TRANSFORMATION OF JALAN KUALA KANGSAR AND JALAN KLEBANG SELATAN FROM UNSIGNALISED TO SIGNALISED INTERSECTION

NURULAKMA BT MD DESA

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ABSTRACT

During peak hour at study at location namely the intersection of Jalan Kuala Kangsar and Jalan Klebang Selatan we observed difficulties to the vehicles using the road due to the heavy turning movements. The intersection also is not in accordance with the design road standards. This will most likely result with occurrence of traffic accidents. Jalan Kuala Kangsar is the main route between the Ipoh city to Kuala Kangsar Town where Jalan Klebang Selatan is linking to residential estet. Road standard for Jalan Kuala Kangsar is of JKR R5 and Jalan Klebang Selatan is of JKR U3. The T-intersection unsignalised intersection had been in operation over the past 10 years. The purpose of this study was to obtain road capacity and evaluating the level of services (LOS) the intersection. This study will focus on not only on the traffic study but also on the transformation of an unsignalised intersection to a signalised intersection. In this study, traffic survey data of vehicles, direction of movement and road geometry data were collected. The survey shows that the number of vehicles passing warrant through the road exceeding 1500 vehicles per hour and this for the installation of traffic lights. Noon peak hour indicated the volume of lane. Transformation of Jalan Kuala Kangsar and Jalan Klebang Selatan from unsignalised to signalised is required because the existing intersection could not accommodate the number of vehicles that pass through the intersection exceed the volume allowable at an unsignalised intersection.

ABSTRAK

Setiap kali waktu puncak di lokasi kajian iaitu di persimpangan diantara Jalan Kuala Kangsar dan Jalan Klebang Selatan telah menyebabkan berlakunya kesukaran kepada kenderaan yang menggunakan jalan tersebut dalam melakukan pergerakan membelok. Selain daripada itu persimpangan tersebut tidak mengikut reka bentuk piawai jalan raya yang telah disediakan. Ini akan menyebabkan kemungkinan besar akan berlakunya kemalangan. Jalan Kuala Kangsar adalah merupakan laluan utama diantara bandar Ipoh ke Pekan Kuala Kangsar dimana Jalan Klebang Selatan menghubungkan kawasan kediaman. Piawaian jalan raya bagi Jalan Kuala Kangsar adalah JKR R5 dan Jalan Klebang Selatan adalah jenis JKR U3. Persimpangan T ini persimpangan tanpa lampu isyarat telah beroperasi sejak 10 tahun yang lalu. Tujuan kajian ini adalah untuk mendapatkan kapasiti jalan raya dan menilai tahap perkhidmatan persimpangan jalan tersebut. Kajian ini bukan hanya memberi tumpuan kepada persimpangan tanpa lampu isyarat tetapi juga mengenai transformasi persimpangan tanpa lampu isyarat kepada persimpangan berlampu isyarat. Dalam kajian ini, cerapan data kenderaan, arah pergerakan dan data geometri jalan di persimpan tersebut telah kumpul. Berdasarkan keputusan daripada cerapan data menunjukkan jumlah kenderaan yang melalui jalan tersebut melebihi 1500 kenderaan sejam dan amatlah wajar bagi pemasangan sistem lampu isyarat. Waktu puncak tengah hari menunjukkan jumlah kenderaan paling banyak menggunakan jalan tersebut. Tranformasi di Jalan Kuala Kangsar dan Jalan Klebang Selatan dari persimpangan tanpa lampu isyarat kepada persimpangan lampu isyarat berlaku kerana persimpangan sediaada tidak mampu menampung jumlah kenderaan yang melalui persimpangan tersebut melebihi jumlah yang dibenarkan bagi persimpangan tanpa lampu isyarat.

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LIST OF SYMBOLS

V_{15}	Volume during the peak 15 min of the peak hour (veh/15 min)
s	Saturation flow rate for subject lane group, expressed as a total for all lanes in lane group (veh/h)
s_o	Base saturation flow rate per lane (pc/h/ln)
f_w	Adjustment factor for lane width
f_g	Adjustment factor for approach grade
f_p	Adjustment factor for existence of a parking lane and parking activity adjacent to lane group
f_{bb}	Adjustment factor for blocking effect of local buses that stop within intersection area
f_a	Adjustment factor for area type
f_{LU}	Adjustment factor for lane utilization
f_{LT}	Adjustment factor for left turns in lane group
f_{RT}	Adjustment factor for right turns in lane group
f_{Lpb}	Pedestrian adjustment factor for left-turn movements
f_{Rpb}	Pedestrian-bicycle adjustment factor for right-turn movements
$t_{c,x}$	Critical gap for movement x
$t_{c,base}$	Base critical gap
$t_{c,HV}$	Adjustment factor for heavy vehicles (1.0 for two-lane major streets and 2.0 for four-lane major streets)
$t_{c,G}$	Adjustment factor for grade (0.1 for Movements 9 and 12 and 0.2 for Movements 7, 8, 10, and 11)
$t_{c,T}$	Adjustment factor for each part of a two-stage gap acceptance process (1.0 for first or second stage; 0.0 if only one stage)
$t_{3,LT}$	Adjustment factor for intersection geometry (0.7 for minor-street left-turn movement at three-leg intersection; 0.0 otherwise)

$t_{f,x}$	Follow-up time for minor movement x (s)
$t_{f,HV}$	Adjustment factor for heavy vehicles (0.9 for two-lane major streets and 1.0 for four-lane major streets)
c_{SH}	Capacity of the shared lane (veh/h)
v_y	Flow rate of the y movement in the subject shared lane (veh/h)
$c_{m,y}$	Movement capacity of the y movement in the subject shared lane (veh/h)

LIST OF ABBREVIATIONS

KK	Kuala Kangsar
KS	Klebang Selatan
PDW	Public Work Department
ATJ	Arahan Teknik Jalan
MHCM	Malaysia Highway Capacity Manual
RTVM	Road Traffic Volume Malaysia
LOS	Level of Service
V/C	Volume Capacity Ratio
BC	Bearing Capacity
N	No of lane
PHF	Peak Hour Factor
FLW	Lane Width Factor
FHV	Heavy Vehicle Factor
DHV	Design Capacity Analysis
V	Hourly volume (veh/h)
G	Percent grade divided by 100
N	Number of lanes in lane group
Td	Minimum length of pavement taper for diverging movement
Tm	Minimum length of pavement taper for merging movement
Yd	Lateral deflection of diverging traffic
Ym	Lateral deflection of merging traffic
V	Speed design
R	Minimum radius of curve in meters

V	Design speed in km/h
e	Maximum rate of superelevation
f	Maximum allowable side friction factor
M	Average number of right turning vehicles in a minute
S	Average headway in distance

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Intersection is one of most the important parts of a road system. This project is the intersection between Jalan Kuala Kangsar and Jalan Klebang Selatan near the city Ipoh. This intersection is unsignalised intersection and the type of intersection is T-junction. Road standard for the Jalan Kuala Kangsar is linking Ipoh to Kuala Kangsar while Jalan Klebang Selatan is linking to a residentials. The distance of the intersection to city Ipoh is 10.9km. The intersection had been in operation over the past 10 years and is experience traffic congestion from all approaches. Figure 1.1 and figure 1.2 above show the map location the study area and type of intersection.

Unsignalised intersection is a cross roads that is used to control the movement of traffic. It is the important role in determining the overall capacity of the road network. A lack of operating unsignalised intersection can affect adjacent signalized intersections. Therefore, it is important to ensure that the intersection is designed accordingly to prevent either below or above the design of the facility. The procedure of analysis of the state of the Malaysian roads needed to design the intersection unsignalised so capacity is always greater than the demand of traffic.

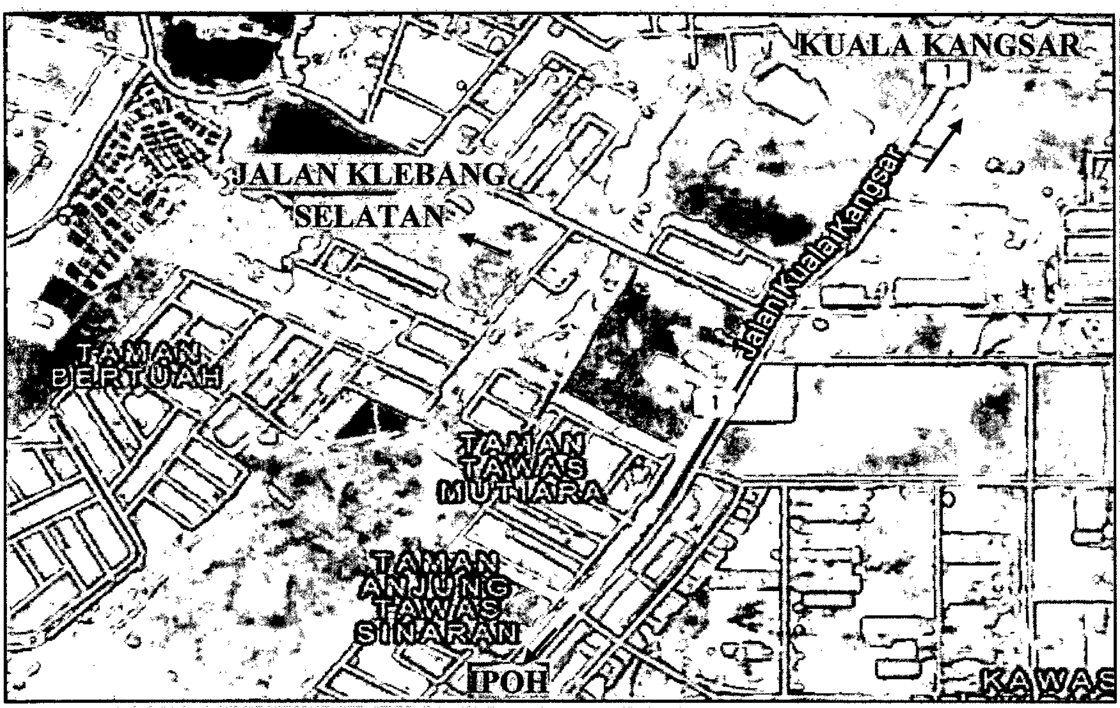


Figure 1.1: The map location Jalan Kuala Kangsar and Jalan Klebang Selatan

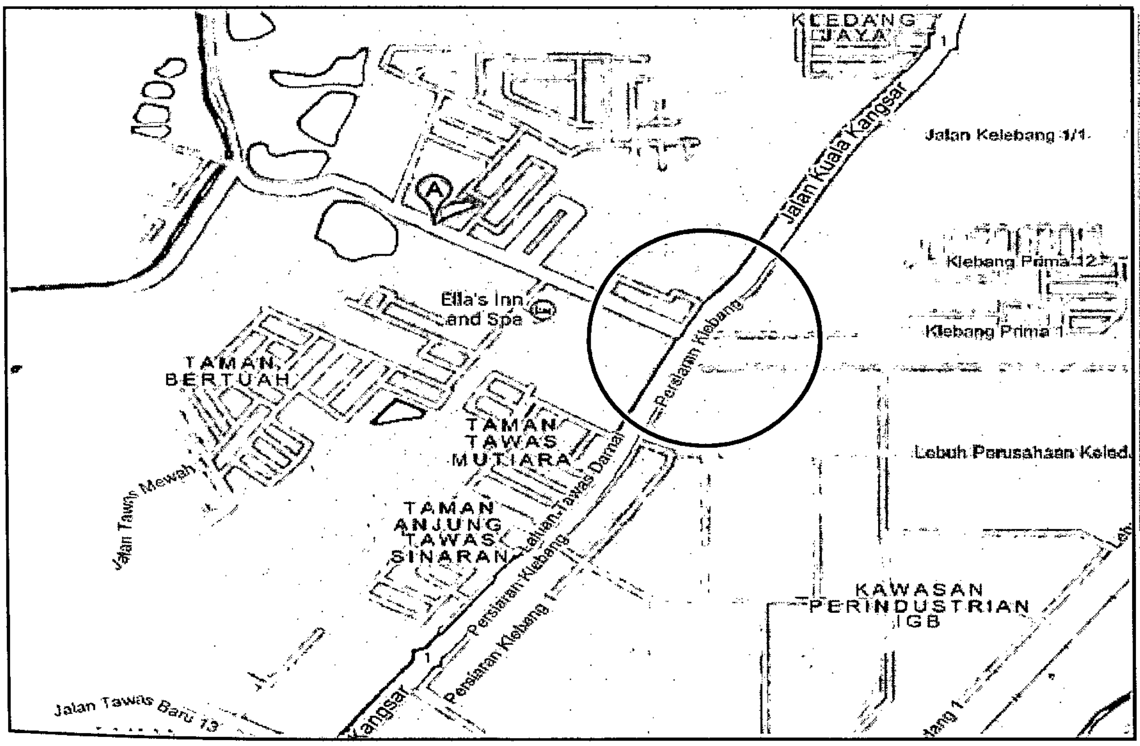


Figure 1.2: Type of the intersection is T-intersection

1.2 PROBLEM STATEMENT

Although, the intersection a meeting point of two or more roads intersect and it is designed to allow the driver to cross the traffic stream or switch from one stream to another stream to change the direction of movement. However, in the existing intersection have occurrence of difficulty to vehicles in doing turning movement during peak hours. Besides that, the intersection is not following road design standard.

1.3 OBJECTIVE OF STUDY

i. To determine the highway capacity and level of service (LOS) at intersection.
ii. To recommend the new design intersection following the design road standard.

1.4 SCOPE OF STUDY

The scope of this study includes the following:

i. Accumulate data volume traffic flow at the intersection.
ii. Monitor the intersection geometry.
iii. Estimation the new design intersection for suitability vehicle through the intersection.

1.5 RESEARCH SIGNIFICANT

This study is intended to identify existing conditions and identify workable intersection existing junction accommodate the increasing number of vehicles due to the increasing number of development units in the area. Besides that, it is also to identifying solutions to the problem.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Intersection is the important part of the road system. Their capacity controls the volume of traffic within the network system. The intersection is an area shared by two or more road whose main function is to provide for the change of route direction. Intersection very in complexity from a simple intersection it has only two roads crossing at the right angle to each other and for the complex intersection it has three or more roads cross within the same area.

The selection of the required design standard should start with make the assessment of the function the propose road. This should generally done by the Highway Planning Unit from Public Work Department (PWD). If there is an overlapping of function, the main function of the road shall be used for the selection criteria.

2.2 TRAFFIC FLOW PARAMETER

The basic variable such as volume or flow rate, speed and density can be used to describe traffic on any roadway. Volume or traffic flow is a parameter common to uninterrupted and interrupted flow facilities but speed and density is for primarily to uninterrupted flow. Volume or flow rate are measures the quantify amount of traffic passing a point on a lane during a given time interval. Volume is the total of vehicle that pass over a given point or lane and can be expressed of annually, hourly or subhourly period. Flow rate is the equivalent hourly rate at which vehicle pass over a given point or lane during a time interval of less 1 hour and usually 15 minute. Consideration of peak flow rates it is important in capacity analysis. Peak flow rate and hourly volume will be producing the peak hour factor (PHF) within the hour, computed by equation 2.1.

$$PHF = \frac{V}{4\,x\,V_{15}} \tag{2.1}$$

Where

PHF = peak-hour factor

V = hourly volume (veh/h)

V_{15} = volume during the peak 15 min of the peak hour (veh/15 min)

Convert a peak hour volume to a peak flow rate when the PHF is known in the equation 2.2.

$$v = V / PHF \tag{2.2}$$

Where

v = flow rate for a peak 15-min period (veh/h)

V = peak-hour volume (veh/h)

PHF = peak-hour factor

2.3 HIGHWAY CAPACITY MANUAL (HCM)

The capacity analysis will be conducted at two-way stop control (TWSC) intersection utilizes a clear description an understanding of the intersection of drivers on the minor or stop-controlled approach with drivers on the major street. Figure 2.1 shows the respective priority of traffic streams at a T-intersection. Subscripts 2, 3, 4 and 5 are the vehicle movement on the major street and subscripts 7 and 9 is vehicle movement on the minor street (C.Jotin Khisty and B.Kent Lall,2003).

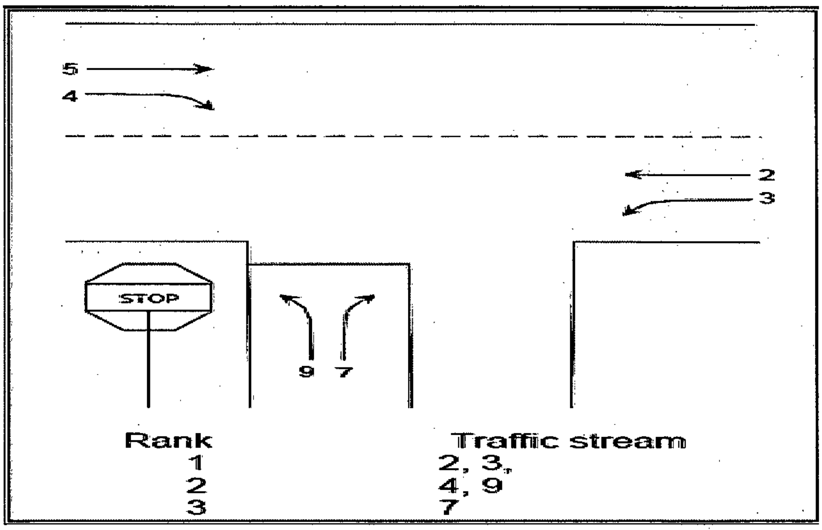


Figure 2.1: Traffic stream at a TWST Intersection

Sources: MHCM 2010

2.4 SATURATED FLOW RATE

The saturated flow rate is the flow in vehicle per hour that can be accommodated by each lane group, computed by equation 2.3.

$$S = so\ N\ f_w\ f_{HV}\ f_g\ f_p\ f_{bb}\ fa\ f_{LU}\ f_{LT}\ f_{RT}\ f_{Lpb}\ f_{Rpb} \tag{2.3}$$

Where

s = saturation flow rate for subject lane group, expressed as a total for all lanes in lane group (veh/h)

s_o = base saturation flow rate per lane (pc/h/ln)

N = number of lanes in lane group

f_w = adjustment factor for lane width

f_{HV} = adjustment factor for heavy vehicles in traffic stream

f_g = adjustment factor for approach grade

f_p = adjustment factor for existence of a parking lane and parking activity adjacent to lane group

f_{bb} = adjustment factor for blocking effect of local buses that stop within intersection area

f_a = adjustment factor for area type

f_{LU} = adjustment factor for lane utilization

f_{LT} = adjustment factor for left turns in lane group

f_{RT} = adjustment factor for right turns in lane group

f_{Lpb} = pedestrian adjustment factor for left-turn movements

f_{Rpb} = pedestrian-bicycle adjustment factor for right-turn movements

2.5 TRAFFIC CONFLICT

The each movement at a TWSC intersection has a different set of conflicts. The numbers conflict to compete through movement is 4, while competing to the right and through the movement is 8. The conflict between the right traffic is 4, and between the left and then merge the traffic is 4. Conflict by pedestrians is 8 taking into account all four approaches. Diverging traffic produces about 4 conflicts. Thus, a typical four-legged intersection has about 32 types of conflict. This is shown in Figure 2.2. This intersection is to resolve the conflict at the intersection for the safe and efficient movement of both vehicular traffic and pedestrians. Two methods of intersection control is sharing time and sharing space. Type of intersection control that should be adopted depending on traffic, road geometry, the costs involved, the importance of roads and others (Tom V. Mathew and K V Krishna Rao, 2006).

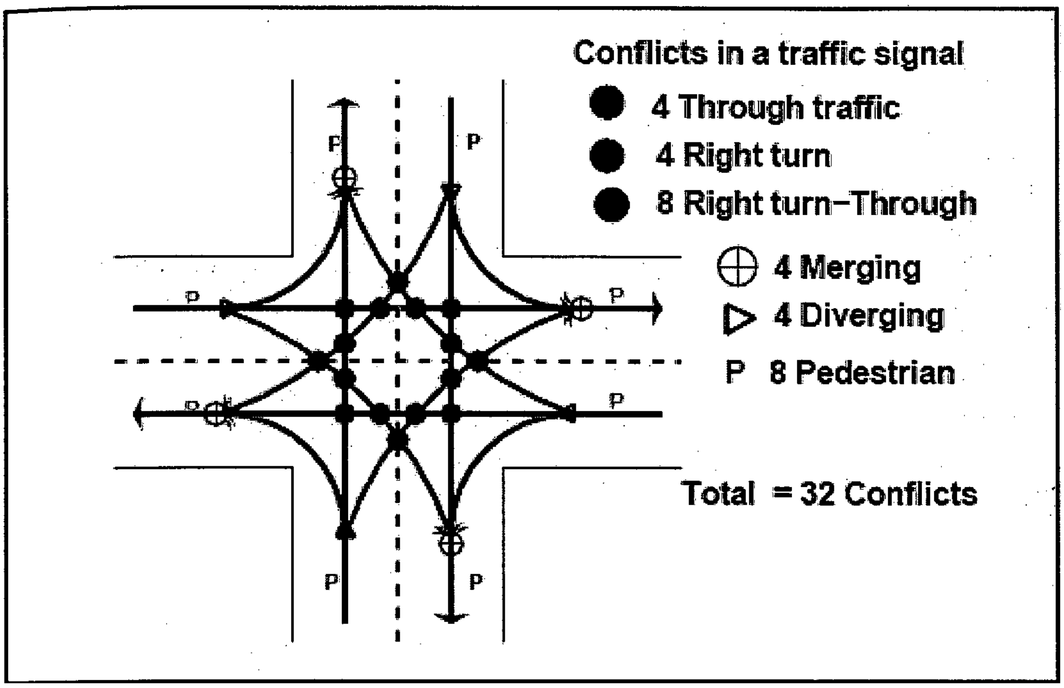
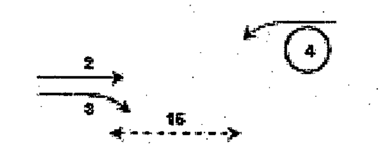
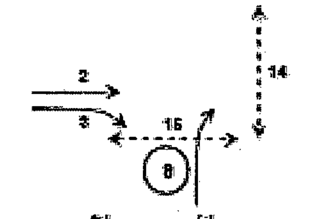
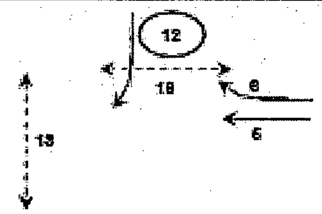
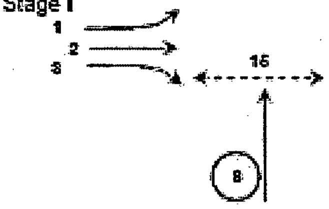
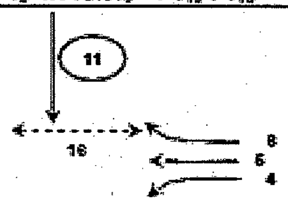
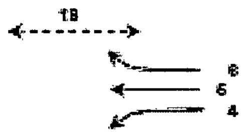
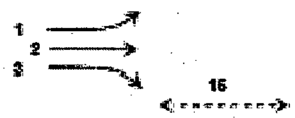
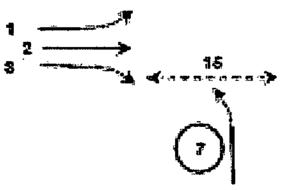
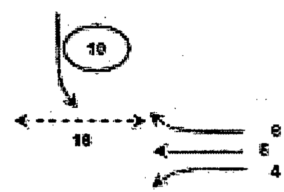
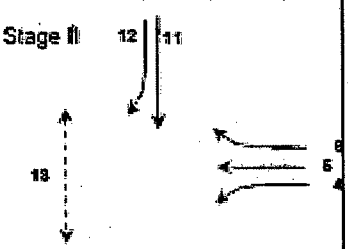
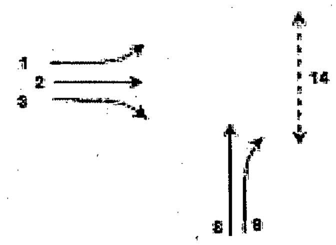


Figure 2.2: Conflict at an intersection

Table 2.1 show the conflict flow and find the conflict flow rate for each stage of a two stage gap acceptance process that takes place at some intersection where the vehicle store in median area.

Table 2.1: Definition and computation of conflicting flows (TRB, 2000)

Subject Movement	Subject and Conflicting Movements Conflicting Traffic Flows, $v_{c,x}$	
Major LT (RT in Malaysia) (1,4)	 $v_{c,1} = v_5 + v_6^{[a]} + v_{16}$	 $v_{c,4} = v_2 + v_3^{[a]} + v_{15}$
Minor RT (LT in Malaysia) (9,12)	 $v_{c,9} = v_2^{[b]}/N + 0.5v_3^{[c]} + v_{14} + v_{15}$	 $v_{c,12} = v_5^{[b]}/N + 0.5v_6^{[c]} + v_{13} + v_{16}$
Minor TH (8,11)	Stage I  $v_{cI,8} = 2v_1 + v_2 + 0.5v_3^{[c]} + v_{15}$	 $v_{cI,11} = 2v_4 + v_5 + 0.5v_6^{[c]} + v_{16}$
	Stage II  $v_{cII,8} = 2v_4 + v_5 + v_6^{[d]} + v_{16}$	 $v_{cII,11} = 2v_1 + v_2 + v_3^{[d]} + v_{15}$
Minor LT (RT in Malaysia) (7,10)	Stage I  $v_{cI,7} = 2v_1 + v_2 + 0.5v_3^{[c]} + v_{15}$	 $v_{cI,10} = 2v_4 + v_5 + 0.5v_6^{[c]} + v_{16}$
	Stage II  $v_{cII,7} = 2v_4 + v_5/N + 0.5v_6^{[d]} + 0.5v_{12}^{[e,f]} + 0.5v_{11} + v_{13}$	 $v_{cII,10} = 2v_1 + v_2/N + 0.5v_3^{[d]} + 0.5v_9^{[e,f]} + 0.5v_8 + v_{14}$

Sources: HCM

2.6 CRITICAL GAP AND FLOW UP TIME

The critical gap is to define the minimum time interval in the major street traffic stream and the estimation of critical gap can be made on basic of observation of the largest rejected and smallest accepted gap for the intersection. Follow up time is the time between the departure of one vehicle from minor street and the departure of the next vehicle the same street gap and it under a condition of continuous queuing on minor street. The critical gap computed by equation 2.4 in separately for each minor movement.

$$t_{c,x} = t_{c,base} + t_{c,HV} P_{HV} + t_{c,G} G - t_{c,T} - t_{3,LT} \qquad (2.4)$$

Where

$t_{c,x}$ = critical gap for movement x
$t_{c,base}$ = base critical gap
$t_{c,HV}$ = adjustment factor for heavy vehicles (1.0 for two-lane major streets and 2.0 for four-lane major streets)
P_{HV} = proportion of heavy vehicles for minor movement
$t_{c,G}$ = adjustment factor for grade (0.1 for Movements 9 and 12 and 0.2 for Movements 7, 8, 10, and 11)
G = percent grade divided by 100
$t_{c,T}$ = adjustment factor for each part of a two-stage gap acceptance process (1.0 for first or second stage; 0.0 if only one stage)
$t_{3,LT}$ = adjustment factor for intersection geometry (0.7 for minor-street left-turn movement at three-leg intersection; 0.0 otherwise)

The adjustments are made for the present of heavy vehicle. The follow up time is computed by equation 2.5 for each minor movement.

$$t_{f,x} = t_{f,base} + t_{f,HV} P_{HV} \qquad (2.5)$$

Where

$t_{f,x}$ = follow-up time for minor movement x (s)

$t_{f,base}$ = base follow-up time

$t_{f,HV}$ = adjustment factor for heavy vehicles (0.9 for two-lane major streets and 1.0 for four-lane major streets)

P_{HV} = proportion of heavy vehicles for minor movement

2.7 CAPACITY AND LEVEL OF SERVICE OF INTERSECTION

Capacity analysis tries to give a clear understanding of how much traffic a given transportation facility can accommodate. Level of service tries to answer how good the present traffic situation on a given facility (Tom V. Mathew and K V Krishna Rao, 2006).

Interrupted traffic flow conditions predominate on most urban roads. Generally, it is the major intersections, signalised or not, which determine the overall capacity and performance of the road network. Significant volume of crossing or turning traffic at minor roads cause, interruptions and capacity reductions which can be lessened by channelisation and intersection control. The capacities of intersections are very important and to achieve balance, the intersection design should take into account the capacity of the approach roads (Arahan Teknik Jalan (5/85)). Capacity is independent of demand in the sense that it does not depend number of vehicle demanding services.

2.7.1 Capacity

Capacity is defined as the maximum number of vehicles, passengers, or the like, per unit time, which can be accommodated under given conditions with a reasonable expectation of occurrence (Tom V. Mathew and K V Krishna Rao, 2006).

2.7.2 Level of Services (LOS)

Level of Service is a qualitative measure of the effect of a number of factors, which include speed and travel time, traffic interruptions, safety, driving comfort and convenience and operating costs (Arahan Teknik (Jalan) 5/85). For a given road or facility, capacity could be constant. But actual flow will be different for different days and different times. The intention of LOS is to relate the traffic service quality to a given flow rate of traffic. It is a term that designates a range of operating conditions on a particular type of facility. Highway capacity manual (HCM) developed by the transportation research board of USA provides some procedure to determine level of service. It divides the quality of traffic into six levels from level A to level F. Level A represents the best quality of traffic where the driver has the freedom to drive with free flow speed and level F represents the worst quality of traffic (Tom V. Mathew and K V Krishna Rao, 2006). The required level of service is show in table below.

Table 2.2: Level of service (LOS)

Level of Service (LOS)	Unsignalized Intersection Control Delay (sec/veh)	Signalized Intersection Control Delay (sec/veh)
A	≤ 10	≤10
B	> 10 - ≤ 15	> 10 - ≤20
C	> 15 - ≤25	> 20 - ≤35
D	> 25 - ≤35	> 35 - ≤55
E	> 35 - ≤50	> 55 - ≤ 80
F	> 50	> 80

Sources: MHCM 2010

2.7.3 Factor Effecting Level of Service

Level of service one can derive from a road under different operating characteristics and traffic volumes. The factors affecting level of service (LOS) such as:

1. Speed and travel time
2. Traffic interruptions/restrictions
3. Freedom to travel with desired speed
4. Driver comfort and convenience
5. Operating cost.