Congestion Monitoring in Nottingham using Permanent Count Sites

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Abstract— *Permanent count sites are widely used for congestion monitoring in Nottingham. This project is aimed at urban congestion monitoring using permanent count sites during evening peak hours. "Congestion" does not have a fixed definition due to its subjectivity; therefore a definition for congestion is presented. Accuracy of loop detectors was analysed. Methodology was formed to estimate space mean speeds. Relationships between parameters and fundamental parameters suggested that space mean speeds could be used as a congestion monitoring parameter.*

Keywords— Space mean speed, Time mean speed, Occupancy, Flow, Free flow speed, Concentration, Jam concentration

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I. INTRODUCTION

The report is aimed at addressing urban congestion, in Nottingham during evening peak hours, and the methods it can be measured and managed using permanent count sites. In order to discuss congestion in urban roads of Nottingham, a standard definition for "congestion" has been presented.

After that the collected data was analysed to evaluate the reliability of the count site data collected by Nottingham Traffic Control Centre (NTCC). Subsequently the present congestion monitoring technique used by NTCC was used to categorise congestion at count sites.

Therefore a methodology was formed to estimate space mean speeds. Space mean speed estimations was compared with time mean speed and occupancy. The results were analysed to check the correlation, enabling to produce equations for each count site with their free flow speeds and jam concentrations.

Finally relationships between fundamental parameters were analysed to check the possibility of using space mean speeds from permanent count sites as a congestion monitoring parameter.

II. AIMS AND OBJECTIVES

A. Definition for congestion

Firstly, the term "congestion" should be defined since it does not have a fixed definition due to its subjectivity. Therefore a definition for congestion was produced with respect to levels of services for classifying traffic which can be used to detect and describe traffic.

B. Accuracy of Permanent Count Site Data

This analysis is aimed at congestion monitoring using loop detectors installed at permanent count sites. Data from count sites are used to collect both real-time operation data as well as to collect census data such as Average Annual Daily Travel (AADT). Therefore the data from count sites should be reliable. After that manual and loop detector data count check and historical count check analyses were carried out at University and Castle Boulevard, east and west bound count sites, in order to check the reliability of data from these count sites.

C. Analyses of Permanent Count Sites

Firstly an analysis was carried out to check the method NTCC uses to measure congestion by checking occupancy levels with the levels of congestion. Secondly, to verify if the loop detectors are capable to be used with speed estimations, a spot speed survey was carried out using a radar gun. Time mean speed estimations were found for each 5 minute interval which was compared with loop detector data.

D. Space Mean Speed Estimation

The permanent count sites in Nottinghamshire uses

conventional inductive loop detectors. They are laid as single loops by lane where no overtaking occurs, or with middle loop straddling lanes where overtaking occurs. They measure the time taken by a vehicle to pass over the loop. The present congestion monitoring method used by NTCC uses occupancy to classify congestion and conveys traffic information to the public via congestion maps in their website. The general public is more familiar with speed rather than the occupancy (Ω). Therefore space mean speed (V_s) had to be estimated from count sites. This was made possible using the equation $V_s=qL/\Omega$ (Coifman et al, 2009).
The mean vehicle length (L) was estimated using the vehicle length estimates and using the classifications during the manual count survey to determine proportions of each category. Some assumptions were used during the process. Then space mean speed estimations were determined using occupancy and flow rate (q) data from NTCC.

E. Congestion Monitoring Using Space Mean Speed

Analyses on space mean speed versus other parameters were carried out to check if the space mean speeds at permanent count sites would be a representation of the vehicle speeds on the link.
An evaluation was carried out to check the possibility of using space mean speed as a congestion monitoring parameter at count sites. Each count site was checked for the relationship of space mean speed with the occupancy and an equation was formed for each count site.

F. Relationships Between Fundamental Parameters

Fundamental flow diagrams are used to determine the efficiency of the road section. They consists three graphs: speed-concentration, flow-concentration, and speed-flow. Therefore estimation for concentration (k) was sought using Ω=Lk (Abdulahi et al, 2004).

III. RESULTS

A. Definition For Congestion

A definition for congestion was sought by measured occupancy of the count site. The classifications are as follows: Free Flow: There is little or no disruption of traffic congestions. Stable Flow: Traffic flow is noticeably affected. Unstable Flow: Traffic queues begin to form. Forced Flow: Traffic flows approach jam conditions resulting very little or no movements.

As the collected data showed the occupancy values from count sites were directly proportional to congestion levels. When occupancy levels of the road section was over 30% unstable or forced flow conditions occurred, and when the occupancy levels were 30% or less free flow conditions occurred.

Comparison of collected data and occupancy values from NTCC suggested that congested flows are present in Westbound direction and free flows present in Eastbound directions from 15.00 H to 18.00 H.

B. Accuracy of Permanent Count Site Data

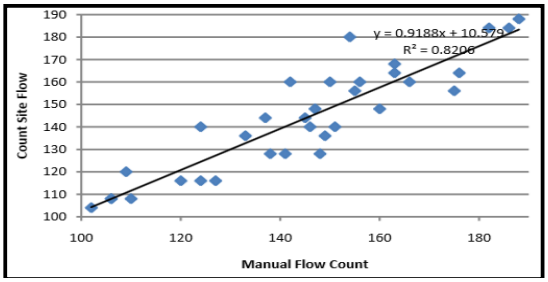

Figure 1. West bound count site flow versus manual flow

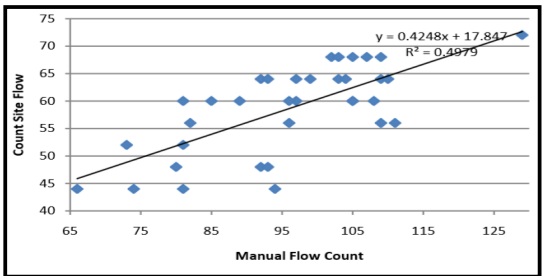

Figure 2. Castle boulevard East bound count site flow versus manual flow

As Figure 1 shows the count sites in westbound direction showed positive correlation between the two data suggesting the data from westbound count sites are reliable. Meanwhile Castle boulevard Eastbound loop detectors did not show any correlation as presented in Figure 2. Hence another analysis was conducted to check the correlation between count site data and historical data. Same results were obtained with a vast variation between flow counts. Therefore it was concluded that permanent count site in Castle boulevard East bound direction was faulty and needed to be replaced or repaired. Although further analysis was carried out assuming the data collected from all four count sites were error free.

IV. ANALYSES OF PERMANENT COUNT SITES

A. Occupancy as a Measure of Congestion

NTCC occupancy data was checked with the levels of congestion in the definition produced. Results showed that the occupancy and the levels of congestion are directly proportional, which proves that the method used by NTCC is effective. When the occupancy levels of the road section was higher (over 30%), unstable or forced flow conditions occurred. When the occupancy levels were 30% or less free flow conditions occurred.

B. Time Mean Speed versus Occupancy Comparison

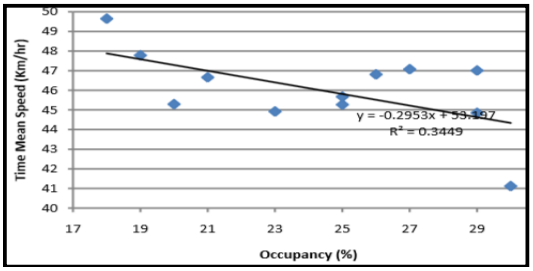

Figure 3. Time mean speed versus occupancy

Figure 3 shows the relationship between occupancy and speed is inversely proportional as expected. This correlation shows that loop detectors are able to measure time mean speed estimations of vehicles passing over them.

C. Congestion Monitoring Using Space Mean Speed and Time Mean Speed

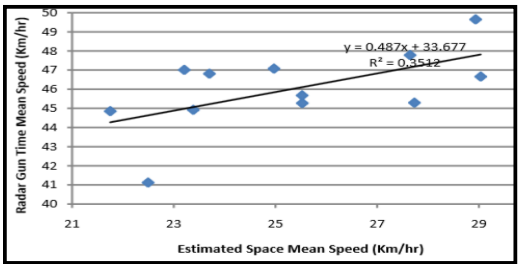

Figure 4. Graph of time mean speed versus space mean speed

Figure 4 shows that the time mean speed measured by the speed radar gun is higher than the estimated space mean speed data. The analysis conducted on the loop detectors showed the expected relationships proving that time mean speed has a direct proportionality to space mean speed, and time mean speed is higher than space mean speed. This indicates the estimated space mean speed values at loop detectors could be used as a parameter for congestion detection.

D. Space Mean Speed versus Occupancy Comparison

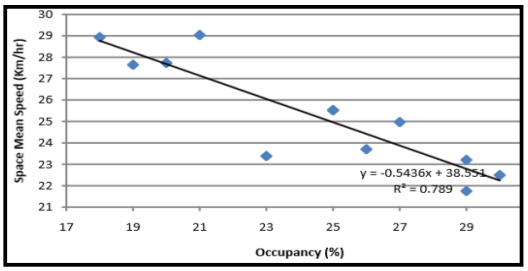

Figure 5. Space mean speed versus occupancy at University boulevard Eastbound count site

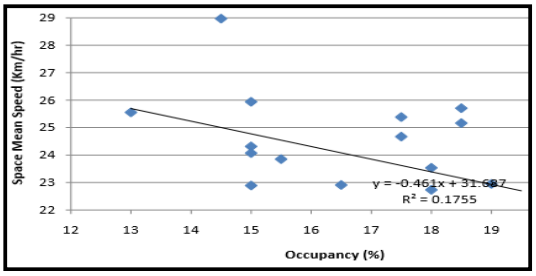

Figure 6. Space mean speed versus occupancy at Castle boulevard Eastbound count site

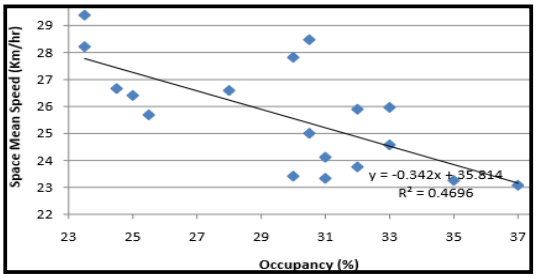

Figure 7. Space mean speed versus occupancy at Castle boulevard Westbound count site

Figures 5,6 and 7 clearly shows there is an inverse proportionality between occupancy and space mean speed as expected. Using these graphs it was possible to estimate equations to monitor congestion using space mean speeds. The formulas determined for each count sites as presented in Table 1.

Table 1. Space mean speed and occupancy equation for each count site

Figure	Countsite	Equation
5	U/B East	V_s=-0.5436Ω+38.551
6	C/B East	V_s=-0.461Ω+31.687
7	C/B West	V_s=-0.342Ω+35.814

V. Relationships between Fundamental Parameters

A. Speed versus Concentration Relationship

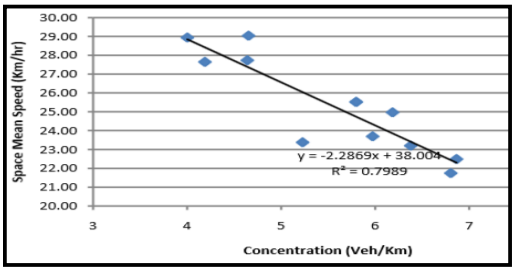

Figure 8. Space mean speed versus concentration at University boulevard Eastbound count site

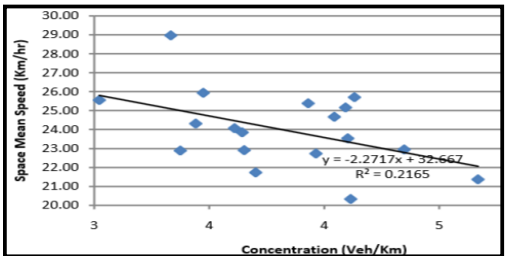

Figure 9. Space mean speed versus concentration at Castle boulevard Eastbound count site

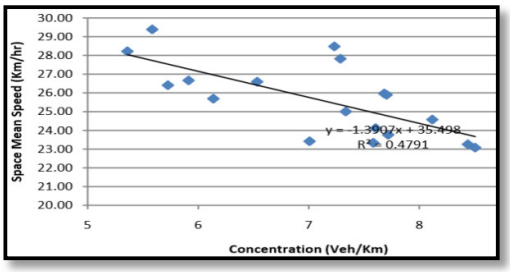

Figure 10. Space mean speed versus concentration at Castle boulevard Westbound count site

As in Figures 8,9 and 10 it could be seen that the space mean speed reduces as concentration increases. The data collected from the count sites shows a linear relationship which suits the road category. The free flow speeds occur when concentration is 0 and jam concentrations occur when Space mean speed reach 0. Therefore free flow speed and jam concentration could be estimated from the equations presented in Table 2.

Table 2. Free flow speeds and jam concentrations of count sites

Fig	Count site	Equation	Free flow speed (Km/hr)	Jam concentration (Vehicle/ Km)
8	U/B East	Y=-2.287x+38	38	17
9	C/B East	Y=-2.272+32.667	32.7	14
10	C/B West	Y=-1.391+35.498	35.5	26

B. Flow Rate versus Concentration Relationship

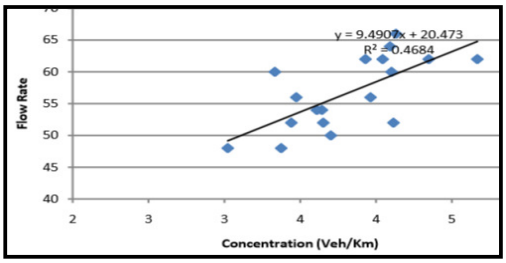

Figure 11. Flow rate versus concentration at Castle boulevard Eastbound count site

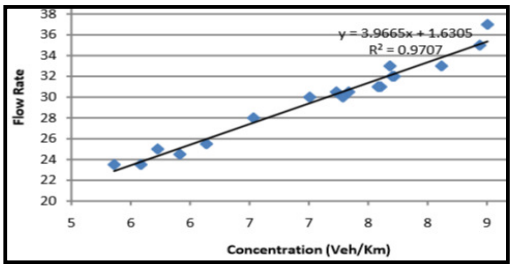

Figure 12. Flow rate versus concentration at Castle boulevard Westbound count site

The data collected are insufficient to check the capacity (where q_{max} is achieved) in both East and West bound count sites. In order to obtain a complete graph with full range more data should be collected during different times of the day which would enable to analyse free flow and congested flow conditions.

C. Speed versus Flow Relationship

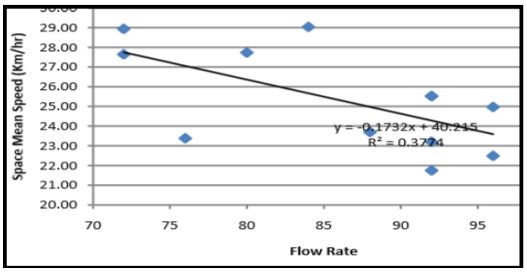

Figure 13. Space mean speed versus flow rate at University boulevard Eastbound count site

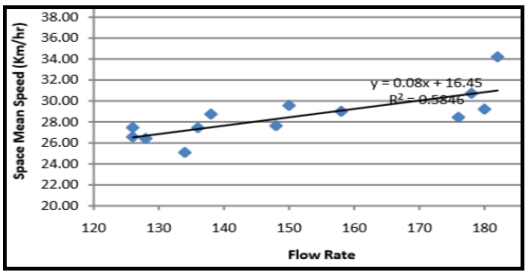

Figure 14. Space mean speed versus flow rate at University boulevard Westbound count site

As Figure 13 shows maximum flow rate of University boulevard Eastbound tends to achieve at 24 Km/hr with 95 vehicles/h. As Figure 14 maximum flow rate of University boulevard Westbound tend to attain at 32 Km/h with 180 vehicles/h.

VI. CONCLUSIONS

Castle Boulevard Eastbound count sites were found faulty and are recommended to be serviced or replaced. The analyses conducted showed positive results in using permanent count sites for congestion monitoring, and using space mean speed estimations as a congestion monitoring parameter. It showed that more results could be obtained using speed as a congestion monitoring parameter instead of using occupancy. The data collection on mean vehicle length would have been improved if a camera was used for length estimations; during spot speed surveys. If the analyses were to be improved more data should have been collected during a longer time span which could have given more realistic curves for flow rate versus concentration and for speed versus flow relationships rather than linear curves.

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