Birmingham City Council

A summary of the recommendations for the calculation of Saturation Flows at Traffic Signals.

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1 Introduction

1.1 There has been considerable discussion on the values to be attributed to saturation flow and how to examine proposals submitted to Birmingham City Council.

1.2 This report sets out the “standard” values, which are recommended for saturation flows at traffic signals.

2 Summary

2.1 The saturation flow at traffic signals is frequently calculated solely on the width of the stop line, resulting in optimistic calculations of capacity.

2.2 Saturation flows have to be calculated based on how people will use the junction, not on a measurement applicable to a few metres of carriageway.

2.3 Saturation flow is dependant on:
   - Whether there are turning vehicles to be considered
   - What effect vehicles in an opposing direction will have
   - Vehicle flows and destinations
   - Traffic signal staging

2.4 Saturation flow is NOT dependant on:
   - Lane width
   - Gradient

   to any significant degree
3 Calculation of Saturation Flows

3.1 Calculations for an approach should be on a lane by lane approach and may be summated if appropriate, for an approach.

4 Unopposed Approach

Defined as a lane where drivers will NOT encounter vehicles turning across their path

a) Straight on lane no turning traffic  
   2080 pcu/h

a) Straight on lane with less than 10% turning traffic  
   1940 pcu/h

c) Straight on lane with more than 10% turning traffic  
   Scale the extra-over turning traffic flow by 1.125 to derive an equivalent flow. (this applies to left and/or right turning traffic)

d) Where the percentage of turning traffic is high, the use of shared ahead and right turn lanes shall be justified. Non turning traffic may be put off by the perception of possible delay. There is no specific standard, but if more than 15% of the traffic in that lane is turning, questions should be asked.

e) Exclusive turning lanes, the saturation flow of each lane is determined by:

\[ S(r) = \frac{S_a}{(1+1.5/r)} \]

This only applies when the lane is unopposed. Ref. 2

Definitions:

S(r) is the Saturation flow in pcu, applicable to the turning lane being considered (a judgement has to be made as to whether a) or b) above applies)

S(a) is the Saturation flow in pcu of an equivalent ahead lane

r is the mean radius of the turning lane in metres

f) Adequate space shall be allowed for turning vehicles without interference between lanes, not less than 5 m on the crown of the bend.
5 **Opposed approach**

Defined as a lane where drivers **will** encounter vehicles turning across their path

a) **Straight on lane**, where the opposing direction of flow contains right turning vehicles 1850 pcu/h

b) **Shared straight on and right turn lane.** The use by straight on traffic is dependent on right turning vehicles being stored to avoid interference. Designers must justify their assumptions where shared lanes are proposed.

c) **Right turn lanes saturation flow:**

\[ Sr = 1286 - 0.78Qst \] pcu/h

Where Qst is the opposing flow in pcu **during** the traffic green.

As the opposing flow is not known initially, it will be necessary to iterate and to re-calculate if alternative cycle times are considered.

Above an opposing flow rate of 1800 pcu, there is no right turn flow during the green and hence no saturation flow.

In a design calculation, this can be spotted by noting that the opposing flow is one of the “critical” flows used in calculating the cycle time and green splits.

**NB** these are flow rates during the green, not flow expressed as a rate per hour.

6 **Roundabouts**

a) Saturation flows should be determined on the basis of the radius of the relevant lane.

b) The flow assigned to each lane **MUST** be determined from an analysis of origin and destination. Where three lanes are present, the offside lane, i.e. the lane adjacent to the island, will be lightly used. The assignment of specific flows to specific lanes must be justified.
c) Specific attention must be given to queue lengths, to prevent the site locking up.

7 Lane Width

a) Unless the lane width is significantly wider than normal for 150 m before the junction and 120 m after the junction, no allowance for lane width shall be made.

b) No lane less than 2.5 m width shall be considered.

c) Lane width on turning movements at the crown of the bend shall be not less than 5 m.

8 Local Widening

a) In a lane provided for local widening at the stop line the headway each vehicle requires is on average 7 m.

b) If there is no viable exit from the extra lane there will be no benefit from the widening. (This is applicable to those cases where the exit has no local widening, whilst the entrance has. The lane will act as an exclusive turning lane.)
Worked Example

In this example:

a) The signals are to operate with two stages only.

b) The right turn flow in lane A2 does not exceed 70 vehicles per hour and as can be seen, there is sufficient space for at least two vehicles to safely wait to turn right.

c) The left turn from the main road lane B3 is substantial in the PM at about 600 vehicles, which is not sufficient for the lane to become an exclusive left turn lane.

c) The left turn in lane C3 is only a hundred or so an hour.

Thus the saturation flows are:

A1 an unopposed straight on lane, with no turning traffic 2080 pcu/hr
A2 a straight on lane with less than 10% turning traffic 1940 pcu/hr
B1 a straight on lane where the opposing lane A2 has right turning traffic 1850 pcu/hr

B2 as for B1 1850 pcu/hr

B3 the controlling section of carriageway for approach B is the two lanes before the left turn.

Thus all the left turn flow in B3 has to be added to the straight on flow in B1 and B2 when calculating the timings for the main junction.

If the numbers increase substantially, then a view will have to be taken as to when B2 becomes a local widening, because on the approach before the left turn, all vehicles in the nearside lane are destined for the left turn B3.

C1 an exclusive right turn lane $S(r) = \frac{2080}{1+1.5/r}$  1680 pcu/hr

C2 equivalent to a local widening only, because there is only storage from the end of the bus lane for 4 vehicles average headway when stationary of 7 m.

With a 90 sec. cycle time an extra 160 vehicles would use this lane.

This number will change with the cycle time.

C3 only the odd left turning vehicle at the head of the queue will be able to take any advantage of this lane 0 pcu/hr

It should be noted that these values are only relevant for the flow Conditions described.

For instance:

a) Change the number of right turn vehicles in A2 and A2 may become an exclusive right turn lane.

b) Remove the bus lane and C2 becomes a full right turn lane with the same capacity as C1, providing that there is not less than 10 m (space for two lanes) on the crown of the right turn.

In other words saturation flows are appropriate for the conditions considered and are not an inherent property of an approach. With changes in flow or staging as well as layout, they may change and should be reassessed.
**NB** For the purpose of manual calculations, A1 and A2 as well as B1 and B2 may be added before calculating the degree of saturation.

Signal calculation programmes such as LINSIG will accept C3 as a length of local widening and calculate the number of vehicles able to make use of the space for each cycle time selected. On manual calculations this has to be done separately.