SELECTING PRIORITY JUNCTION TRAFFIC MODELS TO DETERMINE U-TURN CAPACITY AT MEDIAN OPENING

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Abstract: Median openings are provided along dual carriageway arterial roads to allow access to abutting land and to side roads. One of the functions of these median openings is to provide U-turn opportunities. The U-turn movement at a median opening is highly complex and risky compared with turning movements at intersections. This study examined the suitability of some traffic models to determine U-turn capacity at median openings. The modified random platoon Tanner's formula was found to be the most suitable model. The results further indicated that this model could be used to determine capacity of any priority controlled intersection where platooning occurs in conflicting stream. Full knowledge about the headway distribution of major traffic is very important in selecting a model to determine priority junction capacity. This is no less important than the determination of the acceptable gap and move-up time parameter.

Key Words: gap acceptance, U-turn, median opening, road capacity, mathematical model

1. INTRODUCTION

Continuous medians to separate traffic flows along arterial road are used to improve throughput and safety and to control access from side roads and abutting properties. Openings in the central median are then required at some sites, to allow side traffic to enter or leave the main road and to provide access to properties. The limits on the number and location of median openings mean that U-turn manoeuvres will be required. The U-turn movement at a median opening is highly complex and risky compared with turning movements at intersections, firstly because of the high speed and traffic volume and secondly because the turning vehicle has to make a 180° movement and join the traffic stream in which it is seeking an acceptable gap. The turning vehicle must wait and then turn under low speed conditions in the face of oncoming traffic and may need to accelerate rapidly to reach the speed of the traffic stream. If there are many turning vehicles that have to wait, then a long queue in the stream cannot be avoided and queue spill-back to block through traffic is possible. This can lead to traffic problems, mainly reduced capacity and level of safety. Thus a determination of U-turn capacity is needed.

Currently there is a lack of specialist models that estimate the capacity of U-turns at median openings. As there are similarities between U-turns and priority junctions in term of gap acceptance theory and some of those movements, this study examined the suitability of current priority junction traffic models for determining U-turn capacity at median openings. In particular models using gap acceptance theory are of special interest, as these are widely accepted in traffic engineering practice.

2. HEADWAY DISTRIBUTIONS

A large number of headway distributions have been developed to represent the different pattern of vehicle arrivals. The most widely applied assumption is that vehicles arrive randomly and the headways follow negative exponential distribution. The validity of negative exponential distribution model is restricted to light flow where there is little interaction between vehicles in the stream. To overcome this restriction, some analysts recommend use of the displaced negative exponential distribution (Bennett, 1999). Salter (1974) recommended use of Pearson type III or the Erlang Distribution when a limited amount of overtaking is possible. Another approach is the use of mixed exponential models, such as Cowan's 'Model C' (Troutbeck, 1986).

These other models were developed to overcome a condition that vehicles travelling along highway could be considered to be composed of two types, firstly those who were unable to overtake and were restrained in their driving performance and secondly those drivers who driving freely or unrestrained by other vehicle on the highway, i.e. the traffic stream consists of bunches (platoons) of vehicles.

These models include the doubled exponential headway distribution developed by Schul (Greenshield and Weida, 1978), the geometric distribution, the Borel-Tanner distribution and the Miller distribution (Taylor, Miller and Ogden, 1974). In a high traffic flow condition when all vehicles are in a car-following state, Mei and Bullen (1993) explained that lognormal distribution is applicable to individual headways rather than the other models that were previously presented. This result was based on their study on two lanes of a four-lane freeway. Then, the headway distribution of the traffic stream had been shown to be well represented by the shifted lognormal distribution. More recently, Joubert and Van As (1994) demonstrated that the travelling queue distribution developed by Miller (1961) indicates an agreement with actual headways that consist of platoons.

The capacity of traffic facilities in which drivers are required to select a suitable size of gap for merging safely depends on the availability of acceptable gaps in the conflicting stream (Joubert and Van As, 1994). Consequently the priority junction traffic model selected should be one based on the headway distribution of the conflicting (major) stream at the study location, and which may consist of platoons (e.g. as a consequence of the effects of traffic signal operations).

3. PRIORITY JUNCTION MODELS EXAMINED

Joubert and Van As (1994) define the capacity of a movement at a priority controlled intersection as the mean departure rate of an infinite queue on the controlled approach. According to Al-Azzawi (1997), priority junction models can be grouped into two families: (1) theoretical models which use driver gap acceptance characteristics as well as traffic movements, and (2) models that use a junctions' geometric layout characteristics with traffic flow data to estimate turning capacities.

This paper only considers the first group of the models since these are generally used to evaluate unsignalised intersection performance (Troutbeck and Walsh, 1994). The best known models from the second group are Picady (which was developed at TRRL by Kimber and Coombe in the 1970s) and Transyt (also developed at TRRL, by Vincent, Mitchell and Robertson (Al-Azzawi 1997, p. 268).

The models considered in this study are Tanner's formula, the NAASRA model, the random platoon Tanner's formula, and the model developed by Siegloch and subsequently used in the 1994 US Highway Capacity Manual (HCM).

3.1. Tanner's Formula

One popular method for estimating unsignalised intersections is developed by Tanner in 1962. This method is based on the assumption that headways in the conflicting stream follow a shifted exponential distribution (Joubert and Van As, 1994).

The general form of Tanner's formula is as follows:

$$C = \frac{q_p(1-\beta q_p)}{1-\exp(-t_f q_p)} \exp(-q_p(t_a - \beta)) \tag{1}$$

where:
C = capacity (veh/s)
q_p = arrival rate of conflicting flow (veh/s)
t_a = critical acceptable gap (seconds)
β = minimum headway of conflicting flow (seconds)
t_f = move-up time (s).
Al-Azzawi (1997) indicated that Tanner's model may overestimate the capacities of minor road turning movements.

3.2. The NAASRA Model

The National Association of Australian State Roads Authorities (NAASRA, now known as Austroads) developed a model based on a simplified form of Tanner's formula, when the conflicting stream is assumed to be random (Austroads, 1991). The NAASRA model takes the theoretical absorption capacity (an upper bound on the number of vehicles per hour in a minor stream that can enter a major stream), then modifies this results to estimate a practical absorption capacity. The theoretical absorption capacity is

$$C_T = \frac{q_p \exp(-q_p t_a)}{1-\exp(-q_p t_f)} \tag{2}$$

and the NAASRA practical capacity is

$$C_p = 0.8 C_T \tag{3}$$

where
C_T = the theoretical absorption capacity, and
C_p = the practical capacity

Again, Al-Azzawi (1997) concluded that the NAASRA model may also overestimate the capacities of turning movements from the minor approach.

3.3 . The Random Platoon Tanner's Formula

This model was introduced by Tanner in 1967, then used by Troutbeck (Troutbeck and Walsh, 1994) and modified by Joubert and Van As (1994). It is based on the assumption that the conflicting stream headways contain a combination of the exponential distribution for non-following headways and a non-random distribution of following headways

Because the priority junction capacity depends on the availability of acceptable gaps in the conflicting stream, it was then assumed that only non-following gaps are considered as possible candidates for acceptance and no vehicle will accept a following gap. Thus, it was not necessary to investigate the exact form the non-random distribution of following headways. The maximum rate at which the minor stream vehicles can be absorbed into the major stream using these assumptions is:

$$C = \frac{q_p \phi \exp(-q'(t_a - \bar{h}))}{1 - \exp(-q' t_f)} \tag{4}$$

Joubert and Van As (1994) stated that a limitation of the Tanner's formula is the use of constant acceptable gap t_a, as opposed to a distribution of acceptable gaps. They then modified Tanner's capacity model for random platoons and resulted in the following new equation for the capacity of a priority controlled traffic stream:

$$C = \frac{q_p \phi \exp(-q'(t_a + f\delta - \bar{h}))}{1 - \exp(-q' t_f)} \tag{5}$$

where
C = capacity (vehicles/second)
ϕ = proportion of non-following vehicles in the major traffic stream
δ = standard deviation of distribution of critical gaps
f = an adjustment factor
$\bar{h}$ = average following headway
and

$$q' = \frac{\phi q_p}{1 - \bar{h} q_p}$$

Joubert and Van As tested this model by comparing its estimates of absorption capacity with those determined by microsimulation. It was assumed that the conflicting traffic stream consisted of platoons and that acceptable gaps followed a log-normal distribution. With the adjustment factor 0.35, the model significantly improved the estimation of capacity for the full range of parameters tested. The model also provided fairly acceptable result when applied to cyclic flows (result of traffic signals operation), although it was less reliable than the random platoons.

3.4 Siegloch's Method

Siegloch's work to determine the capacity on the minor stream approach is used in chapter 10 of the 1994 HCM (Kyte et al, 1994). The Siegloch model is a function of the major stream flow, the critical gap and the follow-up time. The critical gap and follow-up time is derived by using Seigloch's critical gap method. Siegloch's capacity model is given as follows:

$$C_p = \frac{3600}{t_f} \exp(-q_p \frac{t_0}{3600}) \quad (6)$$

where $t_0 = t_a - 0.5t_f$ and t_a, t_f and t_0 are in seconds.

Al-Masaeid (1995) tested Siegloch's method by comparing the actual and the estimation capacity of yield controlled streams at a one-way minor street crossing a one-way major street in Jordan. He concluded that Siegloch's method overestimates minor stream capacity even if critical gaps were estimated for local conditions and found that the empirical approach provided a realistic estimation (Al-Masaeid, 1995).

4. DATA COLLECTION

A U-turn median slot on Anzac Highway, a major radial arterial road in Adelaide, South Australia was selected as the study location for data collection. This site was chosen because:

- the study would not look at the effect of geometric parameters and traffic volume on the size of gaps accepted.
- the U-turn design at the site follows the Australian Standard which provides a protected U-turn lane and it is located on a carriageway with three through lanes.

The major data need for this study is data on vehicle headways, plus data for those headways that were rejected and those that were accepted by U-turning vehicles to merge with conflicting stream. These data were needed to measure the simulation capacity value, the critical gap and follow up time. The data were collected in four consecutive days, three days for analysis purpose and one day for validation purpose. About four hours of data were collected on each day. Major stream traffic volumes were estimated by taking the mean headways of all vehicles in the traffic stream in each observation interval.

According to Taylor et al (1996, p.243), measurement of critical gaps is accomplished in somewhat similar fashion to saturation flows measurement. It is based on observation of the headways between vehicles in a traffic stream. Data recording methods are also explained by Taylor et al (1996). The manual method using pencil, paper and stopwatch is still the most common method. Other methods of increasing interest include event recorders, video and portable computers. The advantages and the disadvantages of using these methods in saturation flow measurement are explained by Taylor et al (1996, p.2141), in which methods based on portable computers or video recording are recommended. In this study, because the U-turning vehicles volume was relatively low and only one minor movement had to be recorded, the portable computer method was selected.

The computer program used to collect field data in this study was SATFLOW, as developed by Cuddon (1992). This program enables a single observer to collect the data. SATFLOW is a saturation flow data collection and analysis software package that assists and coordinates real-time data input and performs preliminary data checks and saturation flow/headway analyses (Cuddon, 1992). The software has potential for other uses besides saturation flow data collection because it enables the collection of generic real-time vehicle data that may be used to calculate many other traffic flow parameters.

Originally, the software was configured to collect saturation flows data for two lanes in which vehicles on each lane can be classified into four different classes, car, light commercial, rigid truck and articulated truck. In this study, the headway data had to be collected from a three lane carriageway, plus the movement of minor stream vehicles. Thus SATFLOW could not help the data collection process if it was used in its original form. Since the study did not require classification of vehicles, it was decided to simplify the use of the software. The consequence of the modification was that the data analysis module in the software could not be used, and data analysis had to be done manually.

The keys provided by SATFLOW program were used to record the time of the conflicting stream vehicles on each lanes crossed screen line, the time of U-turning vehicles arrived at protected U-turn lane, and the time of U-turning vehicle crossed screen line. The keys used to record the time of the conflicting stream vehicles crossing the screen line were 'U' for vehicles on lane 1 (the closest lane to the median), 'I' for vehicles on lane 2 and 'O' for vehicles on lanes 3 (the closest lane to the footpath). Then, 'P' key was used to record the time of U-turning vehicles arriving at protected U-turn lane and 'J' key was used to record the time of U-turning vehicles crossing the screen line. At the end of each data collection 'Escape' key had to be pressed and the data would be saved automatically. To understand how to operate the SATFLOW software, the readers are referred to Cuddon (1992). Figure 1 shows a vehicle completing U-turn and the conditions of survey location.

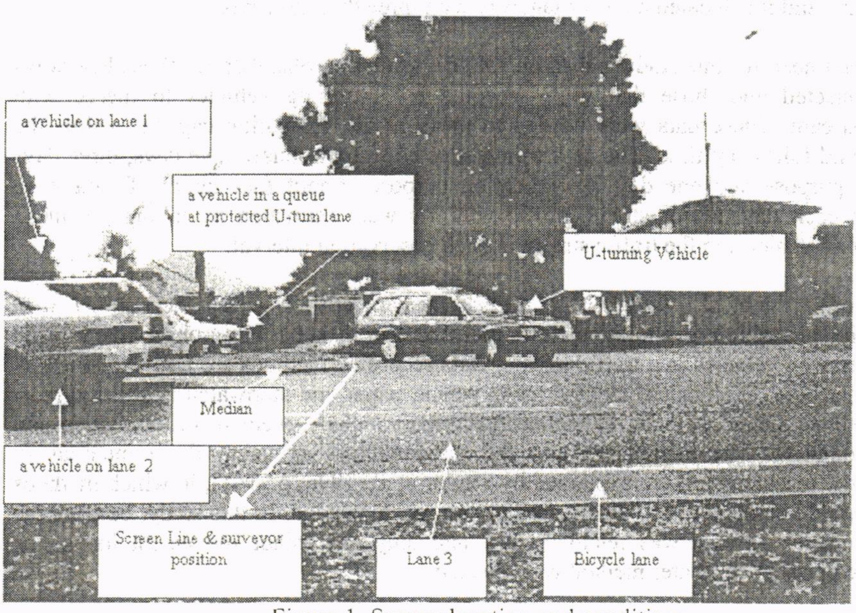

Figure 1. Survey location and conditions.

The modification in using the software had enable the following data to be collected:

- time headway
- number of vehicle on each lane
- accepted and rejected gap
- move-up time
- lag
- waiting time, and
- number of vehicles in the U-turn queue

5. ESTIMATION OF GAP ACCEPTANCE AND MOVE-UP TIME PARAMETERS

Several definitions of critical gap have been produced (e.g. see Wang (2000)); each of which affects the estimation methods for determining the critical gap value itself. In general, critical gap is defined as a suitable size of gap in the conflicting stream which allows drivers or pedestrians to make a safe accomplishment of the manoeuvre.

The Transportation Research Board (1985) defined the critical gap to be the median time headway between two successive vehicles in the major street traffic stream that is accepted by drivers in a subject movement that must cross and/or merge with the major street flow. Recently, Transportation Research Board (cited in Abou-Henaidy et al, 1994) modified the definition of the critical gap to include the 'minimum time interval between vehicles in a major traffic stream which permits one side-street vehicle at a stop controlled approach to enter the intersection'.

There are many articles in this field. One of most popular articles commonly used in studying gap acceptance is that by Miller (1972). In this article Miller made a comparative study of a selection of nine estimators of gap acceptance parameters. The methods investigated by Miller were Raff's method, probit analysis, Ashworth's method, Blunden, Clossold and Fisher's method, Drew's method, Dawson's method, Miller's method, McNeil and Morgan's method, and the maximum likelihood technique. Miller concluded that only Ashworth's method and maximum likelihood gave results with a satisfactorily small bias, and Ashworth's method was slightly less precise than maximum likelihood. Of the nine methods, Raff's method is still commonly cited in many textbooks and articles such as in Bennett (1999), Salter (1974) and Al-Azzawi (1997).

If there is a continuous queue in the minor stream, either Siegloch's method (which provides a direct link between gap acceptance theory and the definitions of these parameters (Kyte et al, 1994)) or the method recommended by Taylor, Young and Bonsall (1996, p.244) could be applied.

Meanwhile, Brilon, Troutbeck and Tracz (in Kyte et al, 1994) recommended the use of either the maximum likelihood technique or Ashworth's method if a continuous queue is not present on the minor stream, which was the situation found at the selected study location. To account for local conditions, some researchers and practitioners use an empirical approach to determine the size of critical gap, such as Al-Masaeid (1995 and 1999) and Abou-Henidi et al (1994).

According to Taylor et al (1996) the use of maximum likelihood method requires a significant amount of data about the size of largest rejected gaps and the size of the smallest accepted gaps. Because the study was not designed to compare gap acceptance estimation methods but rather to suggest one of the current priority junction models for determining U-turn capacity at median openings, the data available in this study was limited. Determination of the critical gap parameter was thus simplified by using the mean value of accepted gap.

Then, a limitation had to be decided to determine the accepted gap data that would be used in the mean accepted gap calculations, as not all of the data reflected critical gap parameters (e.g. gap sizes that were comparatively large). Firstly, the data considered being included in the mean calculation were only the size of gaps that were used by only one vehicle. Secondly, the size of gap that nobody will reject must be removed from the calculation. Thirdly the accepted gaps used in the calculation should follow a log-normal distribution since this distribution is widely accepted as a critical gap distribution, as stated by Troutbeck (1993), Taylor et al (1996), Cohen (in Miller, 1972) and Salter (1974). Then the mean value of log-accepted gaps is the gap acceptance parameter.

Based on the χ^2 test of goodness-of-fit, it was found that the accepted gap data fitted a log-normal distribution when gap sizes equal or larger than 13 s were eliminated from the analysis, with the probability between 0.25 and 0.10 (the computed χ^2 value is 14.63 with 15 degrees of freedom). The SPSS standard normal distribution also indicates the validity of this result.

The mean value of log-accepted gap less than 13 s is 0.81 and the standard deviation is 0.13. If these parameters are transformed back into their original then the mean value of accepted gap based on the gap acceptance parameter is 6.46s ($10^{0.81}$) and the standard deviation is 1.35 ($10^{0.13}$). A confidence interval test using a set of independent data indicates that the value of 6.46 s is valid as a gap acceptance parameter (95 per cent confidence interval). Figure 2 provides an indication of the agreement between the observed data and the true log-normal distribution.

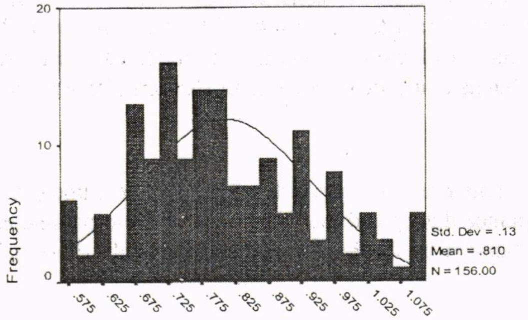

Figure 2. The histogram of log accepted gaps with its normal curve

In this study the distribution of move-up times is assumed to be the same as the accepted gaps distribution. The move-up time is defined as the difference time between a minor stream vehicle and the next vehicle in a queue crossing the screen line. After transforming the move-up time data into its logarithmic value, it was found that the mean of move-up time is 3.02 s ($10^{0.48}$).

6. SELECTION OF PRIORITY JUNCTION MODELS

In selecting priority junction models, again the χ^2 test of goodness-of-fit was employed. The two variables compared were observed capacities which were based on application of gap acceptance mechanism toward four sets of headway data, and estimated capacities which were based on the application of priority junction models with respect to the parameters calculated above.

The use of gap acceptance mechanism theory to determine an absorption rate is based on several assumptions (Taylor et al, 1996). Firstly the individuals behave consistently and are homogenous, secondly the main stream headways follow a negative exponential distribution, and thirdly there are always vehicles queued in the minor stream to take full advantage of every possible gap (there is an infinite queue on the minor stream). The other assumption which determines the observed capacity is for a given traffic situation where drivers require a gap greater than or equal to their critical gap before proceeding. When there are vehicles queued than an additional parameter is needed, this is 'move-up' time.

Because of the assumptions that drivers behave consistently and are homogenous then they require the same critical gap (t_a) and move-up time (t_f). Thus, all those assumption can be translated into the following set of possible events for the vehicle in the minor stream which:

- gaps less than t_a will not be accepted;
- gaps between t_a and $t_a + t_f$ will be used by one minor stream vehicle;
- gaps between ta + tf and ta + 2tf will be used by two minor stream vehicles, and
- in more general terms, gaps between $t_a + (i-1)t_f$ and $t_a + it_f$ will be used by i = 1, 2, 3, … minor stream vehicles.

Troutbeck and Walsh (1994) also used the above mechanism in their study of the difference between queueing theory and gap acceptance theory in estimating delay.

In order to calculate the observed capacity then a mathematical form of the above assumption may be written as follows. For all gaps $h_i \geq t_a$:

$$n_i = 1 + \frac{h_i - t_a}{t_f} \tag{8}$$

$$O_k = \frac{\sum_{i=1}^{k} n_i}{\sum_{i=1}^{k} h_i} \tag{9}$$

where
n_i = the number of vehicles which can use the size of gap $h_i \geq t_a$.
k = the number of headways $\geq t_a$.
O_k = observed/simulated capacity (vehicles per unit time)

An example may help to explain this formula. Consider the size of gap of 6 s with critical gap of 3 s and move-up time of 2 s. The value of 6 s lies within a range of $t_a + t_f$ (5=3+2) and $t_a + 2t_f$ (7=3+(2*2), then according to the above assumption this size will be used by 2 minor stream vehicles. By using equation (8) the number of minor stream vehicle is:

$$n = ((6-3)/2)+1 = 2.5 \approx 2 \text{ vehicles.}$$

The number of 2.5 means that the size of gap of 6 s will be used by 2 minor stream vehicles with remaining gap of $0.5t_f$ (1 s) being of insufficient size for use by another minor stream vehicle.

The traffic volumes of conflicting stream when the four sets of headways data were collected are 0.565 veh/s, 0.634 veh/s, 0.583 veh/s and 0.587 veh/s. In addition, capacity estimation using the random platoon Tanner's formula requires the proportion of non-following vehicles and the average headway of following vehicle. To be able to do so, the minimum free headway has to be decided. In this study a value of four seconds was used. This value was recommended by Hoban for Australian rural highways (in Taylor and Young, 1988) and also used by Joubert and Van As (1994) in their research. One assumption of the gap acceptance mechanism that the main stream headways follow a negative exponential distribution is also applicable for the random platoon Tanner's formula, as this formula only considers the free gaps or inter-platoon headways which are known to follow a negative exponential distribution (Joubert and Van As, 1994).

Table 1 shows the observed capacity volume (2) and the results of capacity estimation using the 5-priority junction' models selected and explained in the literature review. Those are Tanner's formula (3), the NAASRA's model (4), the random platoon Tanner's formula (5), the modified random platoon Tanner's formula (6) and Siegloch's method (7).

Table 1. Observed and estimated capacity values

Data set	Major stream traffic volume	Observed capacity	Estimated capacity values				
			Tanner's formula	NAASRA model	Random platoon Tanner's formula	Modified random platoon Tanner's formula	Siegloch's method
	(veh/s)	(veh/s)	(veh/s)	(veh/s)	(veh/s)	(veh/s)	(veh/s)
1	0.565	0.089	0.018	0.018	0.098	0.086	0.020
2	0.634	0.058	0.012	0.012	0.069	0.057	0.014
3	0.583	0.102	0.016	0.015	0.114	0.105	0.018
4	0.587	0.111	0.016	0.016	0.125	0.116	0.018

Notes:
1. Data set number 4 is the validation data set. Sets 1, 2 and 3 were used to estimate model parameters
2. Although the major stream volume for data set no 1 is the smallest, the lesser extent of platooning in this set meant that there were fewer U-turn opportunities and thus a lower capacity when compared with data sets numbers 3 and 4

This table shows that the models which are based on an assumption that conflicting vehicles (major traffic) arrive randomly seriously underestimates the acceptable gaps in the study area in which platooning occurs, even in the model which allows for a minimum headway.

The result of Tanner's formula which allow for a minimum headway is the same as the NAASRA model of absorption capacity, which was originally derived from Tanner's negative exponential distribution as well. This because the minimum headway in the conflicting stream was very short (mostly less than 0.1 s), and so had no influence on the computations. Furthermore, if the practical capacity of the NAASRA model was applied in which the absorption capacity must be multiplied by a value of 0.8, then the model more seriously underestimates the acceptable gaps in a conflicting stream.

Siegloch's model, which is currently used in the US HCM, gave slightly better estimates than the two models above, but it is still too far from the observed capacities. Of the five models examined, the random platoon Tanner' formula gave reasonably close estimates to observed capacities, as did the modified random platoon Tanner' formula. Based on the χ^2 test only the modified random platoon Tanner' formula is statistically acceptable.

The following results were found for the χ^2test calculations, with all traffic volumes converted into veh/h:

- Tanner's formula, $\chi^2 = 5281.47$ with three degrees of freedom
- NAASRA model, $\chi^2 = 5116.29$ with three degrees of freedom
- random platoon Tanner's formula, $\chi^2 = 18.88$ with three degrees of freedom
- modified random platoon Tanner's formula, $\chi^2 = 1.61$ with three degrees of freedom
- Siegloch's model, $\chi^2 = 4207.87$ with three degrees of freedom

The computed χ^2 for modified random platoon Tanner's formula is 1.61 (3 dof), indicating a probability between 0.75 and 0.50 that the model represents the capacity of U-turn. Then the model is strongly accepted to determine U-turn capacity at median openings. The additional explanatory power of the modified random platoon Tanner model compared to the original version is provided by the use of the standard deviation of acceptable gaps, which is multiplied by an adjustment factor. In this study, by trial and error it was found that an adjustment factor of 0.9 give the best result.

To strengthen the final conclusion a validation using a set of independent headway data was done. The process of observed capacity calculation was the same as in model selection. The observed U-turn capacity of Thursday data was 0.103 veh/s with conflicting traffic flow was 0.58 veh/sec. The value of 0.104 veh/s given by modified random platoon Tanner's formula is again indicating that the model is highly reliable to determine U-turn capacity at median openings.

7. CONCLUSIONS

On the basis of the analysis presented in this paper, the following conclusions may be drawn:

- The modified random platoon Tanner's formula is recommended as the priority junction traffic model which can be used to determine U-turn capacity at median openings. In addition the modified random platoon Tanner's formula could be used to determine capacity of any priority controlled intersection movements where platooning occurs in the conflicting stream. This model may be employed in intersection design where U-turns are important, as is the case for median openings. The limitation on the use of this model is the need to provide estimates of the proportion of following vehicles and the mean headway of following vehicles, but this study has clearly shown the necessity to account for platooning when estimating U-turn capacity

- As noted by Joubert and Van As (1994), the analysis also indicates that information on the headway distribution of the major traffic stream is very important in selecting a model to determine priority junction capacity. This is no less important than the determination of the acceptable gap and move-up time parameters. A bias of (say) 1 s in the acceptable gap parameter might have less effect in the difference between simulated capacity value and estimated capacity value than the effect of the wrong selection of estimation model to be used.
- Based on the model selected, it is clear that the distribution of traffic in Anzac Highway does not follow negative exponential distribution, but might follow a travelling queue distribution which can be modelled as a combination of the negative exponential distribution for non-following headway and a non-random distribution of following headways. Thus this study could also be used to describe the distribution of traffic.
- One point needs to be stressed about the modified random platoon Tanner's formula. This is that the model requires a standard deviation parameter. To get the standard deviation value, the acceptable gap parameter must be determined through a survey of observed traffic rather using a given value. An alternative method might be sought to remove the use of standard deviation of critical gaps and allow for the use of an adjustment factor. Further research is needed to determine appropriate values of adjustment factors. These factors may depend on factors such as the proportion of non-following vehicles, the mean platoon size, etc. Such investigations would widen the scope for the use of the modified random platoon Tanner model in practice.
- As also suggested by Joubert and Van As (1994), the modified random platoon Tanner model should be considered for future inclusion in a Highway Capacity Manual.

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