e., C36, C114, and C165 are put in a single road class- highly recreational. The difference in the seasonal traffic peaking of these sites is largely due to the difference in their AADT values. Site C36 is located on Trans-Canada east of Banff National Park, and has an AADT value of 8120. Sit C114, with an AADT of 1930, is located on Yellowhead highway at the east entrance of Jasper National park. Site C165 is located on highway 11 west of Red Deer and serves tourist-recreational traffic to both Banff and Jasper parks. The AADT value at C165 is only 650.

In addition to the road classes listed in Table 3, there may be some special routes serving needs of a specific community. Sites C156 and C162 included in the seasonal group G8 (Figure 4) are two examples of such class in the province of Alberta. There are seemingly two yearly peaks of travel in the cases of sites C156 and C162. Site C156 is located on Highway 35 north of High Level and represents traffic to and from North-West Territories. It appears that traffic during the spring season is decreased in this case because of such factors as ice melting and thawing of winter roads in these regions. The winter traffic peaking of site C162 is caused by the winter recreational activities in the Kananaskis area.

Table. 3 Classification of road sites in perspective

Road Site Classificaiton	Temporal Volume Characteristics			Road Use Characteristics		
				Trip Purpose[4], %		
	Seasonal Variation Group[1]	Daily Variation Pattern[2]	Hourly Variation Pattern[3]	Work-Business	Social Recreational	Trip Length Distribution[5]
Commuter	G1	COM	Commuter	82	18	Local/regional
Commuter-recreational	G2	CR	Commuter	77	23	Local/regional
Commuter-recreational--tourist	G3	CRT	Partially Commuter	64	36	Regional/provincial
Rural long distance	G4	TOUR	Non-commuter	37	63	Provincial/interprovincial
Non-recreational low volume	G1	COM	Non-commuter	80	20	Regional/provincial
Highly recreational	G5,G6 G7	HREC	Non-commuter	37	63	Regional/provincial/interprovincial

[1]based on Figure 4
[2]based on Figure 5
[3]weekday pattern based on Figure 6
[4]average values based on Table 2
[5]based on Figure 7

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

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CONCLUSIONS AND RECOMMENDATIONS

The conclusions that relate to the proposed classification of roads according to road uses, its merits and applications are summarized below:

The existing methods of road classification according to type of use are subjective in nature, and there exist a diversity of definitions, systems, and procedures which are in evidence across Canada. Consequently, a considerable input of subjective judgement is likely to be used in various planning and design activities pertaining to different types of roads.

The proposed method of grouping road sites on the basis of temporal variations and road use characteristics is more objcective and comprehensive than the conventional methods. It can enable highway agencies to group roads into distinct classes that are significantly different from each other. Here it is to be mentioned that the six categories of road sites in Table 3 are significantly different from each other at least in one variable.

The analysis and classification of road sites into different categories, as suggested in this study, should provide a better frame work for rationalizing the different data collection programs, such as the continous traffic counting by PTCs, the seasonal counting by portable counters, and the short-period manual counting program.

The proposed method has implications for a standard classification of roads on a national basis and provincial basis. Such a clssification can be expected to lead to an overall consistency in planning, design, and operation of road facilities for both safety and economy purposes.

Another application of this method is in the area of policy development. Further research into the area of highest hourly volume characteristics for different classes of roads can help the agencies to develop their own policies regarding the DHV and upgrading of two lane roads.

Even though, Alberta's primary highway system is investigated for the purpose of this study, it is recommended that many other provincial highway agencies could benefit from using this method of analysis for classifying their road sites. Since a majority of these agencies have the same data as used in this analysis avilable to them.

As further work, the present study is useful in conducting cost analysis on the classified roads to determine the changes in cost of construction, travel time costs, roaduser costs, and gross total cost of operation. Such a study will help in understanding the different costs that may occur due to different road use characteristics.

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APPENDIX

APPENDIX

HIERARCHICAL GROUPING OF THE COUNTERS

The application of this procedure to the grouping of counters can perhaps be most easily explained by considering a simple example in which the objects are four permanent counters described by their traffic volumes as a percentage of AADT over a period of three months:

Counter	Volume 1 (June)	Volume 2 (July)	Volume 3 (August)
A	110	111	110
B	109	112	108
C	114	115	112
D	115	117	110

To begin with we have four groups, that is each one of them forming individual groups by themselves. Hence the error within group is zero. The first stage of the process is to compute a matrix of potential error terms for each pair of counters. This error term is defined by the following equation:

$$E(i,i') = \sum_{j=1}^{K} \{(V_j)_i - (V_j)_{i'}\}^2/2 \qquad \ldots\ldots \quad (1)$$

Where,

$E(i,i')$ = Potential error associated with the grouping of sites i and i′

$(V_j)_i$ = value of jth monthly traffic factor for site i

$(V_j)_{i'}$ = value of jth monthly traffic factor for site i′

K = number of monthly traffic factors included in the analysis.

By using equation 1, we obtain the ptential error matrix for our example as follows:

Counter	A	B	C	D
A	0	3.0	18.0	30.5
B		0	25.0	32.5
C			0	4.5
D				0

Since E(A,B) is a minimum, we will form a single group from counters A and B, now leaving a total of three groups instead of the original four. Let the new group be called X. The group X will retain the error measure E(A,B) = 3.0 since it is within-group error, which will be moved to its diagonal element in the error matrix. The other elements reflecting potential error for combination with X must now be modified also. The weighted mean average error of combining two individual groups can be examplified for one cell (XC) by the following relation:

$$E(X,C) = \{E(A,C)\,(N_A+N_C)\quad E(B,C)\,(N_B+N_C)\quad E(A,B)\,(N_A+N_B) - E(A,A)\,(N_A) - E(B,B)\,(N_B) - E(C,C)\,(N_C)\} / (N_A+N_B+N_C)$$

or

$$E(X,C) = \{18.0(2) + 25.0(2) + 3.0(2) - 0(1) - 0(1) - 0(1)\} / (1+1+1) = 30.67$$

Here E represents an estimate of potential error for combining two groups and N represents the number of cases in group.

After the first pairing of A and B into a single group X and using the above calculation to estimate potential error for combining two groups, we obtain the following error terms matrix:

Counter group	X	C	D
X	3.0	30.67	4.4
C		0	4.5
D			0

It should be clarified here that the decision as to which two groups should be combined at any stage is always made by determining the cell in the error matrix that, when its corresponding diagonal-cell values have been subtracted, yields the smallest value.

For example, in the above case of grouping A and B toghether, it was $E(A,B) - E_A - E_B$ (3.0 - 0 - 0 = 3.0). Similarly the error of grouping C and D toghether is minimal in the modified matrix as (4.5 - 0 - 0 = 4.5). Therefore the process will put toghether counters C and D.

Hence the error matrix will change again because of the latest grouping, i.e., grouping of C and D. The new error matrix, which is also our final one for our example, is shown below. The group of counters C and D is called by Y in this matrix. An error of 49.25 (56.75 - 3.0 - 4.5) results, indicating the " cost " of collapsing the two pairs (X and Y) into a single group of four counters.

Counter Group	X	Y
X	3	56.75
Y		4.5

It has to be emphasized at this point that this method is primarily descriptive and does not indicate specifically the optimum number of groups that should be taken for the study objective. However, the errors associated with the successive stages of grouping process will usually reveal a range of grouping stages. By applying the above method and plotting the results helps in choosing the optimum number of counter groups. For deciding the exact number of groups one has to use the Scheffe s S-Method of Multiple Group Comparisions.