The Influence of Width of Road Humps on Operating Speed

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Abstract: Road humps are synonymous with traffic calming seeing as this type of speed control device has the distinction of being highly effective in reducing speeds. Speed reduction brought about by road humps can be attributed to the drop in discomfort levels as vehicle speeds are lowered. Factors that influence speed choice across road humps include drivers' perception of speed that is suitable for safe and comfortable passing, the design of road humps, and the type and condition of the vehicle. This research was aimed at determining the effect of hump width (with respect to road with) on device operating speed of 100 mm Watts profile road humps with fixed length of 3.7 m. It was found that smaller hump width to road width (W_H/W_R) ratios produced lower device operating speeds, and that the use of smaller hump widths is more viable for wide roads (10 m or greater in width).

Keywords: Road hump, traffic calming, speed control, neighbourhood traffic management.

1. Introduction

A road hump is a raised segment of a roadway that is installed primarily to control vehicular speed. This traffic calming device is generally employed on residential streets where low speeds (30 – 40 km/h) are highly desired. When traversing a hump, drivers are compelled to reduce the speed of their vehicles in order to minimise uncomfortable bumping and vibrating sensations.

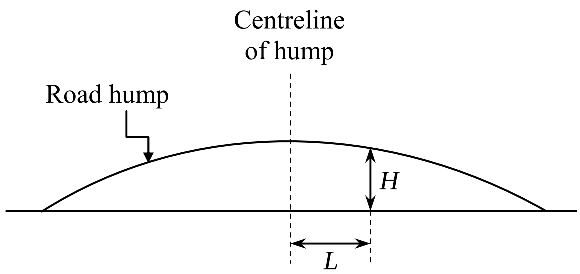
The road hump has the merit of producing the lowest operating speed of all traffic calming devices [1], [2]. Studies have shown that reductions of 11 – 29% in 85th percentile speeds can be attained through the use of road humps, thus making it by far the most effective speed control device [3], [4], [5]. In addition, street speeds (i.e. 85th percentile speeds on unimpeded sections) have been found to be 40 – 45 km/h on streets where road humps were installed. This was considerably lower than on streets with other devices, horizontal deflections in particular [2].

There are many factors that influence a driver's choice of speed when negotiating a hump. The perceived speed for safe and comfortable passing plays a major role in the driver's decision on how slow he would need to steer his vehicle over the hump. Equally, the design of the hump has a huge impact on speed choice. Humps may be parabolic, circular, sinusoidal or trapezoidal in shape. Humps are mostly 75 mm or 100 mm in height, and lengths are 3.7 m, 4.3 m or 6.7 m. Hump widths may vary according to the road width (when constructed fully across the road), or to the constricted road width (when constructed partially across the road).

Hence, this research aims to determine the influence of hump width on the operating speed of circular or what is commonly known as Watts profile road humps that have fixed height and length of 100 mm and 3.7 m respectively.

2. Research Method

A total of 21 Watts profile road humps (see Fig. 1) on nine residential streets in Christchurch, New Zealand were selected for this study. These streets were classified as low volume roads having average daily traffic flows of less than 500 vehicles per hour [6].



L (m)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
H (mm)	100	100	99	97	95	93	90	86	81

0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.85
76	71	65	58	51	43	34	25	16	5	0

Fig. 1 Longitudinal view and dimensions of a typical Watts profile road hump.

Hump widths, W_H, ranged from 5.6 m to 10.4 m, while road widths, W_R, were from 8.1 m to 13.5 m.

Speed data were collected using a ProLaser III light detection and ranging (LIDAR) speed gun during weekday off-peak periods for the purpose of obtaining vehicular speeds unimpeded by other traffic. Data collection took place in clear and dry conditions in order to eliminate factors that affect driving, such as lack of visibility and wet road surfaces.

To minimise the effect of parked vehicles, streets with effective widths wide enough to allow opposing vehicles to pass each other without the need to slow down or stop were selected. Given that parking density was very low

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during off-peak periods, the effect of parked vehicles was negligible.

To rule out the effect an observer might have on drivers' speed choice, observations were made from a vehicle parked by the side of the road, with the observer concealed from the view of drivers. The position of the vehicle was also chosen so as not to impede traffic.

The device operating speed, V_o, which is described as the speed of vehicles traversing the road hump, was taken as the 85th percentile speed of all speeds recorded across the road humps.

Road humps constructed partially across streets generally had islands or kerb extensions included in the design (see Fig. 2). The hump width to road width ratios (W_H/W_R) in these cases were considerably smaller than 1, ranging from 0.44 to 0.68.

For road humps constructed fully across streets (see Fig. 3), the W_H/W_R ratios were between 0.90 and 0.92. It should be noted that a W_H/W_R ratio equal to 1 is not likely, due to the provision of drainage channels along the roadway periphery. Given that the width of a single channel is approximately 0.5 m, therefore a road hump constructed fully across a street will have a width that is 1.0 m less than the street width.

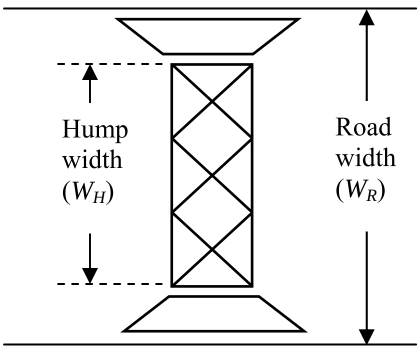

Fig. 2 A road hump constructed partially across a street.

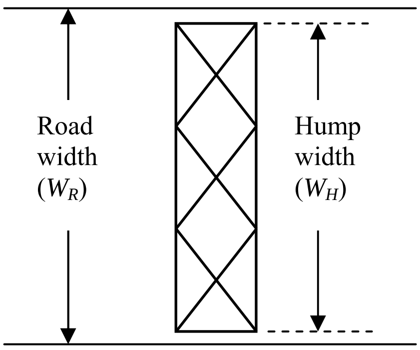

Fig. 3 A road hump constructed fully across a street.

Regression analysis was performed to relate V_o to the W_H/W_R ratio. V_o was taken as the 85th percentile speed recorded across the road humps. Since the W_H/W_R ratio can never be zero, it was decided that the data be fitted into S-curve and Power functions that have basic equations given in Table 1. The one that produced a better fit was selected to represent the relationship.

Table 1 Basic equations for S-curve and Power functions tested using regression analysis.

Function	Basic Equation
Power	$Y = aX^b$
S-curve	$Y = \exp[a + (b/X)]$

where Y is the response variable, X is the predictor variable, *a* is the constant and *b* is the coefficient for the predictor variable

3. Results and Discussion

From the 1,239 vehicle speeds recorded across the 21 road humps, overall device operating speed was established as 29.1 km/h (see Table 2). This overall value is within the 25 – 30 km/h range of operating speeds observed in past studies [7]. The device operating speeds for individual road humps, however, was in a broader range, i.e. from 21.9 km/h to 33.9 km/h. This shows that with the diversity in road hump configurations and the unpredictability of driver attitude, the anticipated range of operating speeds of road humps should be expanded, possibly to 20 – 35 km/h.

Table 2 Descriptive statistics of vehicle speeds recorded across 100 mm Watts profile road humps.

Statistical Parameters	Speed (km/h)
85th Percentile	29.1
Mean	22.3
Standard error	0.2
Standard deviation	6.8
Range	45.2
Minimum	6.1
Maximum	51.3

The large variation of speeds across road humps (range 45.2 km/h, min. 6.1 km/h, max. 51.3 km/h) is a reflection of the varied attitude of drivers towards road humps. It was observed that drivers of heavy and old vehicles were more inclined to travel at low speeds across road humps, while drivers of sports utility vehicles and modern passenger cars were among those found travelling at high speeds. This implies that vehicle type and condition also have influence on drivers' speed choice.

The relationship between V_o and the W_H/W_R ratio showed statistical significance using both S-curve and Power functions. However, the S-curve model demonstrated a slightly higher significance than the Power model (see Table 3). In addition, the shape of the S-curve model explained the relationship more appropriately, particularly for smaller ratios where speeds were expected to fall sharply as narrower road humps were used (see Fig. 4). Therefore the S-curve model was selected to represent the relationship, which took the form of:

$$V_o = exp\left(3.474 - \frac{0.113}{W_H / W_R}\right) \qquad (1)$$

Table 3 Summary of regression output for relationship between device operating speed and hump width to road width ratio.

	S-curve Model		Power Model	
SEE	0.114		0.115	
F-statistic	7.148		6.240	
Sig.*F*	0.011		0.016	
Parameter	W_H/W_R	Constant	W_H/W_R	Constant
Coefficient	-0.113	3.474	0.162	28.916
t-statistic	-2.674	54.063	2.498	35.118
Sig. *t*	0.011	0.000	0.016	0.000

Note: SEE = standard error of the estimate, Sig. *F* = significance value of the *F*-statistic, Sig. *t* = significance value of the *t*-statistic

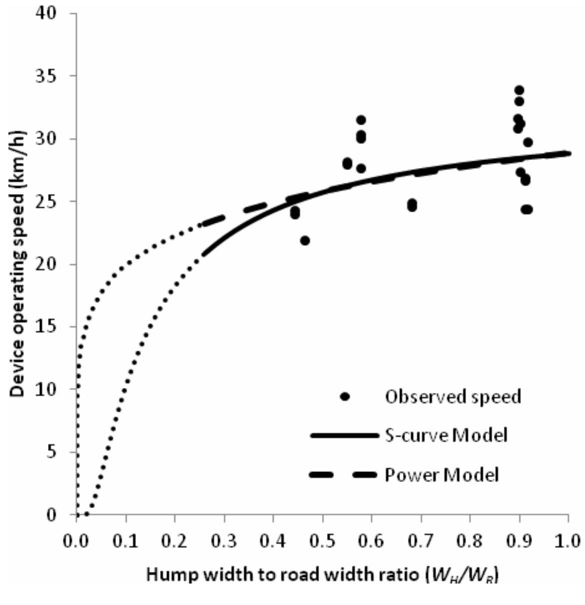

Fig. 4 Fitted curves for models relating device operating speed to W_H/W_R ratio.

It was found that the width of a road hump with respect to the road width had an effect on device operating speed. Smaller W_H/W_R ratios produced lower speeds, as shown by the speed reduction curves in Fig. 5.

Evidently, drivers are influenced by the narrowing of road humps. This influence is more noticeable on wider streets, where the use of a road hump partially constructed across the street causes drivers to perceive that their travel path is not only vertically deflected but also significantly constricted.

On the other hand, if a road hump of similar dimensions was to be placed on a narrower street, the impact it would have on drivers would be smaller, as demonstrated by the estimated speed curves in Fig. 6.

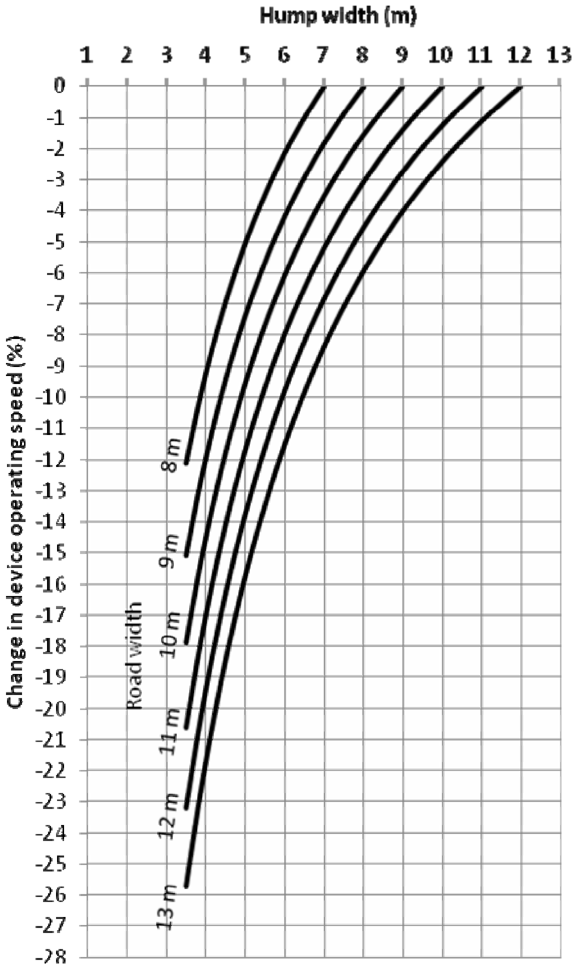

Fig. 5 Change in device operating speed with respect to speed on hump constructed fully across a street. Note that hump width is 1 m less than the road width due to provision of drainage channels.

Also, the model suggests that a 12 m wide street with a 6 m wide road hump will produce an operating speed approximately 10% lower than a road hump constructed fully across the street, i.e. a 11 m wide hump (refer to Fig. 5).

However, an 8 m wide street with a 6 m wide road hump will produce an operating speed approximately 2% lower than a road hump constructed fully across the street (7 m wide hump).

The smaller change in speed predicted on the narrower street can be explained by the lower travel speeds it naturally produces. Therefore, it may be more cost-effective to use a road hump and narrowing combination on wider streets (≥ 10 m) than on narrower streets (≤ 9 m).

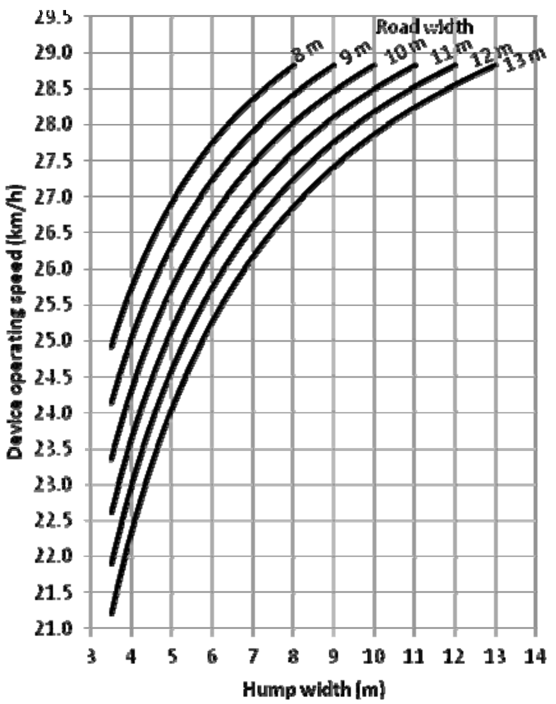

Fig. 6 Estimated device operating speeds based on hump and road widths.

4. Conclusion

This study has found that device operating speeds across 100 mm Watts profile road humps were as low as 21.9 km/h and as high as 33.9 km/h. It can therefore be said that road humps may produce operating speeds in the range of 20 – 35 km/h, as opposed to the 25 – 30 km/h range that has been often quoted. An attempt to relate device operating speed with hump width to road width ratio resulted in a statistically significant S-curve model that showed smaller hump width to road width ratios produce lower device operating speeds. The model also provided some justification that the use of smaller hump widths on wide streets is more pragmatic, and it is not necessary to install narrow humps on already narrow streets as the reduction in speed achieved is not substantially different from humps constructed fully across the street.

References

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