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ESTIMATION OF GENERATED TRAFFIC BY NEW DEVELOPMENTS:

Current Practice And Possible Improvements Based On Bangkok Experience

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ABSTRACT

It is important to be able to predict the amount of traffic that will be generated by new land use developments in order to anticipate impacts on the overall transportation system, and to plan for internal circulation and parking needs at a site. Many factors can affect the amount of traffic generated at a particular site, including the type of land use, its size, local demographics and transport patterns, convenience and price of parking, and other factors.

This paper reviews current methods used in estimating generated traffic caused by new developments such as housing, shopping centres, conventional centres, hospitals, etc. It describes three case studies from Bangkok, Thailand which illustrate conventional assumptions and methods. Several shortcomings of current practices are identified and possible improvements are proposed to more accurately predict the amount of traffic generated by new developments.

The assumptions used to in standard trip and parking generation models are not always appropriate for application in a particular project. Models and assumptions from developed countries are not appropriate for use in developing countries where demographic, economic, and transportation conditions are often quite different. This paper suggests that several additional factors that should be considered to improve the accuracy of such models, particularly in developing countries. It also suggests additional research needed for more accurate traffic generation modeling. Though, based on experience in Bangkok, they reflect general principles that should be considered by traffic planners in any location.

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1. INTRODUCTION

New developments generate new traffic. The amount of new vehicle traffic generated can be affected by a development's size, activity areas, proximity, ease of parking, and other similar factors. Accurate prediction of traffic generation is important to allow regional planners to design the traffic system to accommodate additional traffic, and to plan internal circulation, access points, parking facilities and traffic management at a site.

This paper reviews current methods used in estimating generated traffic caused by new developments such as housing developments, shopping centres, conventional centres, and hospitals. It describes three case studies based on experiences gained in Bangkok. The lessons learned from these case studies would be useful in formulating methodologies suitable to developing countries in the region. A number of shortcomings of the current practice are analyzed and possible improvements are proposed to accomplish a more realistic prediction of traffic generation estimates for new developments.

2. CURRENT PRACTICE IN ESTIMATING GENERATED TRAFFIC

2.1 Review of Current Practice

Estimation of generated traffic is an important feature in planning of new developments. Traffic generation studies are conducted by planners and traffic engineers to predict the volume of new traffic generated by proposed developments and consequently to assess the impact caused by new sites.

Traffic generation rate is expressed in number of vehicular movements generated by different activities of these new developments. These vehicle movements occur as a result of human activities such as buying, meeting, playing, eating, and watching, at particular locations. Activity is merely a concept used for planning purposes to predict the traffic generation behaviour of a development. Traffic generation rate is usually measured for different types of land uses in terms of number of vehicle movements per unit of activity per unit time (e.g. vehicle movements per 100 sq.m per hour). Thus, it is implied that traffic movements are generated through human activity, while traffic generation rates are expressed in terms of land use facility units. In other words, activity is given in land use measures, which is more definite and convenient in estimation and application of different types of development projects.

A few typical measures of land use units that used as activity measure are as follows.

(a) Number of dwelling units - for residential development

(b) Gross floor area - for shopping centre and office development

(c) Number of seats - for theatre, stadium

(d) Number of beds - for hospitals

(e) Net selling area - for retail/commercial developments, hotel bars, restaurant

(f) Number of enrolments - for schools, colleges

(g) Number of rooms - for hotels

(h) Number of acres - for industrial development

Several methodologies are used to determine the traffic generation of new developments. Depending on the nature and importance of the development being analyzed, the selected techniques vary from simple to more sophisticated. These procedures are described in Institute of Transportation Engineers (ITE) documents. The followings are the most commonly used throughout the world.

(a) Traffic generation rates for similar types of developments in the project area are determined by conducting local surveys and then traffic generation rates per unit area are calculated proportionally for the proposed development.

(b) Traffic generation rates from a similar area are assumed as applicable to proposed study area.

(c) In the absence of locally derived rates, by referring traffic generation rates published by the ITE, appropriate rates are obtained according to the area of the development.

(d) Using regression analysis of data obtained by surveys for number of developments of different sizes in the same area, the corresponding traffic generation rates are obtained.

Methods (a) and (b) are the most commonly used. In some cases planners use method (c) due to inadequate budget for surveys. Method (d) is rarely considered since it is costly compared to other methods due to the need of surveys. In all these cases following general assumptions are established in addition to other assumptions, if any.

(i) Traffic generation rate can be expressed in terms of land use units that used as activity measure.

(ii) The traffic generation rates are related to one or two independent variables and mostly only the activity per land use unit.

(iii) The generated traffic by new developments is considered as purely new trips that did not existed prior to the development.

(iv) In the case of commercial centres, all of the shopping trips are assumed as primary trips.

(v) Peak period of the development is mostly considered as critical and hence used for analysis.

(vi) Traffic generation behaviour is generalized and rates derived for other developments are very often used. Thus, site-specific nature has been overlooked in most cases.

Since the current methods of traffic impact assessment are based on historical and non-quantitative procedures, Hallam C.E. and Pinder G. (1983) made an effort to develop reliable methods with the aim of putting predictions and assessments on a more quantified basis. This project has been completed by the Traffic Authority of New South Wales, Australia. Further research is required to explore the degree of transferability of these results to countries other than Australia.

Slade L.J. and Gorove F.E. (1981) pointed out that the present method of estimating generated traffic for commercial centres overestimates the impact due to the fact that the inherent assumption of new trips. They stressed that this assumption is not true because most of these trips are diverted from other centres of same kind of developments. The need of further research to examine the actual new traffic generated by these centres was recognized.

Reid F.A. (1982) criticized the applicability of ITE trip generation rates and its sampling methods. He explained an alternative method of estimating new traffic by developments based on travel survey data. He argues that traffic survey data for an area similar to the one to be estimated would be better basis than ITE manual. Since most metropolitan areas have travel surveys updated for current years, it is suggested as more appropriate method to use these data to estimate traffic generation by new developments.

Most traffic generation studies have been conducted in developed countries and an apparent lack of studies has been noticed in developing countries. This is mainly due to the limited budget available in developing countries for such studies. Thus, research findings from studies conducted in developed countries to estimate the generated traffic are often applied in developing countries. Developing countries' urban structure, trip makers' behaviour, socio-economic factors and other related factors are very different from developed countries and therefore, direct application of traffic generation rates and models derived for developed countries will not give realistic results. Thus, it is recognized the necessity of detail studies to explore appropriate modification required in current methods to estimate generated traffic by new developments in developing countries.

2.2 Critique of Current Methods

When the current methods are approached analytically, it is clear that there are many points to criticize which are not rational. An attempt has been made to summarize following basic critique based on traditional assumptions used in current methodology and subsequently possible improvements are suggested in section 4.

(a) Relationship between land use and traffic generation

Current methods are primarily based on the principle that activity could be expressed in terms of land use. Though there is an obvious close, but not exact correspondence between activity and land use. Further, this method is not established on any sort of theoretical foundation. For instance, it is well known fact that residential vehicle trip ends are better correlated with car ownership, number of residents, and household income level than the number of dwelling units. But, the latter is readily available or easily obtainable in residential development proposal and so it is used as the activity measure. There are situations where this principle is of no use, even it can misguide by giving unrealistic predictions of traffic rates. Thus, its applicability has to be evaluated prior to its use based on past experience and the characteristics of proposed development.

(b) Many determinant factors for traffic generation

The traffic generation rates from ITE and similar data sets are usually estimated using only one or two independent variables. The reason behind this is that the basis of traffic planning for development applications must be limited to the set of information readily available. But, it is a well-known fact that traffic generation is affected by a variety of socio-economic variables. Traffic generation is also affected by the types of activities at a centre, the accessibility to the centre, modal split of the road network, availability and price of parking, proximity and size of similar centres in the area, condition of the adjacent road network, and various other factors. Current modeling techniques often ignore many of these factors.

(c) Special influencing factors in traffic generation behaviour
In addition to the factors described above there are also special factors affiliated with each development, which are qualitative rather than quantitative. These factors are the actual cause of traffic attraction compared to another similar kind of development in the vicinity. Examples are listed below.

a. Marketing strategy of activity centre.

b. Any special characteristics of the development in deciding customers' behaviour.

c. Specific target group of customers.

d. Intensity of each activity in relation with the development.

e. Extent of centre's promotion and popularity.

f. Aesthetics and amenity of the centre.

Current methods of estimating traffic generation often fail to incorporate such qualitative features of developments. Based on the influence of these special factors, the amount of expected traffic could be much different from the amount derived by conventional methods.

(d) Assumption of new trips
Current modeling methods assume that the traffic generated by new commercial developments, such as shopping centres, are purely new trips. But, in most cases the majority of these trips already exist, and are simply diverted to the new development from other similar activity centres.

(e) Assumption of primary trips
Another assumption inherent in present approaches is that all of the shopping trips are primary trips, i.e. the primary purpose of the trip is for shopping with a trip pattern of home to shopping centre and return to home. But in reality, many of the shopping trips are made as secondary part of a linked trip such as from work to shopping centre to home. Thus, present methods overestimate the traffic generated by shopping centres when shopping trips are not primary trips. Of course, some centres generate primary trips due to their unique characteristics. In such cases, these should be considered primary trips.

(f) Selection of peak period for estimation
Traffic design and impact analysis are usually done for the peak periods. In estimation of traffic generation, the current practice is to consider the peak as the period with maximum vehicle per hour to and from the development site. But, in most study areas, the peak hour for the surrounding road network is more important than the peak period of the development. In this kind of situations, planners should use their personal judgment based on common sense and past experience.

(g) Site-specific nature of traffic generation
Due to the site-specific nature of traffic impact studies, ITE rates are not of much use to other localities, other than the provision of general understanding on the land use characteristics. A cookbook approach should be avoided in using traffic generation rates derived by ITE or any other study. Therefore, every study should be accomplished with traffic surveys to select the suitable estimation technique. But, in most cases, surveys are avoided due to the cost accompanied with it and just based on many assumption, the rates from other studies are applied with some modifications.

3. ESTIMATION OF TRAFFIC GENERATION: BANGKOK EXPERIENCE

Three case studies conducted in Bangkok are considered here with established assumptions together with critique and suggestions in relation to traffic generation behaviour.

Case study 1 - Shopping centre 'A'
Case study 2 - Convention centre 'B'
Case study 3 - Bus terminal complex 'C'

3.1 Case Study 1: Shopping Centre 'A'

There are several shopping centres identical to 'A' in Bangkok Metropolitan Administration (BMA) area, as well as all over Thailand. 'A's marketing policy is to serve as a wholesale and retail outlet rather than capturing family customers. Most customers are registered as regular customers and use a special credit card issued by 'A' shopping centre for their transactions. All the 'A' Shopping centres are identical in available products, prices, and concept and even in interior arrangement. Proposed 'A' shopping centre is in BMA area and it is also expected to operate under the same marketing strategy.

Assumptions that adopted in estimating trip generation behaviour of 'A' and related facts are described below.

(a) Relationship between land use and traffic generation

Conventional trip rate analysis methods are based on floor area of the shopping centre was utilized to predict the amount of generated traffic. Since this is not the first of this kind of shopping centre in the project area, there will not be any discrepancy beyond the acceptable limits in estimation of generated traffic.

(b) Identification of special influencing factors in traffic generation behaviour

Shopping centre 'A's traffic generation behaviour is different from any other shopping centre because their target group of customers are very specific. Therefore, traffic generation rates for other shopping centres in the vicinity cannot be applied to estimate the traffic generated by this site. Also, customers of 'A' often determine the products they want to buy and their prices in advance. This allows customers to spend less time in the centre per trip compared to other centres, and so their occupancy time is less than at other shopping centres. This makes the arriving and departing traffic during peak hour of the shopping centre almost equal, which is another characteristic that differ from other cases.

Identification of special features of the proposed centre has to be appreciated, since this could be of use to forecast more realistic values of generated traffic. Further, it is an interesting point to note that how the marketing strategy of centre has become the most prominent decision maker in selecting the appropriate technique to estimate traffic generation.

(c) Assumption of new trips

It is assumed that all trips generated by proposed shopping centre 'A' will be new trips, which is not true. The amount of generated traffic cannot be totally a new traffic to system. Some traffic is surely diverted due to the close proximity of the shopping centre otherwise these customers are used to do shopping at another 'A' shopping centre. Hence, the estimated value of generated traffic is an over-estimate. On this point, it is very difficult to estimate the amount of actual new traffic. It is necessary to make sound assumptions by using previous experience on the same kind of shoppers.

(d) Assumption of primary shopping trips
Most of the trips made by customers of 'A' are primary trips since they are mainly business people. So, most of them make trips from home or their business place to 'A' only to purchase products for their business. Hence, this assumption is applicable in this case.

(e) Site specific nature
It is assumed that trip generation behaviour of 'A' will be the same as another 'A' branch in BMA, which is under operation for many years. Therefore available data on passenger car arrivals for existing 'A' shopping centre was used as the basis for estimation of generated traffic by the proposed 'A' shopping centre. Using average passenger car arrivals data and floor area information, generated traffic during evening peak hour of road traffic was derived by assuming a peak factor of 1.2.

If data were available on generated traffic in terms of passenger car arrivals and gross floor area for several 'A' shopping centres, it could have been used to formulate a simple linear regression equation, which could be used to predict more realistic estimates.

(f) Selection of peak period for estimation
Shopping centre 'A's peak hour is not coinciding with the peak hour of road traffic. The influencing factor for peak hour of road traffic is trips made by commuters. Generally it is expected that people who return back from work make shopping trips on their way back home from working place. Since the target group of customers for 'A' shopping centre are mainly composed of whole sellers, retailers and shop owners, the shopping trip pattern is entirely different in this case and they tend to make their trip during off-peak hours of road traffic. Thus, peak hour of the road traffic was considered for analysis that is more realistic due to the fact that congestion in road traffic is prevalent in Bangkok. But it is doubtful about the reliability of the assumed peak factor due to lack of survey data on this aspect.

3.2 Case Study 2: Convention Centre 'B'

The convention centre 'B' is a multi-facility complex with an exhibition hall, convention centre, office area, hotel and a parking area. Followings are the established assumptions to estimate generated traffic by 'B' convention centre.

(a) Relationship between land use and traffic generation
Traffic generation rates for office area were assumed to be equal to values obtained by traffic generation survey of another office building. Similarly, hotel traffic generation rates were obtained from another study of hotel trip generation in Bangkok. Based on available parking units, traffic generated by the convention centre and exhibition hall were assumed with different possible operating hours.

(b) Assumption of new traffic
All of traffic to the convention centre is assumed to be new trips. This is likely to be true since the most of visitors are attracted to the uniqueness of its conventions and exhibitions. Since there is no similar kind of centres at present, there is no diverted traffic in this case.

(c) Assumption of Primary trips
Further, these new trips are considered as primary trips. This assumption is also partially true because trips to conventions are directly from home but some of trips to exhibitions can be secondary trips.

(d) Selection of peak period
Evening peak of the road traffic was considered due to the fact that during this time visitors for exhibition are generally greatest because people often make such visits after the working hours. This is a sound assumption according to the nature of the traffic in Bangkok.

(e) Site specific nature
It is assumed that the trip generation behaviour of different facilities of 'B' will be the same as similar facilities of other existing developments. Thus, the site-specific nature is ignored and no surveys have been conducted to identify any site-specific characteristics of this development.

3.3 Case Study 3: Bus Terminal Complex 'C'

The proposed bus terminal 'C' is a complex with a transport company, offices, commercial and retail store and parking areas. This terminal complex will be used as a depot for the new-elevated transit system as well as the new intercity bus terminal. This will be the first-ever bus terminal complex in Bangkok. There are five types of trips generated, namely; intercity bus passengers, employees, shoppers, business trips and goods handling. Traffic generation estimates are made based on following assumptions.

(a) Consideration of other determinant factor
Shopper demand was assumed based on maximum hourly arrival rate for cars to the parking station. The conventional trip rate analysis based on gross floor area was not adopted in this case. Accessibility to the centre became the deciding factor rather than land use activity unit.

(b) Assumption of new trips
Trips to this proposed bus terminal are considered as new trips which is an appropriate assumption because this will be the only bus terminal complex of this type in Bangkok.

(c) Assumption of Primary trips
The basis for calculation of shopping trips was the maximum hourly arrival rate of cars to the parking area, which is related to the capacity of the entry ramps of the development. Therefore, there is no need to consider whether the trips are primary or not since the capacity of the entry ramps are already known and so the number of shopping trips.

(d) Site specific nature
Intercity passenger arrivals made by different modes are found by surveys conducted at the existing bus terminal. Number of bus bays allocated at the terminal is used as the basis for this estimation. Data on employee arrivals by different modes was found by surveys at another shopping/office complex with the assumption that the behaviour of employee arrivals is similar at the both the places. Business trips are expected to be very few and estimated based on the floor area. Goods handling traffic is not considered for analysis as it is totally separated from the other traffic.

(e) Peak hour selection
Peak hour was evaluated by integrating all activities and choosing the hour with maximum volume of traffic in the bus terminal. It is realistic to consider the peak period of the bus terminal as the demand estimation was based on the maximum hourly arrival rate for cars to the parking area, which is again related to the surrounding road capacity.

3.4 Analysis of Case Studies

Table 1 gives the comparison of generated traffic by all three case studies together with the summary of assumptions. It tries to evaluate the validity of the assumptions that are used on a broader scale to provide a general idea of their accuracy. A point system is used to indicate how realistic the assumptions are likely to be in each case. Evaluation of each assumption is solely based on findings derived from this study. According to another study, these may be interpreted in different way in relation with the study approach.

Realistic = 1 *Partially realistic = 0.5* *Unrealistic = 0*

Assigned points are given in brackets together with the assumptions made for each case study in Table 1. The following results are drawn from this point system.

(a) The total points obtained by 'A' is 4/6 or 66.6%. Therefore, estimation is 66.6% close to the real amount of traffic supposed to be generated by 'A'.

(b) The total points obtained by 'B' is 3.5/6 or 58.3%. The estimated value of generated traffic is 58.3% close to the actual amount of traffic that 'B' is supposed to be generated.

(c) The total points obtained by 'C' is 4/6 or 75%. The estimated value of generated traffic is 75% close to the actual amount of the traffic that is expected to be generated by 'C'.

It is noted that the estimation of generated traffic by the bus terminal 'C' is more realistic than the other developments considered here. Thus, it can be stated that based on assumptions made in the process of estimation, the validity of those estimates vary on a broader scale.

Table 1 Comparison of Generated Traffic by Case Studies

Case Study	Shopping Centre 'A'	Convention Centre 'B'	Bus Terminal Complex 'C'
Facilities	Shopping	Convention centre Exhibition hall Office & Hotel	Transport company Department store Offices & Restaurants
Total floor area, sq.m	23,200	82,000	480,000
Predicted Generated traffic during peak, car/hr. -in -out	460 460	2700 2700	3700 3000
Predicted Generated traffic during peak,car/100 sq.m/hr. -in -out	1.96 1.96	3.3 3.3	0.77 0.62
Deciding factor for estimation ? - Land use unit as activity measure - Other determinant factor	 Floor area (1) Not considered	 Floor area (0.5) Parking units (0.5)	Not considered Maximum flow rate of access to the centre (1)
Special influencing factors ?	Marketing policy (1)	No (0.5)	Unique facility (1)
New trips?	All new (0)	Partially new (0.5)	All new (1)
Primary trips?	Totally (1)	Partially (0.5)	Not considered (1)
Peak period?	Evening peak of road traffic (1)	Evening peak of road traffic (1)	Peak of bus terminal 'C' (1)
Any surveys to reflect site-specific nature?	No (0)	No (0)	Few surveys (0.5)
Total points	**(4/6) = 66.6%**	**(3.5/6) = 58.3%**	**(4.5/6) = 75%**

4. POSSIBLE IMPROVEMENTS AND SUGGESTIONS

This paper illustrates some major weaknesses with current traffic generation modelling practices that can lead to inaccurate results. Below are some suggestions to improve traffic generation prediction methods. They are actually only minor extensions to the current practice. Althgough these improvements have been derived based on traffic impact studies conducted in Bangkok, they are applicable in estimating traffic generated by new developments in any locality or country with appropriate changes and modifications.

(a) Application of relationship between land use and traffic generation with caution

The relationships between traffic generation and land use variables are functional rather than causal. Current assumptions and modeling methods are selected largely because they fit well with available data. When a system is appartently stable, the causal variables of a new development are similar (but not identical) to existing functional variables. In such situations, current methods for predicting traffic generation would be generally accurate. However, when major changes are introduced by a new development in a stable system, such as 'C' bus terminal project that is the first bus terminal complex in Bangkok, problems may arise. Bus terminal complex 'C' is introduced in a system that was previously served by a small-scale bus terminal. In this case, the variation in functional variables could not be used to represent the variation in causal variables as introduction of 'C' disrupts the previously stable system. In these situations, conventional methods are inacurate, and use of behavioural models is invaluable. On the other hand, floor area which is the land use activity unit, is used for shopping centre 'A' and convention centre 'B', since they are built in areas where many similar developments are in operation, and the system is not disturbed due to the introduction of these developments.

(b) Consideration of all determinant factors for traffic generation

Since traffic generation is a function of many more factors as listed below, it is recognized that inclusion of these determinant factors as appropriate in different situations can improve the accuracy of traffic generation forecasts.

(i) Different types of activities facilitated by the development.

(ii) Overall accessibility to the centre.

(iii) Modal transportation system choices, especially the availability of public transport services.

(iv) Availability of parking facility.

(v) Socio-economic characteristics of people within the catchment area.

(vi) Proximity and size of similar centres in the area.

(vii) Condition of the adjacent road network.

Out of these factors only (i) is taken into account in current generated traffic prediction models. Since, other factors, (ii) to (vii), are quantitative, it is not difficult in determining, but no attempt has been made to include these factors in the current practice of traffic generation process. Since trip generation is a function of socio-economic variables, there is a reason to believe that these variables would also be deciding factors of traffic generation as seen in the case of bus terminal 'C' where the overall accessibility was considered as the determinant factor to estimate generated traffic by shoppers. Availability of different modes, such as public transport services, is another determinant of traffic generation. Therefore, vehicle trips could be obtained by estimating person trips and applying the modal split. Modal split of the study area could be found by present mode split model from transport study data in the development area or by conducting a survey.

(c) Identifying the role of special influencing factors in traffic generation behaviour

Some of the special influencing factors in traffic generation of new developments are as follows and there can be many more factors depending on the nature of the development.

(i) The intensity of each activity in relation to the development.

(ii) The marketing strategy of the centre and expected target group of customers.

(iii) Extent of centre promotion and popularity.

(iv) Aesthetics and amenity of the centre.

It may be difficult to use these factors directly in estimation of generated traffic, since these are qualitative measure rather than quantitative measures. However, based on intensity of use of an activity, the amount of traffic generated by certain activity could be more or less than the predicted value. For example, the office employees per 100 sq.m which is called intensity of use can be ranged from 1 to 20 depending on the job type, price of space (office rent, real estate price), city size, population, economy of the country, etc. and even average size of people of the country. Hence, intensity of the activity plays a significant role in determining traffic generation behaviour within a wide range of values.

As shown in the case of shopping centre 'A', its' marketing policy was the deciding factor in establishing assumptions. Similarly, the extent of centre promotion and its popularity over other centres are also possible factors in attracting more customers. Hence, further research studies are vital to incorporate such qualitative factors in estimating traffic generation.

(c) Identification of actual "new traffic" generated by the development

The conventional method of calculating the traffic impact of a new development is simply adding its estimated generated traffic to existing road network. This method may be over-estimating the actual impact because a portion of generated traffic is actually diverted from existing trips that would otherwise ben made to other similar centres. Thus, it would be more advantageous to construct modelling techniques to identify the actual portion of new trips included in the estimated "generated" traffic by new developments such as shopping centres, theatres, hospitals, etc. New developments may divert some traffic from other congested activity centres and thus relieve congestion in other locations. This social benefit may be overlooked by common practices, and so developers are burdened by an extra social cost for non-existing traffic impacts. Further research is necessary to examine this fact in detail and identify that how many new trips are actually generated.

(d) Site-specific treatment of each development project

A site-specific approach is recommended since traffic impacts can vary considerably depending on many factors, such as those discussed here. It is particularly important to use traffic generation that take into account the site-specific nature of traffic generation behaviour, and that reflect conditions in each country and geographic region. In particular, standard ITE values and assumptions should not be used in developing countries.

When the proposed development is more of the same as existing ones, such as expansion of a shopping centre, hospital, school, the present traffic characteristics should be surveyed as a basis for prediction. This would be more reliable than extrapolating from other sources. In the case of purely new developments, more survey work to be done to collect comprehensive data sets to formulate regression equations.

5. CONCLUSIONS

This paper reviews current practices for estimating the amount of traffic generated by new developments, identifies weaknesses in these practices, and suggests possible corrections. Although this analysis is based on case studies conducted in Bangkok, the conclusions and recommendations should be considered by traffic planners in any locality or any country. Our key findings are summarized below.

(a) The relationships between land use and traffic generation may vary considerably, so it is necessary to account for the individual characteristics of each project. For instance, estimation of traffic generation for shopping centre 'A' and convention centre 'B' were based on floor area as the land use activity, while for bus terminal 'C', floor area was not used.

(b) Consideration of other possible determinant factors can give more realistic results as in the case study of bus terminal 'C' where the shopper demand was estimated using maximum hourly arrival flow rate based on the overall accessibility of the centre.

(c) It is important to identify any special factors that may influence traffic generation. For example, shopping centre 'A's marketing policy should be considered when making assumptions about the types and duration of vehicle trips.

(d) It is important to identify the portion of generated traffic that is actually new trips, rather than trips diverted from similar destinations in the region. In the case of shopping centre 'A', all trips are not truly new. On the other hand, all trips to bus terminal 'C' are expected to be new.

(e) Site specific treatment of each project is recommended for realistic estimation of traffic generation. As in case of 'C' bus terminal, surveys at existing developments with similar traffic generation characteristics are very useful.

The relationship between traffic generation and land use variables has been explained in relation with traffic generation behaviour. Behavioural models are needed to explain these relationships. Present techniques for estimating traffic generation can be improved by including additional determinant factors. There are often special influencing factors that affect the amount of traffic attracted to new developments. It is desirable to identify these special factors since their role is significant in establishing assumption for prediction of generated traffic. Further research is needed to quantify their impacts on traffic generation.

Conventional methods of estimating traffic impacts of a new development have been criticized because they may over-estimate actual impacts. It is important to develop modelling techniques that can accurately identify the actual portion of new trips in estimates of "generated" traffic. Again, further research is needed to examine these factors in detail.

ITE trip and parking generation rates should not be used outside of North America, due to the site-specific nature of traffic generation behaviour. Thus, depending on the budget available, traffic surveys at the same kind of existing developments in the project area are appreciated for reliable estimation of generated traffic by proposed developments.

It is recognized that the addition of these factors are only an extension to current practice but the value of including these additional factors depends on the degree of accuracy required and the budget allocated for the study. Finally, the need for more research to develop practical modelling techniques that accurately describe traffic generation behaviour is stressed.

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