

# **EFFECT OF ON-STREET PARKING ON TRAFFIC SPEEDS**

**Gautham Praburam**, MET, BEng  
Assistant Engineer, TDG, Hamilton  
Email: *gautham.praburam@gmail.com*

**Glen Koorey**, PhD(Trptn), ME(Civil), BE(Hons), BSc, MIPENZ  
Senior Lecturer, Dept. of Civil and Natural Resources Engineering  
University of Canterbury, Christchurch  
Email: *glen.koorey@canterbury.ac.nz*

## **ABSTRACT**

The purpose of this study was to collect and analyse data to determine the extent that traffic flow (notably speed) is affected by on-street parking. Similar studies were done previously on major arterial roads; this research was concentrated mainly on local streets. Ten roads in Christchurch of various widths were chosen, between 8m and 13m. Sites that had only on-street parking as the main hindrance to traffic flow were chosen, for the purpose of obtaining clear relationships.

Observed speeds were recorded at various parking demand levels and then analysed. The results showed that the vehicular speeds fell noticeably with an increase in parking levels. On average, there was approximately a 10km/h reduction in mean speeds between empty and full on-street parking levels. An even bigger effect was noted in 85<sup>th</sup> percentile speeds. The magnitude of fall in speed varied only slightly based on the road widths.

Further research, by increasing the number of sites and performing speed surveys for more parking levels at the same sites, may yield more accurate results. This may be useful for policy makers to consider the role of on-street parking as part of their local area speed management strategies.

## 1 INTRODUCTION

Traffic speeds are a growing concern in New Zealand for safety reasons (MOT 2010) and there is a lot of interest in street treatments that can influence driver speeds. One factor that may affect driver's choice of speed is the presence of on-street parking (whether continuous or intermittent), which can narrow the perceived available width of the road ahead.

This study aims to provide an insight about the effect of on-street parking on the speeds of moving traffic in local residential streets. Studies were undertaken earlier (as described below) to study the impact of on-street parking in major arterial roads. This research would provide an idea about its impact in local streets – a topic where not much data is available and no major research work has been identified.

The major objectives of this research, undertaken as part of a Masters research project (Praburam 2014), were:

- To study and analyse the impact of on-street parking on traffic operations.
- To compare how the vehicular speeds vary for various levels of on-street parking demand in roads of different widths.

### 1.1 Background Literature

Earlier research has demonstrated that on-street parking has an effect on speeds and other traffic operations. They were found to hinder the traffic flow directly and indirectly. For example, research by Sisiopiku (2001) studied the impact of on-street parking on major state roads in Michigan, based on a synthesis of the state-of-practice. An increase in on-street parking levels was found to decrease the capacity of roads, while increasing the risk of crashes. Sisiopiku also noted the impact of on-street parking on traffic speeds, but recommended that its use as a traffic calming measure should be restricted to facilities with speed limits at or below 25 mph (40 km/h) and should be avoided on major arterial and collector streets.

Similar effects of on-street parking on traffic speeds have been noted in other international studies (e.g. Naseri 2013; Lim *et al* 2012). Some of this was due to the effective width available and some of it was due to the increased amount of manoeuvring in and out of parking spaces affecting adjacent traffic. Kladeftiras and Antoniou (2013) investigated the operational effects of double-parking and found that, if double-parking is eliminated, average speed can increase by up to 44%.

Most of the earlier studies were on major arterial roads and main roads. Not much research however has been done in residential areas or on local streets. For example, Australasian guidelines on Local Area Traffic Management (LATM, Austroads 2008) provides no specific advice on the impact of on-street parking on traffic speeds. This was one of the main reasons for working on this topic.

## 2 RESEARCH METHODOLOGY

For the purpose of this research, appropriate urban (50 km/h) sites in Christchurch were filtered and chosen from a list of potential locations based on certain conditions discussed below. The parking demand levels were calculated based on the space available for parking and the total space occupied by parked vehicles during the observed time period. For example, if three-quarters of the available parking space was occupied, then the "parking level" was 75%. The free speeds of moving vehicles (i.e. not following other vehicles) on each street were then monitored. The method of survey was chosen based on the site location and a few other parameters. They are explained in more detail below.

## 2.1 Site Selection

The sites were selected based on the road widths. Roads of various widths, ranging from around 8m to 13.5m, were selected for study. Most of the roads were found to be ~8.0 – 8.8m wide or ~13 – 13.6m wide. A few roads of about 10m wide were identified and selected.

Much attention was given to select sites where the on-street parking would be the only notable factor hindering the speed of vehicles. There were many streets where there were a few other factors that may hinder the vehicle operations. For example, certain streets had frequent LATM features adopted that, by themselves, would have a major effect on the speeds. A few other streets had places of high commercial interest like malls, restaurants etc., which may obstruct the traffic flow mainly because of the entry and exit of their high number of customers' vehicles. They also tend to cause traffic "stagnation" in certain places.

Streets with parking lanes or separately marked parking spaces were not taken into consideration as they would cause less of an impact. This is because these parking lanes are extra additions to the road and they do not reduce the operational road width. Streets with painted or solid medians were also not selected as they tend to affect the traffic flow to a certain extent. Moreover, roads and streets with medians were often too wide for parking to have an impact on the traffic speeds and not many residential streets were found to have medians anyway. For roads that ended at traffic signals or other intersections, sufficient care was taken such that the speeds were measured at a suitable distance away to minimise their effects; typically there was at least 100m to the nearest intersection.

After various site visits and through analysis of the road environments, ten streets were chosen for observations. Table 1 lists the final sites that were chosen.

~8m wide	~10m wide	~13m wide
Newnham Terrace	Office Road	Dallas Street
Plunket Street	Clarence Street South	St. Albans Street
Suva Street		Edinburgh Street
Poulson Street		Maxwell Street

**Table 1: List of Sites Studied**

## 2.2 Speed Gun and Speed Tube Surveys

The above mentioned streets were found to have varying parking demand that was good enough to draw comparisons between speeds at various parking levels for roads of similar widths. The number of streets that were around 10m wide was relatively few when compared to the other two. Most of the streets that were found to be around 10m wide had other factors like speed bumps and other LATM techniques at regular intervals and therefore could not be chosen.

Rubber speed tubes connected to an automated (MetroCount) recorder were generally used in quiet streets (or) those with a very low traffic volume (typically <1000 vehicles/day). This is because, it would take a very long time to stay on site and get the necessary number of samples using a manual survey. Moreover, it is very easy to setup speed tubes in such streets as the traffic was very low and no-one would experience any sort of disturbance while setting them up.

A laser speed gun was used in sites where the traffic volume was high. The high volume of the roads did not give enough time gap for safely setting up the speed tubes without requiring

specialist contractors. Also, the time consumed to individually monitor the speeds for the required number of vehicles was much less due to the high volume.

Where possible, the aim was to collect at least 50 samples per site for each parking level observed. Where the speed gun was used, care was taken to position the observer discreetly out of view, so as to minimise observer bias. Upper and lower cut-off speeds of 80 km/h and 30 km/h respectively were used to filter out potentially anomalous data, either due to measurement error (e.g. two vehicles crossing the tubes simultaneously) or due to manoeuvres being undertaken (e.g. vehicles starting to accelerate from or decelerate to a stop).

### 3 RESULTS

As discussed earlier, the selected sites were grouped according to the road widths. Speed surveys were undertaken based on the road volumes and the necessary numbers of samples were collected at various observed parking levels. The results are summarised in the following sections.

#### 3.1 Narrow Streets (between 8m and 9m wide)

Speed tubes were used for the speed surveys in all of the narrow width sites. The results are shown in Table 2. The table also has a column showing the “mean speed slope”. The slope is the ratio of the difference in mean speeds to the difference in parking levels at each site. The slope value numerically depicts the change in mean speeds with respect to change in parking levels, e.g. a value of -0.024 suggests that mean speeds would fall by 2.4km/h as parking levels went from 0% to 100%. Note that, in the case of Plunket Street, no distinctly different parking levels were observed and so only one set of data is provided.

Site	Width (m)	Sample Size	Parking Level (%)	Lowest Speed (km/h)	Highest Speed (km/h)	Mean Speed (km/h)	85 <sup>th</sup> %ile Speed (km/h)	Standard Deviation (km/h)	Mean Speed Slope
Newnham Terrace	8.7	99	50%	30.1	69.0	41.1	47.5	7.06	-0.024
		362	75%	31.1	69.3	40.5	46.4	6.39	
Suva Street	8.7	269	50%	30.2	74.6	44.6	52.2	7.84	-0.064
		261	75%	30.0	77.3	43.0	50.0	8.47	
Poulson Street	8.8	213	50%	30.1	69.6	37.1	41.8	5.82	-0.008
		29	75%	30.1	54.2	36.9	42.1	5.38	
Plunket Street	8.7	102	40%	30.7	62.0	44.2	54.0	8.26	-

**Table 2: Speed survey results for narrow streets**

The above data shows that traffic speeds generally fell gradually with an increase in parking levels, although the rate varies across the different sites (in fact, the 85<sup>th</sup> percentile speeds on Poulson Street rose slightly). In hindsight, given the relatively low mean speeds observed in some cases, it may also have been prudent to have used a lower cut-off value than 30 km/h for the analysis.

#### 3.2 Medium Width Streets (between 10m and 11m wide)

A speed gun was used for the speed surveys in the medium width sites. The results are shown in Table 3:

Site	Width (m)	Sample Size	Parking Level (%)	Lowest Speed (km/h)	Highest Speed (km/h)	Mean Speed (km/h)	85 <sup>th</sup> %ile Speed (km/h)	Standard Deviation (km/h)	Mean Speed Slope
Office Road	10.1	100	50%	30.0	58.0	38.6	44.0	6.26	-0.060
		88	70%	30.0	53.0	37.4	42.0	5.24	
Clarence Street South	10.2	89	25%	30.0	59.0	42.0	50.0	6.81	-

**Table 3: Speed survey results for medium width streets**

Again, the data shows a trend for traffic speeds to fall gradually with an increase in parking levels.

### 3.3 Wide Streets (over 13m wide)

Speed tubes were used for the speed survey in Edinburgh Street and a speed gun was used in the remaining sites. The results are shown in Table 4:

Site	Width (m)	Sample Size	Parking Level (%)	Lowest Speed (km/h)	Highest Speed (km/h)	Mean Speed (km/h)	85 <sup>th</sup> %ile Speed (km/h)	Standard Deviation (km/h)	Mean Speed Slope
Dallas Street	13.3	51	50%	30.0	46.0	37.5	41.5	3.88	-0.012
		59	100%	30.0	54.0	36.9	42.0	4.60	
Maxwell Street	13.5	71	50%	30.0	50.0	40.5	47.0	5.64	-0.071
		30	100%	30.0	55.0	37.0	42.0	6.32	
Edinburgh Street	13.7	576	5%	30.6	70.4	49.1	55.4	6.51	-0.133
		158	20%	30.2	69.8	47.1	54.7	8.17	
St. Albans Street	13.6	112	40%	42.0	62.0	51.2	56.0	4.22	-0.092
		110	85%	37.0	62.0	47.0	52.7	4.83	

**Table 4: Speed survey results for wide streets**

### 3.4 Comparison of Sites

As the tables indicate, the mean speeds fell with an increase in the parking percentage. A graph combining all the results is shown in Figure 1. For each group of streets, a linear trend-line has been interpolated to determine the average change in speeds (although it is acknowledged that a non-linear trend might be a reasonable relationship to apply here too).

Figure 1 indicates a reasonably consistent average reduction in mean vehicular speeds as parking levels increase. This was evident in all the width categories. The speeds were found to fall approximately by ~1km/h for every 10% rise in the parking level. It is recognised however that the degree of correlation ( $R^2$  value) is not good in many cases (especially for narrow streets); this may reflect the variation in road environment between different streets. Getting additional sites observed may help to confirm the trend identified.

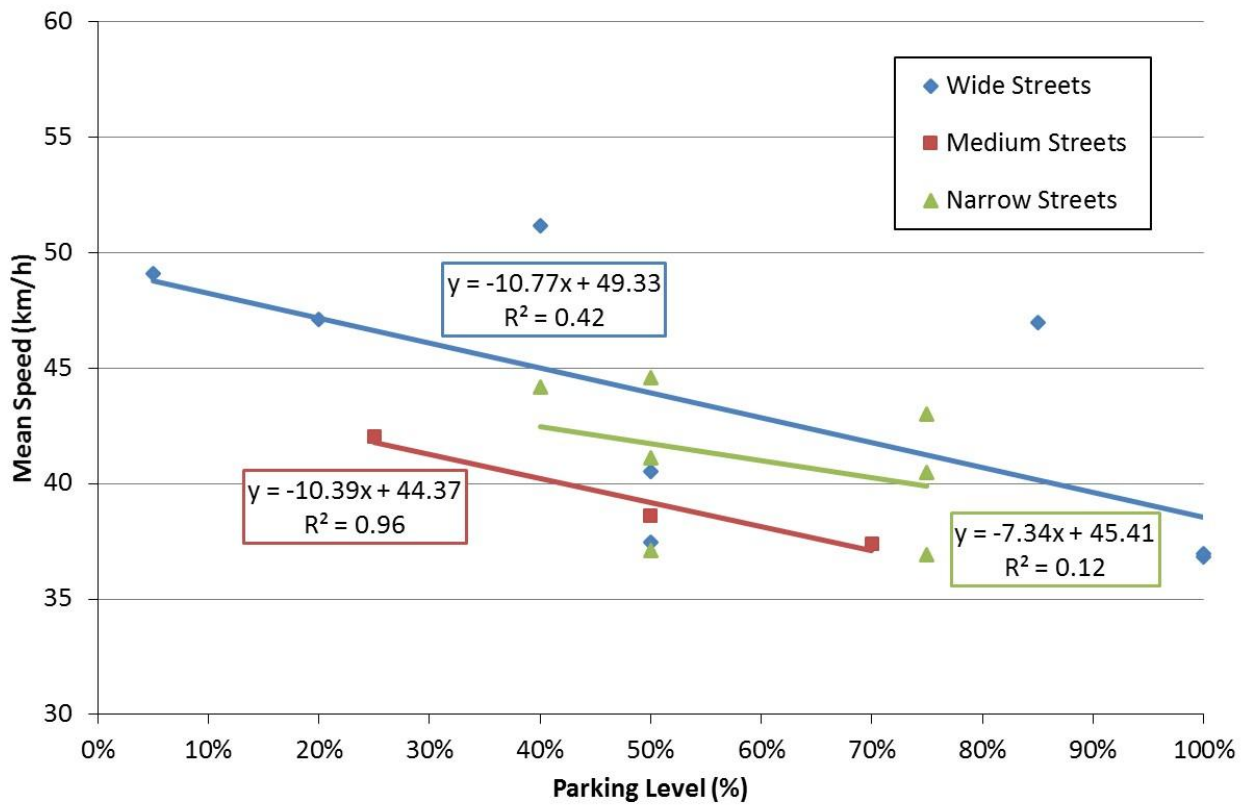


Figure 1: Variation of mean speeds across different parking levels

Similarly, 85<sup>th</sup> percentile speeds for each group of streets were plotted for the different levels of parking, which is shown in Figure 2:

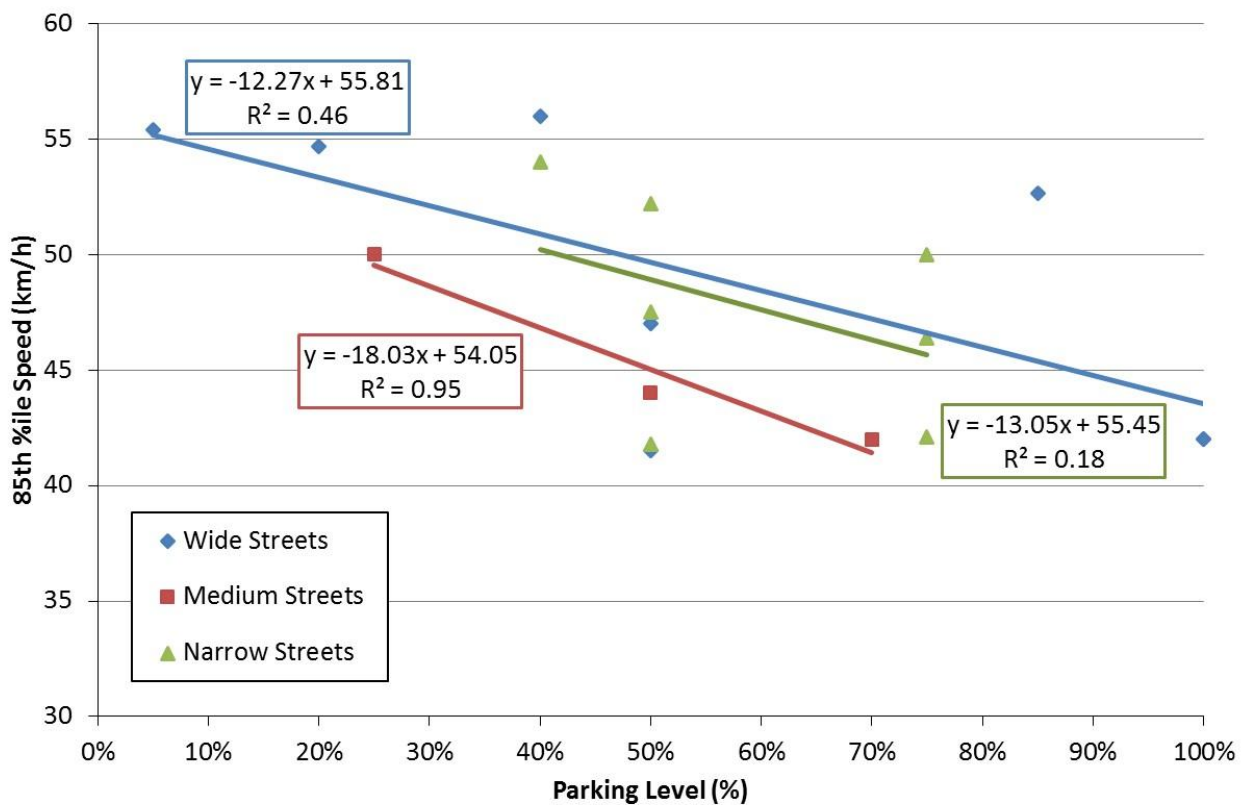
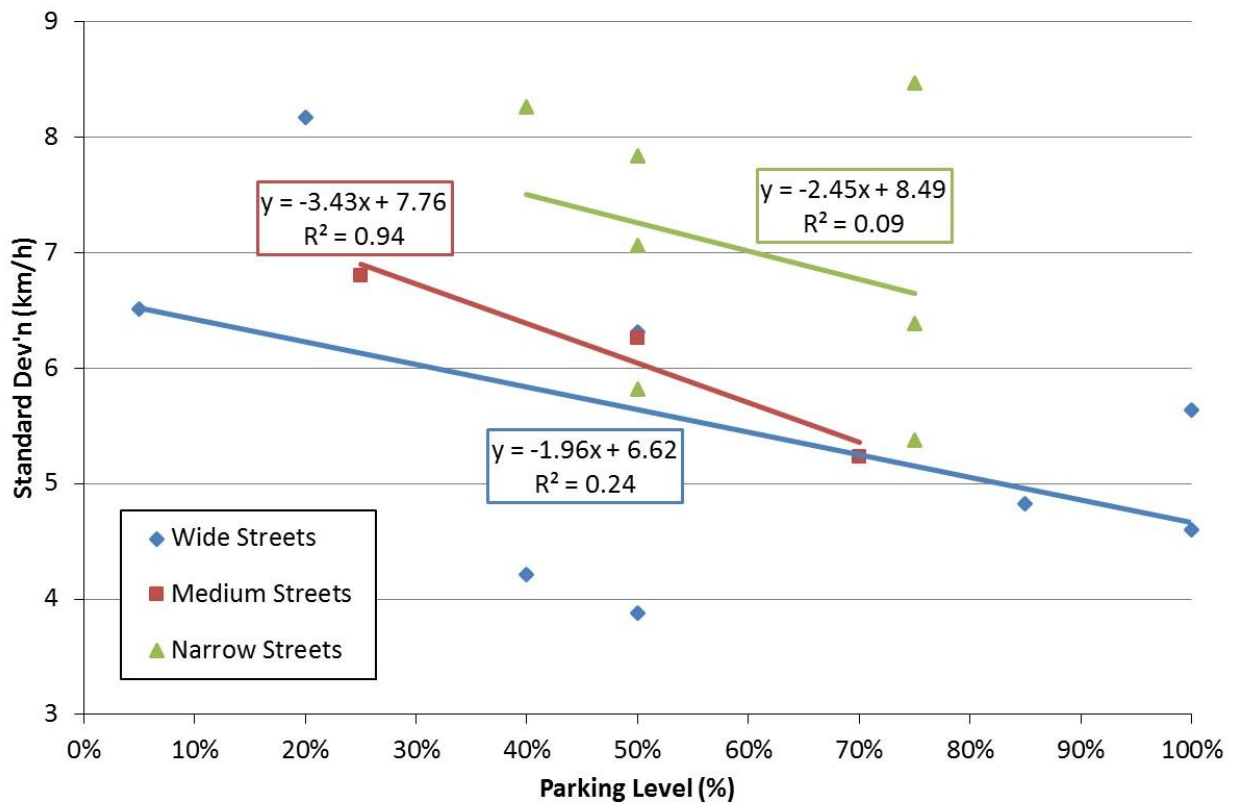


Figure 2: Variation of 85<sup>th</sup> percentile speeds across different parking levels

Figure 2 shows increased trend-line slopes compared with the mean speed relationships, which suggests that on-street parking has an even greater effect on vehicles travelling at higher speeds (notwithstanding the low  $R^2$  values again for narrow streets). This is a good sign, as we can infer that on-street parking tends to slow down speeding vehicles.

The change in standard deviations of speeds with parking levels for each group of streets have also been plotted; these are shown in Figure 3:



**Figure 3: Variation of standard deviation of speeds across different parking levels**

Again, the broad results indicate a reduction in standard deviations of speeds as parking levels increase. Previous research has suggested that crash rates tend to decrease as the standard deviation of speed decreases (e.g. Garber & Ehrhart 2000, Fildes & Lee 1993), so this would suggest that increased parking could provide a beneficial effect for safety. However, this needs to be considered in conjunction with other evidence suggesting that the obstructive effect of parking causes safety concerns (e.g. Sisiopiku 2001).

## 4 DISCUSSION

The results have shown that on-street parking has a noticeable (albeit not always significant) effect on traffic speeds even in local streets. The effects were strongest on medium width streets, more moderate on wide streets, and not very apparent at all on narrow streets. Based on previous literature, it was hypothesised that a greater level of on-street parking would have a constraining effect on traffic speeds; the results seem to support this premise.

It was also expected that narrower streets would have lower speeds, all other factors being equal. However, the observed speeds in the streets between 10-11m wide were lower than those in the streets that were between 8-9m wide. This fall in speed is mainly due to the fact that the road environment of the 10-11m wide streets that were chosen for this study didn't favour free flow of vehicles.

A major part of Office Road was congested due to excess parking. Trees that were present at regular intervals had a significant impact on vehicular speeds due to the visual hindrances caused. The west end of the road had a "Give way" junction and the east end was close to the Merivale Mall. There were a few other LATM techniques that were adopted in the road as well. Clarence Street South had similar limitations as well. One end of the road had a bank and shopping centre on either side, which could block flowing traffic. There were frequent sub-streets along the road that may have minor impacts as well. Thus, in both the streets, the best possible locations for observing speeds were not completely free from other speed hindrances. This was the main reason for the lower speeds in such roads.

Hence, the overall road environment needs to be considered while determining the speeds. Sufficient sites with the necessary criteria were not available for the 10-11m width category. Although it was earlier decided that the sites chosen should be free of speed impeding factors, these sites had to be chosen as they were the best available to analyse the traffic behaviour in this specific width category. Better results could have been obtained if some other roads with no other speed hindering factors were chosen as the project sites in this category. These facts also clearly reveal that on-street parking is not the only factor affecting the traffic speeds in local streets.

The results for 85<sup>th</sup> percentile speeds also demonstrated a similar effect of parking on traffic speeds. The results reveal that the impact of on-street parking on vehicles travelling at higher speeds is greater than the impact to vehicles travelling at lower speeds. As the 85<sup>th</sup> percentile speed is often above the posted speed limit, on-street parking helps to slow down speeding vehicles and serves as a major tool to keep the speeds under check.

Another hypothesis suggested was that narrower streets would have been more affected by the presence of parking than wider streets, and that this would have been demonstrated by different slopes for the trend-lines. However, the data to date does not seem to indicate such a relationship (for either mean or 85<sup>th</sup> percentile speeds). It would be interesting to see whether a larger sample of streets and parking levels would be able to discern any notable pattern in this respect.

The results suggest that allowing (or keeping) on-street parking could be a useful speed management device on typical local streets. Although not tested in this case, on particularly narrow streets allowing parking on just one side only, alternating at regular intervals, could provide additional benefits by also restricting forward sight distances and further reducing speeds.

#### 4.1 Study Limitations

There are a few limitations in the overall results as well. The parking levels did not remain exactly the same for long periods of time. Invariably, there were a reasonable number of vehicles entering and leaving the parking spaces during the observed time periods. Although there wasn't much deviation from the parking levels that were investigated (and reported in the results section), there were minor changes (around 2-3%) occasionally due to the addition or removal of one or two vehicles at some point of time. These changes were neglected as they were very minor. It is possible that even greater changes sometimes occurred during time periods not observed, as they couldn't be monitored consistently. However, the analysed data was taken from the observed time periods or the immediately adjacent time periods to minimise such differences.

There were some practical issues with the survey. It was quite difficult to get more than two ranges of parking levels in a single street for a considerable amount of time. This was an issue in all the sites that were chosen. For example, as seen above, only 40% and 85% parking levels could be found in St. Albans Street. The parking level was low during quiet hours and high during the peak and busy hours. Any other parking level was not found to remain long enough to conduct speed surveys and get the necessary number of samples. Thus, it is highly recommended to find out and choose sites that show at least three different ranges of parking levels over time so that an effective comparison can be obtained. Also, speed data from more than two parking levels could also enable checking whether the linear assumption is valid across the whole parking range (0% to 100%).



Although steps were taken to monitor the parking levels regularly (in sites where speed tube surveys were done, which required the tubes to be on site for a few days continuously to get the necessary number of samples), it was quite difficult to monitor all the streets as they were quite far from each other (there was no such issue in sites where the speed guns were used as it required the surveyor to be on site throughout the survey and the parking levels were also monitored simultaneously). Thus, installing cameras at the sites (if permitted) could be a possible option to overcome this issue. Using speed cameras could enable tracking of even minor changes in parking levels from which it would be possible to analyse variations in vehicle speeds for even small changes in parking levels. This could also be useful to check whether the linear assumption is valid. This option could be useful in sites that were found to have only two different parking ranges with very minor changes occasionally.

Invariably with any traffic study using real-world sites, it is difficult to isolate the studied feature (in this case, on-street parking) from other attributes of the road environment. This makes it particularly difficult to compare the effects of on-street parking across a set of multiple streets as we have attempted here. Comparing different parking levels over time on the *same* street minimises these additional confounding factors, and more of these observations should be undertaken. However, it does not guarantee a perfectly like-for-like comparison, e.g. driver behaviour may also vary at different times of the day, due to trip purpose and other factors.

Another minor issue in the survey method was inclement weather. Inclement weather did not permit speed gun surveys for a long time. But, since harsh weather was also a factor that would affect speed (Liang *et al* 1998), surveys were completely avoided during such weather conditions. Thus inclement weather didn't create much impact but it had interrupted a couple of speed gun surveys when there was a sudden change in weather.

## 5 CONCLUSION

To summarise, the impact of on-street parking in local streets has been studied at ten urban sites in Christchurch. The results were generally as hypothesised and were quite similar to the studies that had been done earlier on major arterial roads.

### 5.1 Findings

There were many inferences from this research:

- On-street parking had a noticeable effect on traffic speeds along local streets, but the effect was not meaningful on narrow streets.
- Mean speeds fell at a rate of ~1km/h for an increase of 10% in the parking levels.
- Vehicles travelling at higher-than-average speeds were found to be affected more greatly.
- The magnitude of fall in speed varied only slightly based on the road widths.

While there was still considerable scatter in some of the results, probably due to the inherent variation in road environment between streets studied, the results are promising for on-street parking as a speed management tool. However, more research is needed to confirm the size of the speed management effect.

### 5.2 Recommendations

A number of further tasks are recommended:

- Policy makers should consider the role of on-street parking as part of their local area speed management strategies.
- Future national guidance on speed management and local area traffic management should highlight the role that on-street parking can play in constraining traffic speeds.

- Increasing the number of sites in each width category and choosing sites that have a greater number of different parking demand levels would be helpful in obtaining more accurate and/or more conclusive results.

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